

Surgical Care for Children

A GUIDE FOR PRIMARY REFERRAL HOSPITALS



Stephen Bickler
& Emmanuel Ameh



SURGICAL CARE FOR CHILDREN

Guidelines for the primary
referral hospital

Edited by

Stephen W Bickler • Emmanuel A Ameh

A hundred years from now, it will not matter what my bank account was, the sort of house I lived in, or the kind of car I drove ... but the world may be different because I was important in the life of a child.

From *Within my power*

Forest E. Witcraft 1894–1967

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► PREFACE

The surgical care of children is one of the most neglected aspects of child health in low- and middle-income countries. Poor surgical care has not been without consequences. In many of these countries, congenital anomalies go untreated, children die of easily correctable surgical problems, and injuries result in lifelong disabilities.

The surgical care of children in low- and middle-income countries presents many challenges. Not only must the correct diagnosis be made, but resources must be available for treatment. Moreover, paediatric surgical patients come from low-income families and often have multiple social, cultural and health issues.

The most common surgical problems affecting children in settings of limited resources are injuries, congenital anomalies and surgical infections; these three categories account for approximately 90% of paediatric surgical admissions. Injuries occurring at home, on the roads, along with blast injuries from wars and conflicts, are a growing problem.

Most children with surgical problems in low- and middle-income countries will first present to the primary referral hospital. Surgeons with a specialized knowledge of paediatric surgical conditions are rarely available at this level; there is therefore a need for a concise guide to the management of the most common childhood surgical conditions. The majority of surgical conditions in children require relatively simple procedures and can be managed at the primary referral hospital. For children with problems that cannot be managed at this level, there is still a need to properly assess and stabilize the child before transferring or referring to a specialist centre.

Several excellent publications within the past 5 years have addressed the surgical care of children at the primary referral hospital. Foremost are two published by the World Health Organization:

- *Surgical care at the District Hospital*
- *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources.*

Surgical care for Children has been written to complement these publications and fills some of the gaps.

This handbook describes a limited number of surgical procedures, selected for the doctor who does not have formal paediatric surgical training. Procedures that require specialist skills have largely not been included, although we have included some procedures that may appear technically difficult because they may offer the best chance for saving a child's life.

It is our hope that this handbook will help improve the care of infants and children who might otherwise die because of poor access to quality care.

Stephen W Bickler & Emmanuel A Ameh

▶▶ INTRODUCTION

This handbook provides a guide to managing the most common paediatric surgical problems that present to the primary referral hospital.

The initial section focuses on the fundamentals of paediatric surgery. Following are clinical sections on: perioperative care, neonatal problems, injuries, head and neck problems, abdominal problems, urological/gynaecological problems, surgical infections and chronic disabilities. The appendix includes information on commonly used drugs, intravenous fluids, immunization and essential surgical supplies.

This handbook is *not* intended to be a textbook of paediatric surgery. It has been written for the non-specialist working at a primary referral hospital. It provides an important resource for individual practitioners, and for use in undergraduate and graduate programmes, in-service training and continuing medical education programmes. To help you navigate through the text, we have used different styles of bullet points to indicate diagnostic signs or symptoms and management guidelines:

- diagnostic sign or symptom
- ▶ treatment recommendation.

The management described in this handbook is based on paediatric surgical practices that have been adapted for the primary referral hospital. Suggested medications are from the *Pocket Book of Hospital Care* (WHO, 2005). We would be pleased to receive comments and suggestions regarding the manual and its use, which can be sent via the publisher.

ABBREVIATIONS

°C	degrees Celsius
AIDS	acquired immunodeficiency syndrome
CMV	cytomegalovirus
CSF	cerebrospinal fluid
G	gauge
HIV	human immunodeficiency virus
IM	intramuscular
ISFBH	International Federation for Spina Bifida and Hydrocephalus
IU	international units
IV	intravenous
kg	kilogram
mg	milligram
mL	millilitre
NSAID	non-steroidal anti-inflammatory drug
SC	subcutaneously
WHO	World Health Organization

▶▶ CHAPTER 1: **Fundamentals of Paediatric Surgery**

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▶▶ 1.1 General principles

Key points

- ◆ Many paediatric surgical procedures are simple to do and can be performed safely and effectively at the primary referral hospital.
- ◆ Managing children with surgical problems at the primary referral hospital allows the child to remain close to home and spares the parents the anxiety and expense of making trips to another facility.
- ◆ Most procedures can be done quickly, safely and with little discomfort to the child.
- ◆ Some surgical problems do not require an operation. Knowledge of the natural history of some conditions will help avoid unnecessary surgery.

The main principles for managing children with surgical problems at the primary referral hospital can be summarized as follows.

- Limit the procedures to those that can be done safely and effectively.
- Safe anaesthesia is essential.
- Ensure that the necessary help and supplies are available.
- Prepare yourself and your team for the procedure.

Limit the procedures to those that can be done safely and effectively

Safety should be the single most important consideration when deciding whether a procedure can be done at the primary referral hospital. Safety implies that the person doing the procedure can deal with any complication that arises and that the facilities to deal with such problems are available. A properly done operation is done quickly, successfully and with minimal discomfort to the child.

Because no two procedures are the same, the decision to do a procedure on a particular child must be individualized. The question that should always be asked is “Can the planned procedure on this child be done safely and effectively with the skill and resources available?” If the answer is no, the child should be transferred to a facility that can provide the needed care.

Safe anaesthesia is essential

Procedures requiring either general anaesthesia or sedation must be done by trained individuals. Moreover, these procedures should only be done at facilities that have the resources to properly monitor children during and after procedures and to care for anaesthetic complications should they arise.

Ensure that the necessary help and supplies are available

It is essential to assemble the necessary help and supplies *before* starting a procedure, to ensure that completion of a procedure is not delayed. Supplies should be selected

and arranged for use before the child is brought into the area where the procedure will be done. Pre-prepared kits for common procedures (e.g. repair of lacerations, drainage of abscesses) can greatly simplify preparation.

Prepare yourself and your team for the procedure

Much can be learned from the standardized airline safety regulations. Checklists are a good method to make sure that everything has been prepared, both in terms of human resources and supplies.

Before each procedure a 'time out' should be taken to check that the procedure is being done on the correct patient, on the correct side (left or right), whether blood is available for transfusion if needed, and that your assistants know what is planned. This should be performed on every patient once fully anaesthetized and before the procedure is started.

In summary, safe surgery means careful planning before, during and after the operation. Most essential is a team approach, with the doctor as the captain who oversees everything. Procedures have to be performed regularly to keep the team in good shape and to allow recognition of any deficiencies in either human terms or facilities. Finally, an operation is not over with the last stitch, but when the patient is cured and leaves the hospital.

1.1.1 Surgical audit

Keeping accurate records of your outcomes will enable you to assess the effectiveness of your treatment. If the outcome are not as good as would like, you need to find out the reason: poor instruments, inadequate preparation, wrong indications? Ideally, discuss your results with a senior colleague or visit his or her hospital to exchange views. Never forget that surgery is lifelong training.

▶▶ 1.2 Physiology of children

Key points

- ◆ Children are NOT small adults!
- ◆ Recognizing the differences between children and adults can improve the surgical care of children.

The following sections describe some of the basic physiological differences between children and adults.

1.2.1 Thermoregulation

Compared with adults, children have thinner skin, less subcutaneous fat and a larger body surface to mass ratio. These factors allow children to become cold more quickly

than adults. Hypothermia (defined as a body temperature less than 35°C) in a child can affect blood clotting, drug metabolism and central nervous system function.

1.2.2 Glucose storage

Infants and children are at risk for developing hypoglycaemia because of a limited ability to utilize fat and protein to synthesize glucose. Moreover, the amount of glucose stored in the liver as glycogen is small and is exhausted within 3 hours of starvation.

1.2.3 Ability to fight infection

Young children, and infants in particular, are more susceptible to infection than adults. This is largely because their neutrophils have poor phagocytic function and the complement pathway is poorly developed. Malnutrition can further contribute to this relative immune deficiency.

1.2.4 Blood volume

Children have smaller blood volumes than adults (75–85 mL per kg body weight). Even small amounts of blood loss in a small child can be life threatening.

1.2.5 Response to shock

Children compensate differently to increased demands for cardiac output. Whereas adults increase cardiac output by increasing heart rate and stroke volume, children have a limited ability to increase stroke volume. Consequently, an increase in heart rate (tachycardia) is the main mechanism by which a child increases their cardiac output. Severe tachycardia is an ominous sign and can indicate impending cardiovascular collapse.

1.2.6 Renal function

Children, particularly neonates and infants, are unable to concentrate urine to the same extent as adults. They are therefore unable to excrete a sudden large fluid load. This means that they are easily overloaded with intravenous (IV) fluids if the volume is not carefully calculated and administered. Immature renal function means that drugs that are excreted predominantly through the kidneys can rapidly reach toxic plasma levels. For this reason, drugs such as aminoglycosides should be given with caution.

1.2.7 Hepatic function

The liver is not fully mature in newborns and some of the functions are suboptimal. The synthesis of vitamin-K-dependent clotting factors is limited. Newborns are therefore at increased risk for bleeding problems and should be given parental vitamin K before an operation.

1.2.8 Psychological status

Surgical conditions can cause psychological problems. In the very young, emotional instability frequently leads to immature behaviour. Stress, pain and other perceived threats contribute to these behavioural changes.

1.2.9 Long-term effects

Always consider what effect the surgical problem and the operation will have on the emotional and physical development of the child. Surgical problems often disrupt the normal process of growth and development. In addition, childhood surgical conditions can have a significant impact on the family. Frequently the child's problem imposes a strain on the whole family, including financial and sometimes employment hardships. Most importantly, the condition may impact on the child's quality of life for years to come.

▶▶ 1.3 Vital signs

Key points

- ◆ Vital signs vary with age.
- ◆ Always compare a child's vital signs with normal values for their age, given in Appendix 1.

1.3.1 Heart rate

Heart rate gradually decreases from about 150 beats per minute (bpm) in newborns to normal adult values of 60–100 bpm by 12 years of age. The most common causes of an increased heart rate in a child are fear, pain, hypovolaemia, anaemia, fever and infection. Heart rate goes up or down by approximately 10% per degree Celsius change in body temperature.

Warning!

- Severe tachycardia (increased heart rate) is an ominous sign because it may indicate impending cardiovascular collapse.
- Bradycardia (slow heart rate) in a child indicates insufficient oxygen until proven otherwise.

1.3.2 Blood pressure

Normal systolic blood pressure in a child is 80 mmHg plus twice their age in years (e.g. for a 5 year old: $80 + (2 \times 5) = 90$ mmHg). Diastolic blood pressure should be two-thirds of the systolic pressure. The most common causes of low blood pressure in a child are dehydration (from vomiting, diarrhoea or poor fluid intake) and bleeding.

1.3.3 Respiratory rate

An increased respiratory rate can be due to increased levels of carbon dioxide in the blood or decreased levels of oxygen. Other causes of increased respiratory rate include fever, infection, pain and emotions such as fear and anxiety.

▶▶ 1.4 Fluid and electrolytes

Key points

- ◆ Most surgical conditions either limit oral intake or increase fluid requirements.
- ◆ Volume depletion (hypovolaemia) is the most common fluid problem in children with surgical conditions.
- ◆ Providing too little, or too much, fluid is a common cause of death in paediatric surgical patients.

1.4.1 Determination of fluid status

A great deal can be learned about a child's fluid status by taking a careful history and doing a meticulous physical exam.

- A history of vomiting or loss of appetite suggests that the child may be dehydrated. Asking when the child last urinated is the simplest way to assess the degree of hydration. Recent urination usually means that the child is well hydrated.
- Review the vital signs. The primary response to decreased intravascular volume is an increase in heart rate (tachycardia). The triad of tachycardia, cool extremities and low blood pressure is a clear indicator of evolving shock and requires immediate fluid resuscitation. However, heart rate should not be used as the sole indicator, as increased heart rate can be a result of fever, fear or psychological stress (see section 1.3.1, page 5).
- On physical exam, search for the signs of volume depletion. These include mottled skin in a light-skinned child or loss of skin 'shine' in a dark-skinned child, cool extremities compared with the torso skin, and diminished level of consciousness. A severely dehydrated child may have sunken eyes, dry mucous membranes and poor skin turgor.
- Urine output is the most sensitive and reliable indicator of fluid status. Urinary output varies with age – normal values are shown in Appendix 1. In critically ill children urine output should be monitored hourly by placing a Foley catheter.

1.4.2 Maintenance fluid

Maintenance fluid refers to the amount of water and electrolytes that is required to maintain normal metabolism. Maintenance fluid requirement is directly related to body weight and can be calculated in several ways (e.g. surface area and caloric intake) but by far the easiest is by weight.

The total daily fluid requirement of a child is calculated using the following formula:

- 100 mL/kg for the first 10 kg
- then 50 mL/kg for the next 10 kg
- thereafter 25 mL/kg for each subsequent kg.

For example:

- an 8 kg baby should receive $8 \times 100 \text{ mL} = 800 \text{ mL}$ per day
- a 15 kg child should receive $(10 \times 100) + (5 \times 50) = 1250 \text{ mL}$ per day.

Maintenance fluid requirements by body weight are given in Appendix 2. Because most surgical conditions increase fluid requirements, estimates for 125% and 150% of maintenance fluid are also included.

The type of IV fluid needed depends on the age of the child.

- **Newborn < 3 days old:** 5% glucose or preferably 10% glucose if available.
- **Newborn > 3–28 days:** 0.18% NaCl / 4% glucose + 20 mmol KCl per litre. Do NOT use IV glucose and water without sodium after the first 3 days of life – babies over 3 days old need some sodium.
 - Mix D10W with normal saline (0.9% NaCl) in a 1:4 ratio (e.g. 20 mL D10W + 80 mL normal saline in a 100mL buretrol). Can substitute Ringer's lactate (Hartmann's) for normal saline.
- **Infants and children:** 0.45% NaCl / 5% glucose + 20 mmol KCl per litre.
 - Mix D10W with normal saline (0.9% NaCl) in a 1:1 ratio. Can substitute Ringer's lactate (Hartmann's) for normal saline.

The composition of standard IV fluids is given in Appendix 3.

1.4.3 Correcting fluid deficits

Many surgical patients will present with or develop fluid deficit during the course of their illness. As such, it is important to know how to rapidly restore intravascular volume.

If a patient is unable to take liquids orally, the best way to correct a fluid deficit is to give a bolus of crystalloid fluid (normal saline or Ringer's lactate, 20 mL/kg). If a child is severely dehydrated, multiple fluid boluses may be required to restore circulating volume. Children should be monitored closely during administration of the fluid boluses.

Fluid resuscitation is deemed successful if the following are observed:

- slowing of the heart rate
- increased systolic blood pressure
- brisk capillary refill
- warm extremities
- urinary output more than 1 mL/kg per hour.

Frequent and repetitive assessment of the child is essential to confirm adequate response to fluid resuscitation and assess the need for further intervention.

▶▶ 1.5 Airway management

Key points

- ◆ A child's airway has a smaller diameter than an adult's, making it more susceptible to obstruction from secretions, swelling or compression.
- ◆ The higher oxygen requirement of infants and children per body weight means that airway obstruction will produce hypoxia more rapidly than in an adult.
- ◆ Ensure that all the necessary equipment is available before starting intubation.

1.5.1 Preoperative assessment

An airway history should be taken to detect medical, surgical and anaesthetic factors that may indicate the presence of a difficult or obstructed airway. Enquire about:

- prematurity (birth before 37 weeks' gestation)
- congenital and acquired diseases
- cough
- snoring
- mouth breathing
- history of trauma
- previous anaesthesia
- the time it takes to feed the child.

A thorough physical examination, with emphasis on the respiratory and cardiovascular systems, should be done to detect physical characteristics that may indicate the presence of a difficult airway. Check for:

- ability to open the mouth (should be >2 cm); this assessment can be difficult in young children
- craniofacial deformities
- prominent upper teeth
- large tongue (macroglossia)
- small jaw (micrognathia)
- others (e.g. choanal atresia, cystic hygroma)
- congenital heart disease – this often forms part of a syndrome (approximately 15% have other abnormalities)
- factors that may put the patient at increased risk should there be a problem with tracheal intubation (e.g. full stomach, intracranial disease, suspected cervical spine instability, anterior mediastinal mass, chest wall abnormalities, cardiac problems)
- problems with previous anaesthesia; if available, review the records for information on previous airway management.

Formulate an airway management plan on the basis of your findings. The plan will depend on the intended surgery, condition of the patient and skills and equipment available.

Infants and children scheduled to undergo an elective operation who have a severe upper respiratory tract infection (fever, cough, wheezing) should have their surgery postponed for a minimum of 6 weeks. This avoids the problem with airway sensitivity that can be associated with upper respiratory tract infections.

1.5.2 Preparation for intubation

Remember that a child's airway has a smaller diameter than an adult's and a different structure.

All necessary equipment and personnel must be assembled and checked beforehand. Have an experienced assistant available if a difficult airway is expected.

The following are required (mnemonic SDAMMIT):

- **Suction:** working suction and large-bore catheter with side holes
- **Drugs:** sedative hypnotic, muscle relaxant, resuscitation medications
- **Airway:** bag, oxygen, mask, laryngoscopes, endotracheal tubes, oral / nasal airway
- **Monitors:** pulse oximeter (set to tone modification), electrocardiogram (ECG), blood pressure cuff, temperature monitor
- **Machine:** fully checked and ready to go
- **IV fluid:** connected to tubing and ready to use (the cannula should be in place before intubation)
- **Table / Temperature / Tape:** functioning table; warm room; readily available tape.

Selecting the correct size endotracheal tube

The size of the endotracheal tube is critical, as one that is too large will exert pressure on the internal surface of the cricoid cartilage which could result in airway obstruction when the tube is removed. An uncuffed endotracheal tube with an air leak around it should be used in children less than 2 years of age because it provides a larger internal diameter than a cuffed tube and is also less likely to cause airway swelling. Table 1.1 shows suggested endotracheal tube sizes for different age children.

Alternatively, the following formula can be used as a rough guide for normally nourished children more than 2 years old:

$$\text{Internal diameter of the tube (mm)} = \frac{16 + \text{age}}{4}$$

Another rough indicator of the correct tube size is the diameter of the child's little finger. Always have tubes one size bigger and one size smaller available. When a non-cuffed tube is used there should be a small air leak around the tube with each breath. Listen to the lungs following intubation to ensure equal breath sounds.

Table 1.1 Approximate endotracheal tube size by age

Age (years)	Tube size (mm)
Premature infant (< 37 weeks' gestation)	2.5–3
Term infant	3.5
1	4.0
2	4.5
3–4	5
5	5.5
6	6
7–8	6.5
8	cuffed 5.5
10	cuffed 6.0

The depth at which the endotracheal tube is inserted is critical. For small or premature infants, use the 1-2-3-4, 7-8-9-10 rule. 1-2-3-4 represents the baby's weight in kilograms, and 7-8-9-10 the depth of insertion in centimetres measured from the gum. Alternatively, the depth of insertion of the endotracheal tube (in centimetres) can be estimated using the 'age + 10 at the gums' rule. For example, an endotracheal tube for a 1-year-old child should be inserted 11 cm from the gums (1 + 10 cm).

1.5.3 Tips for successful intubation

- The head position is critical. The 'sniffing position', with a towel placed under the head, will align the airway for intubation. In infants, the head is large and needs to be stabilized by a towel under the neck. A common mistake is to place a towel under the shoulders, which exaggerates the anterior position of the glottis.
- Use a laryngoscope with a straight blade for babies less than 1 year of age.
- When holding the jaw to maintain the airway, hold only the bony parts of the lower jaw so as not to cause airway obstruction.
- After intubation, secure the tube to the maxilla rather than the mandible, which is mobile.
- Always check the position of the tube by auscultation.

After intubation, **tape the eyes closed** to prevent corneal abrasions. Forgetting to do this is a critical error.

1.5.4 Laryngeal mask airway

One of the greatest advances in airway management in recent years has been the development of the laryngeal mask airway (LMA). This alternative to intubation can be used for general surgery cases and to manage difficult airways. There are various sizes, but the essential LMAs are the Classic and the Proseal (available in disposable and non-disposable forms). The sizes vary from #1 Classic for infants less than 5 kg to large adult sizes. LMAs have the weight range printed on them to simplify the choice. The Proseal has the advantage of an oesophageal suction port, which allows a catheter to be placed down into the stomach. A LMA should not be used in a patient with a full stomach.

Indications for referral

If a difficult airway is known or suspected or proper assistance is unavailable, refer the patient to a specialist centre for expert management.

▶▶ 1.6 Intravenous access

Key points

- ◆ The preferred methods for establishing IV access – in the order they should be attempted – are:
 - ◇ percutaneous peripheral
 - ◇ intraosseous
 - ◇ percutaneous central (femoral or internal jugular vein)
 - ◇ venous cutdown – saphenous vein at the ankle or antecubital fossa veins.
- ◆ If a child is in shock, an intraosseous cannula can be lifesaving.

Establishing IV access can be a major challenge in infants and children. The experience of the practitioner, clinical status of the child, presence of additional staff and available supplies will influence the site and type of IV access attempted.

1.6.1 Percutaneous peripheral access

Proper restraint is the key to successful cannulation. Restraining a child requires the help of nurses or other support staff. Infants and toddlers are best restrained by wrapping them safely in a bed sheet or towel with the prospective limb exposed. Distracting the child with toys, music and books can also be useful. A topical anaesthetic patch (which may take 45 minutes for effect) or spray is worthwhile if the clinical situation allows. The careful use of sedation may occasionally be justified for a difficult cannulation in a particularly anxious child.

Cannula size is important: the smallest gauge appropriate for the age of the child that will do the job required should be selected. A smaller gauge needle is acceptable for

IV fluid, while a large-bore needle is needed for a blood transfusion. In the initial resuscitation period, IV fluid is the usual requirement.

- Yellow (24G) cannulas are appropriate for neonates.
- Blue (22G) cannulas are appropriate for infants.
- Pink (20G) cannulas are appropriate for older children.

Scalp vein cannulation (Figure 1.1)

A scalp vein is appropriate for children who require short-term IV fluid therapy. A scalp vein infusion set consists of a butterfly needle, tubing, female Luer lock and protecting cap. A disadvantage of scalp vein cannulation is the tendency for the cannula to infiltrate the tissue easily.

- ▶ Placement of a scalp vein IV may require the hair to be shaved; parents should be advised of this at the onset.
- ▶ Set up the IV solution and tubing and clear the line of air by flushing it with fluid.
- ▶ Apply pressure to the hairline to cause venous engorgement. In the small infant, an appropriately sized rubber band placed around the head is an alternative.
- ▶ Identify a suitable vessel and palpate to ensure the vessel is not pulsatile, indicating an artery.
- ▶ Swab the site with alcohol-based solution and introduce the scalp vein needle into the selected vein, with the bevel upwards.

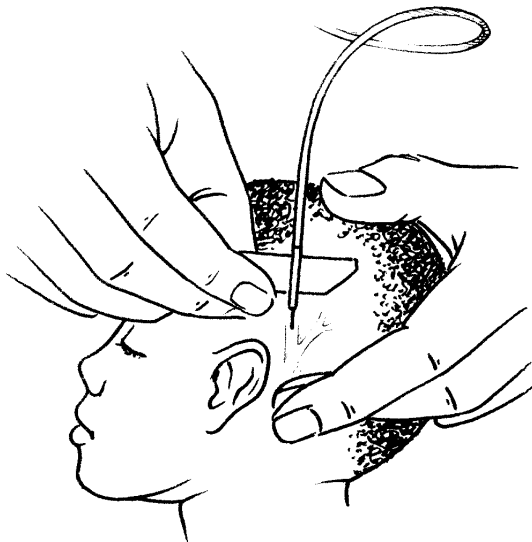


Figure 1.1 Insertion of a butterfly needle into a scalp vein of a young infant to set up an intravenous infusion. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

- ▶ As soon as the vein is entered, there should be a flash-back of blood into the tubing of the butterfly set. The Luer lock should be connected to the drip set, which is opened to allow fluid infusion to dilate the vein. The needle is then gently advanced into the vein.
- ▶ Flush the catheter to demonstrate its patency and to prove that it has not infiltrated the tissue.
- ▶ Tape the cannula securely in place.

Complications of a scalp vein IV include infection (thrombophlebitis and cellulitis), scalp necrosis and arterial puncture. Arterial puncture is suggested by bright red blood progressing up the tubing against gravity and blanching of the scalp.

Other peripheral veins (Figure 1.2)

A cannula placed in a peripheral vein is the preferred site for longer term fluid and drug administration and access during surgery. The greater saphenous vein at the ankle is one of the more easily accessible.

- ▶ The best way to approach the saphenous vein is to place a tourniquet just below the knee, which produces distension of the vein. Immersion of the limb in lukewarm water can also help, as it allows the veins to dilate.
- ▶ Clean the skin.
- ▶ If you are right handed, hold the foot extended with your left hand and place the needle with your right. Introduce the IV cannula, holding it at an angle almost parallel to the skin.
- ▶ When a flash-back of blood is seen, withdraw the needle and advance the plastic cannula into the vein.
- ▶ Secure the cannula with tape.

1.6.2 Intraosseous access (Figure 1.3)

Intraosseous infusion is a useful technique for quickly establishing temporary IV access in a dehydrated child. The intraosseous route is safe and much quicker than a cutdown. It is usually done on the upper tibia, provided the limb is not injured and there is no focus of infection. Intraosseous access is useful for children of any age.

- ▶ Place the patient in the supine position, with support under the knee of an uninjured limb. The knee should be in approximately 30 degrees of flexion with the heel resting on the bed or stretcher.
- ▶ The proximal tibia is the preferred site. Insertion is made at the midline of the flat surface of the anterior tibia, 1–3 cm below the tibial tuberosity. Prepare and drape the skin at the selected site. Infiltrate with local anaesthetic, which usually takes effect within a few minutes.

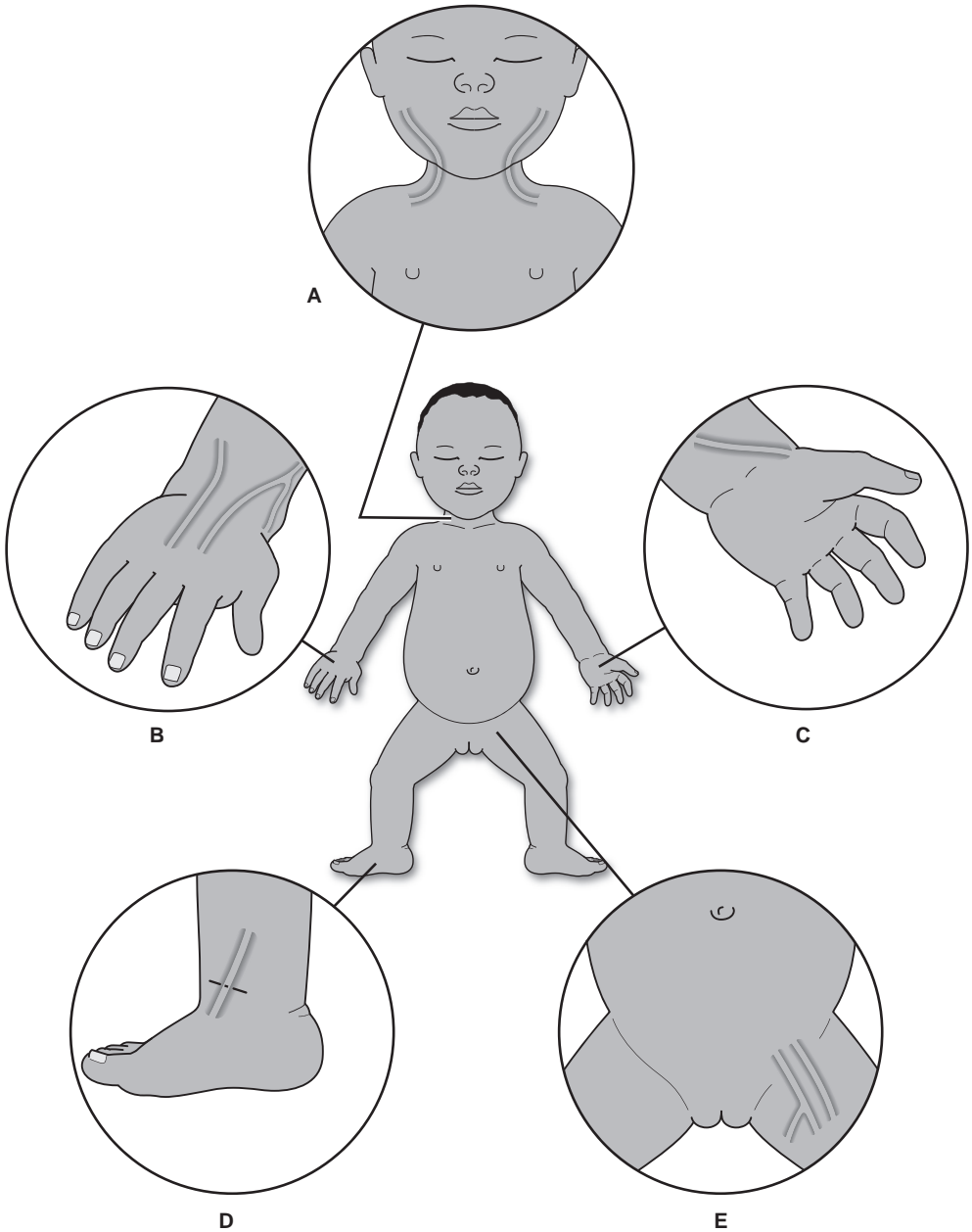


Figure 1.2 Sites for placement of cannula in peripheral veins in children: (A) external jugular vein; (B) dorsal hand; (C) wrist; (D) foot; (E) femoral vein

- ▶ Introduce a short large-calibre bone-marrow aspiration needle, or a short 18G spinal needle with a stylet, at a 90-degree angle through the skin and periosteum, with the bevel directed away from the epiphyseal plate. Below 18 months of age,

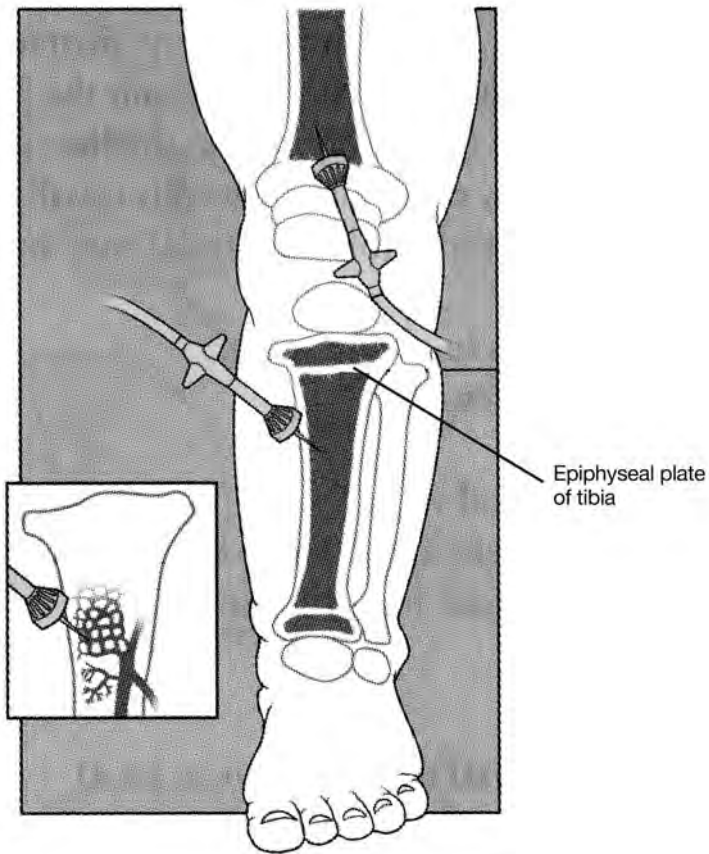


Figure 1.3 Intraosseous access. (Reproduced with permission from *Paediatric Trauma and Child Abuse*, S Van As, S Naidoo (eds), Oxford University Press, 2006.)

an 18–20-gauge bone marrow needle is sufficient. Above 18 months of age, a 14–16-gauge needle is used. Adjust the direction of the needle away from the epiphyseal plate, at a 40–60-degree angle with the tibia.

- ▶ Specifically designed intraosseous needles have a flange that limits the depth of bone entered. When an improvised needle is used, care should be taken to ensure that the opposite side of the bone is not penetrated.
- ▶ A test aspirate is done which should obtain bone marrow.
- ▶ Flush the needle with saline and then connect to the IV infusion. The needle should be taped in position and a peripheral line should replace it as soon as practicable.
- ▶ An intraosseous line can be used to administer fluid, drugs and blood products.

Complications include damage to the epiphyseal plate, bone and joint infection, haematoma, cellulitis, compartment syndrome and neurovascular injury.

1.6.3 Percutaneous central lines

Central venous lines can be used to administer fluids, blood products and irritating drugs. Access is best obtained via the internal jugular or femoral vein.

Warning!

The subclavian approach is not recommended because of the risk of pneumothorax (puncturing the lung).

As a general principle, the Seldinger guide-wire technique should be used, as it is associated with fewer complications than catheter-over-needle or catheter-through-needle systems. Short, wide, single- or double-lumen catheters are best for rapid fluid resuscitation, while the long, narrow multi-lumen catheters are suitable for measurement of central venous pressure and administration of maintenance fluid.

Femoral vein cannulation (Figure 1.4)

This is the site of choice for a central line in a hypotensive child, as it avoids the risk of pneumothorax. If available, a 4F double-lumen catheter can be inserted via the femoral route in most children in whom peripheral access is unsuccessful. Alternatively, a long (5 cm or longer) 18G or 20G cannula can be used.

- ▶ Position and hold the child in the frog-leg position. Palpate the femoral artery just lateral to the vein with the fingers of your non-dominant hand.
- ▶ Insert the needle at an angle of about 30 degrees to the skin, about 1 cm below the inguinal ligament and in the direction of the umbilicus.
- ▶ When blood flows freely into the syringe, introduce the guide wire while preventing air embolism.

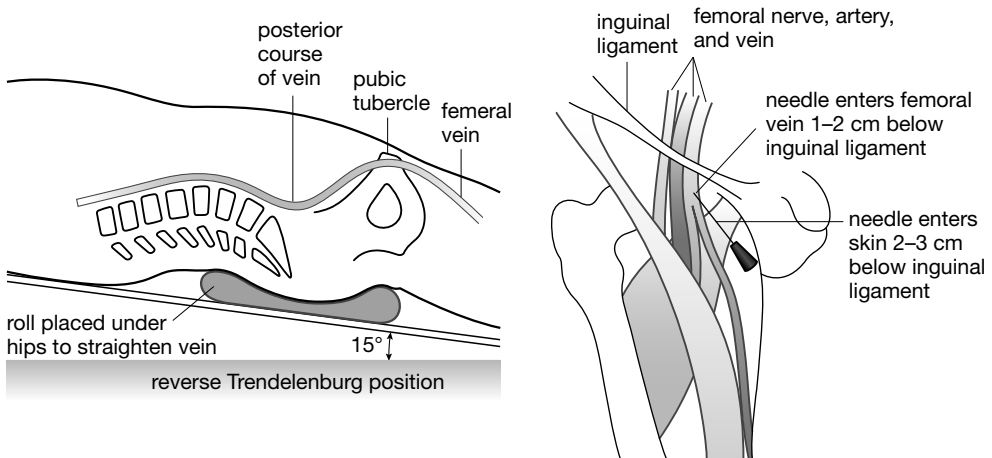


Figure 1.4 Cannulation of the femoral vein. (Reproduced with permission from *Pediatric Emergency and Critical Care Procedures*. R Dieckman, S Selbst, Mosby, 1997)

- ▶ Remove the needle, place the dilator, followed by the IV catheter. Connect the IV line and fix the catheter to the skin.

Complications include arterial cannulation with a risk of lower-leg ischaemia, bleeding, infection and thrombophlebitis.

Internal jugular access (Figure 1.5)

The internal jugular vein is another option for central venous access but can be difficult to access if a cervical spine collar is in place.

- ▶ If a cervical spine injury is not suspected, place the child in the supine position with the head turned away from the planned insertion site. Tilting the bed downwards helps to distend the internal jugular vein and reduces the risk of air entering the vein (air embolism), which can be fatal.
- ▶ The easiest approach to the internal jugular vein is through the anterior triangle of the neck, formed by the two heads of the sternocleidomastoid muscle and clavicle. The internal jugular vein is lateral to the carotid artery, which is usually easy to palpate.
- ▶ After administration of local anaesthetic, insert the needle at the apex of the anterior triangle. Advance the needle at a shallow angle towards the child's nipple on the same side. In children, the internal jugular vein is at a depth of less than 1–2 cm. Exceeding this depth risks pneumothorax.
- ▶ When blood flows freely into the syringe, advance the guide wire while keeping an eye on the ECG monitor to note any disturbances of rhythm.

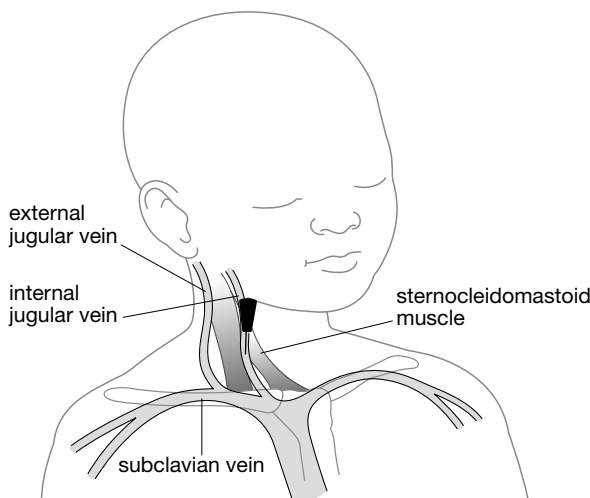


Figure 1.5 Cannulation of the internal jugular vein. (Reproduced with permission from *Paediatric Trauma and Child Abuse*, S Van As, S Naidoo (eds), Oxford University Press, 2006.)

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- ▶ Remove the needle and advance the dilator over the guide wire, after slightly enlarging the skin puncture wound with a scalpel blade. Remove the dilator and advance the catheter over the guide wire.
- ▶ Connect the catheter to the IV line, and lower the IV fluid bag slightly to observe the drainage of blood into the tubing. Hang the bag up immediately.
- ▶ Fix the catheter to the skin with a 3-0 nylon suture, and place a sterile dressing over the area.
- ▶ Obtain a chest radiograph to ensure proper placement. The tip of the catheter should be at the atrial–superior vena cava junction.

1.6.4 Venous cutdown

A venous cutdown is usually done only when all other venous access attempts have failed. Two of the best cutdown sites are the long saphenous vein at the ankle and the antecubital fossa. In the latter, multiple veins can be exposed through a single incision (Figure 1.6).

First, prepare a sterile tray with a large IV cannula (18 or 20G), size 15 surgical blade and handle, small curved artery forceps, fine-toothed forceps, fine non-toothed forceps, fine dissecting scissors, needle holders, 3-0 absorbable suture ties and 4-0 silk skin suture.

1.6.4.1 Procedure for saphenous vein cutdown

- ▶ Clean the medial aspect of the lower leg with alcohol swabs, drape with sterile towels and inject local anaesthetic such as 1% lidocaine (lignocaine).

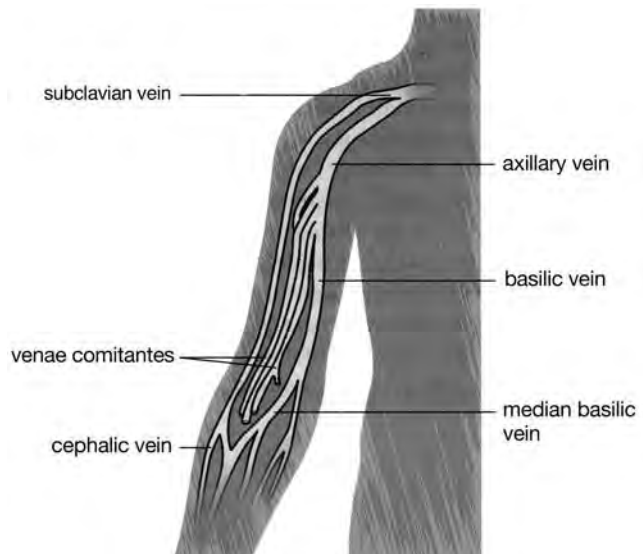


Figure 1.6 Veins of the arm.

- ▶ Make a 2 cm transverse incision a fingerbreadth above and slightly anterior to the medial malleolus, through the dermis into the subcutaneous tissue. Dissect out the saphenous vein by blunt dissection, spreading the curved artery forceps close to the vessel wall then using it to dissect behind and control the vein. Tie off the distal vein with an absorbable suture.
- ▶ The cannula should be flushed before placement. Make a small incision in the vessel wall and insert the flushed plastic cannula. It may not bleed back. Place an absorbable tie around the vessel containing the cannula to secure it in place.
- ▶ Close the skin with silk suture.
- ▶ A similar technique is used for antecubital cutdown.

Complications include bleeding, infection and thrombophlebitis.

▶▶ 1.7 Nutrition

Key points

- ◆ The history and physical examination are critical aspects of nutritional assessment.
- ◆ The gut is the preferred route for feeding a patient.
- ◆ The patient's nutritional status should be part of the daily assessment.

Many surgical conditions interfere with a child's ability to eat a regular diet. In addition, many surgical patients have other medical conditions, often infections, that contribute to poor nutrition. The high prevalence of chronic infections such as malaria and gastrointestinal parasites in the tropics means that the majority of surgical patients will have some degree of malnutrition.

In addition to calorie deficits, chronic deficiencies in vitamins and trace minerals can affect recovery from surgery and impair wound healing.

1.7.1 Assessment

- The history and physical examination are critical parts of nutritional assessment. A history of decreased oral intake, presence of nausea, vomiting and persistent diarrhoea, and decreased energy level are all cause for concern.
- The physical examination should pay particular attention to loss of subcutaneous fat, muscle wasting, ankle oedema, sacral oedema and ascites. If possible, all children should have a weight-for-height (or length) determined. This can be calculated from standard tables as found in the *Pocket Book of Hospital Care for Children* (WHO, 2005). Severe malnutrition is defined as a weight-for-height (or length) of less than 70% and implies a high risk for death.

- If a weight-for-height can not be calculated, use the clinical signs to assess the degree of malnutrition. A child with severe malnutrition appears very thin, with no fat. There is severe wasting of the shoulders, arms, buttocks and thighs, with visible rib outlines.

1.7.2 Caloric requirements

Daily caloric requirements for children in an unstressed state are shown in Table 1.2. These requirements highlight the need, especially in newborns, to ensure a greater energy provision per body weight compared with other periods in a child's life. In addition, neonates have a much higher protein requirement (2.2 g/kg per day) than older children (1.0 g/kg per day) and adults (0.8 g/kg per day).

In the stressed state, as occurs in many surgical conditions, the caloric needs may increase several fold. For example, nutritional requirements are increased by 25% following elective operations, 50% with infection and up to 100–150% in the face of a burn injury. Burn injuries impose the greatest catabolic stress of all conditions.

1.7.3 Nutritional support

The goal of nutritional support is to supply the calories and micronutrients needed to enable full recovery from surgery. In general, this means providing the baseline requirements plus the increased caloric needs associated with the surgical condition.

Nutritional support can be given by the enteral route (using the gut) or by IV infusion.

Enteral nutrition

- ▶ The gut is the preferred route for feeding a patient. In addition to providing calories, enteric feeds are important in preventing atrophy of the gut mucosa, stimulating the immune system, and preventing gut-associated bacterial translocation. Breast milk is the best source of nutrition for infants. For older children, the parents should be encouraged to bring the child's favourite foods to the hospital.

Table 1.2 Daily caloric and protein requirements in an unstressed child

Requirements increase with surgery, infection and particularly burns.

Age (years)	Calories (kcal/kg body weight)	Protein (g/kg body weight)
0–1	90–120	2.0–3.5
1–7	75–90	2.0–2.5
7–12	60–75	2.0
12–18	30–60	1.5

- ▶ For the patient who is unable to take oral feeds, nasogastric tube feeds are an important means of nutritional supplementation. Nasogastric feeds are not difficult to do. However, facilities and sufficient staff must be available to prepare the formula and do the round-the-clock feedings. A recipe for standard tube feeding formula can be found in the *Pocket Book of Hospital Care for Children* (WHO 2005).
- ▶ Measuring the amount of tube feed left in the stomach (gastric residual) prior to the next feed is a simple way to determine if the child is tolerating feeds. If it is expected that a child will be unable to take oral feeds for a long period of time, consider inserting a feeding gastrostomy tube.
- ▶ Oral intake should not be suspended more than 4 hours before surgery and should be restored as soon as possible after surgery. The presence or absence of nausea, vomiting, bowel sounds, flatus and bowel movements can help assess gut function. If necessary, the stomach may be suctioned before attempted feeds and to assess gut function.

Intravenous nutrition

- ▶ Standard IV fluids (5 or 10% glucose) do not contain enough calories to meet baseline caloric needs. However, some calories are better than none. Glucose solutions provide 3.4 kcal/g glucose. Thus, 5% glucose has 5 g glucose/100 mL and provides $(5 \text{ g} \times 3.4 \text{ kcal/g}) / 100 \text{ mL}$, or 0.17 kcal/mL. 10% glucose has 0.34 kcal/mL.
- ▶ Solutions given through peripheral veins should not exceed 12.5% glucose. Solutions given centrally, if available for administration, must not exceed 20% glucose. Prolonged reliance on IV glucose alone will lead to protein-deficient malnutrition. It is feasible to provide all the calories via an IV route. However, total parenteral nutrition is not usually available at primary referral hospital and may not be available even at many referral centres.

1.7.4 Micronutrients

Vitamin and mineral deficiencies are common in malnourished children. All severely ill children have vitamin and mineral deficiencies. Although anaemia is common, do not give iron until infections are cleared, as it can make infections worse.

To correct micronutrient deficiencies in severely malnourished surgical patients, supplement with the following:

- multivitamin
- folic acid (5 mg on day 1, then 1 mg/day)
- zinc (2 mg/kg per day)
- copper (0.3 mg/kg per day)
- ferrous sulphate (3 mg Fe/kg per day) once the patient is gaining weight
- vitamin A on day 1 (aged <6 months: 50 000 IU; aged 6–12 months: 100 000 IU; older: 200 000 IU).

1.7.5 Nutritional monitoring

The patient's nutritional status should be part of the daily assessment. Weight is the easiest parameter to follow but may not accurately represent the nutritional state, as many surgical conditions cause fluid retention.

Failure to grow is an important sign that nutritional needs are not being met. For an infant, the expected weight gain should be approximately 1% of the patient's body weight per day.

▶▶ 1.8 Pain management: anaesthesia and analgesia

Key points

- ◆ Treat pain pre-emptively and in a timely manner.
- ◆ Treat both pain and anxiety.
- ◆ Know the characteristics of drugs and always have reversal agents available should they be needed.

Pain can be physically and psychologically harmful to the child. Pain can cause hypertension, increased bleeding, unnecessary energy expenditure and disrupted sleep cycles. If left untreated for prolonged periods, pain can result in psychological and emotional problems. Untreated pain and anxiety can also make dressing changes and drain management more difficult, compromising patient care.

A variety of methods can be used to manage pain in children. These include non-pharmacological interventions, systemic analgesics (opioid and non-opioid) and anaesthesia (local, regional and general). Each method of pain control has advantages and disadvantages and their use must be individualized for each patient.

1.8.1 Pain assessment

Pain assessment and pain measurement in children can be difficult because it is subjective and is often based on the assessor's own personal experiences. Pain assessment takes into account factors such as previous pain experiences, medical history, level of cognitive developmental, pathology and ongoing medical interventions, as well as the measurement of the actual level of pain present.

Pain assessment is also complicated by other factors:

- continuing misconceptions about paediatric pain, for example that neonates have an immature nervous system and are unable to feel pain, young children do not remember pain, or pain is character building
- very young children are unable to pinpoint or describe the nature and intensity of their pain; older children may exaggerate their pain to gain attention
- language barriers and cultural background of the patient.

Table 1.3 Scales for assessment of pain in children of different ages


Neonates (up to 28 days old)	Use physiological cues: <ul style="list-style-type: none"> • restlessness • crying • refusal to feed • reluctance to move certain body parts • facial expression of distress, pain and discomfort
Infants and toddlers	Objective pain scale <div style="text-align: center; margin: 10px 0;">  </div> <div style="display: flex; justify-content: space-around; margin: 0 100px;"> no pain moderate pain severe pain </div> <p>Recommended for use by an adult observer, as children may rate mood instead of pain.</p>
Older children	Visual analogue scale (100 mm scale) <div style="text-align: center; margin: 10px 0;"> 0..... 5..... 10 </div> <div style="display: flex; justify-content: space-around; margin: 0 100px;"> no pain moderate pain severe pain </div>

Table 1.3 shows three of the most commonly used pain measurement methods designed for infants, toddlers and older children.

1.8.2 Non-pharmacological interventions

These methods are useful for minor procedures and pose little risk to the patient.

- ▶ **Breastfeeding** provides excellent analgesia for minor procedures such as venipuncture, heel lancing or cannula insertion.
- ▶ **Sucrose** (2 mL of 24% solution) provides analgesic support when given orally or with a pacifier to an infant.
- ▶ **Swaddling** of newborns can make them feel more secure.
- ▶ **Distraction** (e.g. with games, puppets and toys) can be used with great success to supplement analgesic or anxiolytic agents.

1.8.3 Non-opioid analgesics

Non-opioid analgesics are effective for mild and moderate pain. The main advantage of this group of medication is that they do not cause respiratory depression or sedation.

- ▶ Paracetamol (acetaminophen):
 - ▷ oral: 10–15 mg/kg up to 4 times a day
 - ▷ safe and effective analgesic for infants and children

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- ▷ reduces the amount of opioid required
- ▷ May be administered rectally – 20 mg/kg every 6–8 hours; absorption through the rectal mucosa is poor and erratic.
- ▶ **Non-steroidal anti-inflammatory drugs (NSAIDs)** are now used widely for postoperative analgesia in children after minor, intermediate and major surgery.
 - ▷ Seldom cause nausea or vomiting.
 - ▷ Administration before surgery provides optimal analgesia by virtue of anti-inflammatory activity.
 - ▷ Not recommended in children less than 6 months of age because of the possibility of immature renal function and hepatic metabolism.
 - ▷ Avoid NSAIDs if the child has asthma, is taking systemic steroids, is known to be NSAID sensitive or has a bleeding disorder.
- ▶ **Ibuprofen (oral):** age <6 months: 5 mg/kg every 6–8 hours; age >6 months: 7.5 mg/kg every 6–8 hours (maximum 500 mg per day).

Warning!

Aspirin should not be given to children under 12 years of age because of the risk of Reye's syndrome.

1.8.4 Opioid analgesics

These analgesics should be reserved for treatment of severe pain. Opioid drugs can cause respiratory depression and sedation.

- ▶ Morphine
 - ▷ Dose: IV: 0.05–0.1 mg/kg every 4–6 hours; 0.025–0.05 mg/kg every 4–6 hours for children < 1 year old; Oral: 0.2–0.4 mg/kg every 6 hours
 - ▷ Effective for severe pain.
- ▶ Codeine
 - ▷ Dose: 0.5–1 mg/kg orally every 6–12 hours
 - ▷ The intramuscular (IM) route should not be used, as it painful and leads to peaks and troughs in plasma concentrations.
 - ▷ Can be given as a suppository: 1 mg/kg every 4 hours.
 - ▷ Must *never* be given IV as hypotension and cardiovascular collapse can occur.
 - ▷ Has the same potential side effects as stronger opioids but in practice is usually well tolerated.

Adverse effects of opioids

Although effective in controlling pain, opioids can cause a number of adverse effects. These can be minimized by using opioid-sparing techniques, such as combining the

opioid with a local anaesthetic or paracetamol, and by careful titration. The adverse effects of opioids are:

- respiratory depression
- sedation
- nausea and vomiting
- itching (may be generalized, or just an itchy nose)
- urinary and gastrointestinal symptoms
- muscle spasm.

Respiratory depression and sedation

Respiratory depression and sedation are more common in infants and young children receiving opioids than in adults. Children must therefore be monitored carefully. Opioids should not be given concurrently by different routes. In case of respiratory depression:

- ▶ Ensure an adequate airway.
- ▶ Administer oxygen.
- ▶ Discontinue any opioid drug being given.
- ▶ If the patient is cyanosed and/or bradycardic, administer naloxone 2–4 micrograms/kg IV immediately, and repeat as needed according to response, to a total of 10 micrograms/kg. A continuous infusion of 1–10 micrograms/kg per hour may be required to maintain reversal. If venous access is not available, naloxone can be given by IM injection at the same dose. The IM route may produce a more prolonged effect.
- ▶ Ventilatory support may be required in severe overdose.

Warning!

Oxygen, suction, face mask, self-inflating bag and naloxone (opioid antagonist) must be readily available when any patient is receiving opioids, in whatever form. Children must be monitored for signs of respiratory depression.

Itching

Itching is more common when spinal opioids are used. It is usually generalized but often manifests as an itchy nose. Itching can be relieved by administration of the anti-histamine chlorpheniramine: 0.25 mg/kg IV or subcutaneously. This dose can be given up to 4 times in 24 hours.

Urinary and gastrointestinal symptoms

Urinary retention, gut immotility and postoperative ileus may follow opioid administration. In small babies, apply gentle suprapubic pressure to relieve bladder distension. Older children with urinary retention may require a catheter.

Muscle spasm

Skeletal muscle spasm may be seen as chest wall rigidity, particularly when larger doses of fentanyl are used. Severe cases may result in paralysis and require intubation.

1.8.5 Local anaesthesia

Local anaesthetics can be applied topically or injected locally. Topical agents are simple to use and highly effective, but can be toxic if used on large surface areas or left in place for long periods of time. They should be used before any needle procedures in children. Topical agents are also helpful when repairing lacerations. The following topical agents are useful.

- **EMLA (an abbreviation for eutectic mixture of local anaesthetic) cream** contains lidocaine (2.5%) and prilocaine (2.5%): it is effective when applied 60–90 minutes before venipuncture. However, it should not be used in open wounds because of the risk of increased systemic absorption.
- **Tetracaine gel (4%)** has a slightly more rapid onset of action (40 minutes) and produces vasodilatation. It can be used to provide analgesia at the site of lumbar puncture, bone marrow sampling, and skin graft donor sites and after circumcision.
- **Lidocaine (lignocaine) gel (2%)** can be used at the site of circumcision to maintain analgesia after a caudal or penile block wears off. Parents can be taught to apply this for the first 24–36 hours after circumcision.
- **Topical local anaesthetic eye drops** (tetracaine, oxybuprocaine, proxymetacaine) are useful for providing instant analgesia during removal of small superficial foreign bodies from the eye.
- **Gauze soaked in bupivacaine plus epinephrine (adrenaline)** can be applied to an open wound to produce effective analgesia. The wound edges can then be infiltrated with local anaesthesia from within via the anaesthetized area.

Locally injected anaesthetics are appropriate for minor procedures in cooperative patients. The most commonly used are lidocaine and bupivacaine – see Table 1.4. Wound infiltration combined with paracetamol (15 mg/kg orally) will usually ensure a rapid return to oral feeding after minor and some intermediate procedures.

Table 1.4 Commonly used local anaesthetics

Agent	Concentration	Duration of action	Maximum dose
Lidocaine	1% solution (10 mg per mL)	1 hour	4.5 mg/kg (0.45 ml/kg)
Bupivacaine	0.25% (2.5 mg per mL)	2–6 hours	2.5 mg/kg (1.0 ml/kg)

Adverse effects of local anaesthetics

Excessive amounts of local anaesthetics are toxic to the central nervous system and cardiovascular system (see Table 1.5). The central nervous system is more sensitive to local anaesthetics, and manifestations tend to occur here earlier. Brain excitatory effects occur before the depressant effects.

Toxicity can be caused by: 1) accidental rapid IV injection, 2) rapid absorption, such as from a highly vascular site (e.g. mucous membranes), or 3) absolute overdose if the dose used is excessive.

Precautions

A number of precautions should be taken to reduce the risk of local anaesthetic toxicity.

- ▶ Calculate the maximum dose that can be used and stay below that amount. Use lower doses in neonates and infants.
- ▶ Inject the drug slowly (slower than 1 mL per minute). Aspirate regularly, looking for blood to indicate an accidental IV injection.
- ▶ Injection of a test dose of 2 mL lidocaine containing epinephrine will often (but not always) cause a significant tachycardia if accidental IV injection occurs.
- ▶ Most nerve blocks depend more on the volume of drug injected than the total dose. Therefore, if more volume is needed it is better dilute the local anaesthetic with 0.9% saline than to add more local anaesthetic and increase the dose unnecessarily. This approach can be extremely valuable when dealing with larger wounds.

Table 1.5 Signs and symptoms of local anaesthetic toxicity

System	Early or mild toxicity	Severe toxicity
Central nervous system	<ul style="list-style-type: none"> • Light-headedness • Dizziness • Ringing in the ears • Numbness around the mouth • Abnormal taste • Confusion and drowsiness 	<ul style="list-style-type: none"> • Convulsions leading to loss of consciousness • Coma • Respiratory depression • Respiratory arrest
Cardiovascular system	<ul style="list-style-type: none"> • Tachycardia • Hypertension • If epinephrine was not added to the block, bradycardia with hypotension occurs 	<ul style="list-style-type: none"> • Severe and intractable arrhythmias • Cardiovascular collapse

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- ▶ Addition of epinephrine reduces the rate of absorption and will reduce the maximum blood concentration by about 50%. Usually epinephrine is added at a concentration of 1:200 000, with a maximum dose of 200 micrograms. Epinephrine is supplied in ampoules containing a concentration of 1:1000 (= 1 mg/mL = 0.1 mg%). Add 0.1 mL of this to each 20 mL of the local anaesthetic solution. Withdraw the required quantity from this anaesthetic/epinephrine mixture using a clean syringe and needle. The addition of epinephrine will not change the toxicity of the local anaesthetic if it is injected IV.
- ▶ Monitor the patient closely during the administration of the local anaesthetic and following surgery.
- ▶ ALWAYS secure IV access before injecting any dose that may have toxic effects.
- ▶ Always have adequate resuscitation equipment and drugs available before starting to inject.
- ▶ Patients may not volunteer information about these symptoms unless asked, so talk to the patient throughout the injection, asking them how they feel.
- ▶ Any suggestion of confusion should alert you to the possibility of toxicity and you should stop any further injection.
- ▶ Depending on the drug and the rate at which the blood level rises, it is possible for a patient to go from awake to convulsing within a very short time.

Treatment of local anaesthetic toxicity

Patients with local anaesthetic toxicity usually do well if the problem is recognized and treated quickly. The key is to monitor patients closely whenever using local anaesthetics. If a reaction occurs:

- ▶ Stop the injection and assess the patient.
- ▶ Call for help while treating the patient.
- ▶ Follow the ABC of resuscitation (airway, breathing and circulation):
 - ▷ Ensure an adequate airway.
 - ▷ Administer 100% oxygen.
 - ▷ Ensure that the patient is breathing adequately. Ventilate the patient with a self-inflating bag if there is inadequate spontaneous respiration. Intubation may be required if the patient is unconscious and unable to maintain an airway.
 - ▷ Treat circulatory failure with IV fluids and vasopressors.
 - ▷ Treat cardiac arrhythmias.
 - ▷ Start chest compressions if cardiac arrest occurs.
 - ▷ Administer drugs to stop convulsions: diazepam 0.2–0.3 mg/kg IV slowly over 5 minutes, repeated after 10 minutes if required. Alternatively, diazepam can be given rectally, 0.5 mg/kg.
 - ▷ Observe the patient closely after any reaction.

1.8.6 Peripheral nerve blocks

A peripheral nerve block is performed by injecting a local anaesthetic agent adjacent to a nerve that supplies the painful area. In children, these blocks should be done under sedation. Peripheral nerve blocks are easy to learn and work well when properly done. As with local anaesthetics, there is an associated risk of toxicity.

Preparation

When performing nerve blocks, the following principles should be followed.

- ▶ **Fasting:** if an elective procedure is planned, fast the patient as if general anaesthesia is planned. This increases safety in the event that a general anaesthesia or resuscitation is required.
- ▶ **Monitoring:** continuous observation of the patient is important. An assistant should be available to help with this.
- ▶ **IV access** should be secured before any block is performed. This also allows administration of fluids, sedative agents and resuscitation drugs if required.
- ▶ **Positioning:** position the patient and make sure they are comfortable, as this will make the block easier to perform and avoid injuries.
- ▶ **Identify** the bony landmarks.
- ▶ **Clean the site:** the skin over the block site should be cleaned with an antiseptic agent and surrounded with sterile drapes. The operator should wash his/her hands and wear sterile gloves.
- ▶ **Allow time** for the local anaesthetic to take effect. At least 15–20 minutes will be required for surgical anaesthesia. With weaker concentrations of bupivacaine, 30–45 minutes may be required.
- ▶ Use of bupivacaine alone for peripheral and regional blocks in infants may cause problems as there will be a lack of sedation despite excellent pain control. Anxiolytic agents such as diazepam given IV in doses of 0.1 mg/kg will not provide additional analgesia but will enhance the quality of the block.

Penile block

This is an effective block for controlling the pain associated with circumcision. The paramedian approach is preferred because of a lower incidence of complications such as IV injection, haematoma and ischaemia.

- ▶ To perform the block, insert a short, bevelled needle perpendicular to the skin at the inferior edge of the symphysis pubis at the 11 and 1 o'clock positions (see Figure 7.7, page 182). Advance the needle until there is loss of resistance.
- ▶ After careful aspiration, administer 1 mL plain 0.25% bupivacaine.
- ▶ For a better effect, infiltrate the local anaesthetic subcutaneously at the base of the penis from the 3 o'clock to the 9 o'clock position. Avoid a full ring block.

Brachial plexus block

This is an effective block for upper extremity surgery, especially when the procedure is being done below the level of the elbow. The axillary approach is the safest, most reliable and most commonly used in children.

- ▶ Place the child supine with the arm abducted to 90 degrees and rotated externally. Flex the forearm to 90 degrees.
- ▶ Insert a short, bevelled needle perpendicular to the skin at the most proximal part at which the artery can be palpated. Advance the needle until a 'fascial click' is felt and the needle moves with arterial pulsation.
- ▶ After a negative aspiration test, inject 0.6 mL/kg 0.25% bupivacaine.

Warning!

A brachial block can be difficult to do and may be dangerous in inexperienced hands.

Femoral nerve block

This is a useful block to control the pain associated with taking a skin graft from the anterior thigh.

- ▶ The femoral nerve is situated just lateral to the femoral artery, below the inguinal ligament and deep to the fascia lata and iliaca. Therefore, when the needle is advanced, two losses of resistance must be felt.
- ▶ Usually 0.3 mL/kg 0.25% bupivacaine provides adequate block of the femoral nerve.
- ▶ In a 3-in-1 block, the lateral cutaneous nerve of the thigh and obturator nerve are blocked in addition to the femoral nerve. The volume of local anaesthetic should be doubled so that it can spread adequately between the iliacus fascia and muscle to reach the other nerves. Apply distal pressure to the femoral sheath during and after the injection to improve the quality of nerve block.

Greater auricular nerve block

This block can provide excellent analgesia after ear surgery (for example, otoplasty).

- ▶ The block is performed by injecting 1 mL 0.25% bupivacaine subcutaneously between the mastoid process and the descending ramus of the mandible.

1.8.7 Spinal and epidural anaesthesia

Spinal and epidural blocks can be used in children to provide analgesia for procedures below the umbilicus. When administered properly they are a very effective method of controlling pain.

Warning!

Spinal and epidural anaesthesia should only be done by individuals with proper training.

Contraindications to epidural analgesia in children are similar to those in adults. Absolute contraindications include local infection, systemic sepsis, coagulopathy, operator inexperience, and patient or parental refusal. Relative contraindications include spinal anatomical abnormalities and neurological disease.

1.8.8 General anaesthesia

Major procedures should be done under general anaesthesia.

Warning!

Inhalational anaesthetics should be administered by trained personnel in monitored settings.

Ketamine is an excellent anaesthetic when muscle relaxation is not required.

▶ Ketamine can be given by IM injection (5–8 mg/kg) or IV (1–2 mg/kg).

If ketamine is given IM, an IV cannula should be inserted after the child is asleep. The child should be ready for surgery 3–5 minutes after IV ketamine or 5–10 min after IM ketamine. Give an incremental dose of ketamine if the patient continues to respond to a painful stimulus: use one-half of the initial IV dose or one-quarter of the initial IM dose.

At the end of the procedure, turn the patient into the lateral position for a supervised recovery in a quiet place. In most patients, ketamine stimulates the respiratory drive. In small infants, it may cause apnoea, so one must always be prepared to manage the airway in any patient given ketamine. Unintubated patients who are inadequately anesthetized may respond to stimulation with laryngospasm. In this situation, stop the surgery, deepen the anaesthesia and use airway measures to break the laryngospasm. In severe cases muscle relaxants may be necessary.

▶▶ 1.9 Kangaroo (skin-to-skin) care

Key points

- ◆ Kangaroo care – also known as skin-to-skin care – was developed to provide a warm environment for sick or preterm infants in circumstances where neonatal intensive care resources and equipment are limited.
- ◆ Kangaroo care has been shown to reduce morbidity for a wide range of newborn problems.

Kangaroo care is a valuable adjunct to surgical care of the newborn. It can be used at all levels of the care to:

- stabilize premature and sick term infants immediately after delivery
- safely transport newborns to or between medical facilities

1 Fundamentals of paediatric surgery

- maintain the normal body temperature during the first few days after birth
- warm up cold infants
- continuously care for sick and low-birth-weight infants during hospitalization
- nurse sick, low-birth-weight and preterm infants after discharge home.

1.9.1 Method

- The infant is placed upright on their mother's bare chest between the breasts, facing the mother, with the head turned to the side, with the mother in an upright or semi-reclined position (Figure 1.7). The infant is naked except for a diaper, and a hat to reduce heat loss from the exposed head.
- The infant is then covered with a blanket or piece of cloth which is tied firmly around the mother's chest, supporting the infant securely, conserving body heat and maintaining the infant's head and airway in a stable, upright position. When the infant is well secured, the mother can move about easily, with both hands free and can sleep in a semi-reclined position. Ideally, the infant is maintained in kangaroo care for 24 hours per day. Most mothers readily accept this type of care, as it allows them to maintain contact with, and actively participate in the care of, their sick or premature newborn. While in kangaroo care, the infant can easily be given IV fluids and medications, oxygen and gavage feeds as needed.

1.9.2 Effectiveness

During kangaroo care, the mother provides warmth, sensory input and unrestricted access to breastfeeding. Kangaroo care prevents hypothermia, improves oxygenation



Figure 1.7 Kangaroo care

and decreases episodes of apnoea and bradycardia. Gastroesophageal reflux and risk of aspiration are also reduced. Kangaroo care has also been shown to decrease the reaction to painful stimuli and reduce irritability, and improves weight gain and growth. Infants managed with kangaroo care have fewer nosocomial infections and increased survival. Improved emotional bonding with the mother decreases the risk of child abandonment. When newborns are physically constrained by kangaroo care, they cry less and sleep more.

Kangaroo care is particularly useful in preventing and treating hypothermia. Hypothermia is a common neonatal problem worldwide, including in tropical regions, and contributes substantially to neonatal deaths. Hypothermia can cause apnoea, bradycardia, hypoglycaemia, thrombocytopenia, coagulopathy, sepsis and death. Hypothermia develops very rapidly unless the newborn is maintained in an environment that conserves and provides body heat, such as a radiant warmer or a temperature-controlled incubator.

Kangaroo care is at least as effective as an incubator in preventing and treating hypothermia by reducing conductive, radiant, convective and evaporative heat loss and increasing conductive heat gain. During kangaroo care, the mother's skin temperature has been shown to increase or decrease as needed to maintain her infant's body temperature in the normal range. Fathers and other adults can also provide effective thermoregulation for newborn infants. Kangaroo care safely warms hypothermic infants by avoiding the risk of tissue burns from hot water or objects or the adverse effects of too rapid warming.

▶▶ 1.10 Transferring sick children

Key points ◀◀

- ◆ When deciding whether to transfer a patient, consider the expertise and resources available at the receiving hospital and whether the patient is stable enough to survive a transfer.
- ◆ It is better to stabilize and transfer a child than to end up with a disaster.
- ◆ Develop a standardized policy for transferring patients and how the information about the patient will be communicated to the receiving hospital.

An important question is *when* it is appropriate to transfer a child to another facility for further treatment. In general, this decision should take into account the expertise and resources available at the receiving hospital, and whether the patient is stable enough to survive a transfer. Transport is a dangerous procedure because the facilities available during transport are always less than in a hospital or health centre. If the child's condition is deteriorating, do not wait too long before transferring the child.

Warning!

If a child cannot be stabilized at your hospital, it is unlikely that they will reach the referral centre alive.

In the event that an infant or child needs to be transferred from one hospital to another, consider the following guidelines.

1.10.1 Ensuring a safe transfer

The responsibility of the referring doctor ends not with the departure from the referring centre, but with the safe arrival of the patient at the destination. The child should be accompanied by an appropriate healthcare professional. Oxygen and suction should be available for use if necessary. A critically ill child may need to be accompanied by a doctor, for example if the child is intubated and is being maintained by hand ventilation.

The actual transfer must be as quick as possible, but should not be done in a fashion where the individuals assisting with the transfer are placed in jeopardy. (No reckless driving!)

1.10.2 Informing the family

If possible, have one parent accompany the child. If a parent cannot travel with the patient, ensure that another family member gives consent for treatment. The family should also have a clear understanding of why the child is being transferred, and the expected outcome.

1.10.3 Communicating with the receiving hospital

Information regarding the patient's condition must be communicated to the receiving hospital. Ideally, this information should be communicated *before* the transfer. It can be helpful to send with the patient a letter describing the problems and treatment given; include radiographs and laboratory results.

1.10.4 Special considerations

The safest mode to transport a premature baby is in the womb of the mother. If you know that the care for a premature baby in your hospital is not adequate, or that the infant has an antenatally diagnosed congenital malformation, consider making a referral before delivery.

When a newborn is transferred it is important to ensure that the infant remains warm. Wrap the infant in warm loose clothing, and have someone hold the infant to keep them warm. Children with a suspected bowel obstruction should be transferred with a nasogastric tube and IV line in place.

▶▶ CHAPTER 2: Care Before, During and After Surgery

2.1 Preoperative care

- 2.1.1 Consent for surgery
- 2.1.2 Correcting medical problems
- 2.1.3 Laboratory studies
- 2.1.4 Antibiotics
- 2.1.5 Preparation for general anaesthesia

2.2 Intraoperative care

- 2.2.1 Preventing hypothermia
- 2.2.2 Avoiding hypoglycaemia (low blood sugar)
- 2.2.3 Blood loss

- 2.2.4 Intra-operative fluid management

2.3 Postoperative care

- 2.3.1 Monitoring
- 2.3.2 Fluid management
- 2.3.3 Pain control
- 2.3.4 Nutrition
- 2.3.5 Antibiotics
- 2.3.6 Psychological considerations
- 2.3.7 Common postoperative problems

▶▶ 2.1 Preoperative care

Key points

- ◆ Good surgical care neither begins nor ends with the procedure.
- ◆ In most instances, it is the preparation for surgery that ensures a good outcome.

2.1.1 Consent for surgery

Both the child and the parents need to be prepared for the procedure. Explain why the procedure is needed, the anticipated outcome and the potential risks and benefits. Informed consent must be obtained before performing any procedure, and the parents should sign a consent form.

2.1.2 Correcting medical problems

Correct fluid and electrolyte deficits

Fluid deficits should be corrected before emergency procedures (Ringer's lactate or normal saline bolus, 10–20 mL/kg, repeated as needed). Signs of adequate fluid resuscitation include immediate capillary refill, normalization of vital signs and restoration of urine output. In certain situations, checking and correction of electrolyte abnormalities will be necessary. In small babies, hypoglycaemia should be corrected before induction of anaesthesia.

2 Care before, during and after surgery

Correct anaemia

Severe anaemia interferes with oxygen transport, and the heart has to pump harder to deliver the same amount of oxygen to tissue. Surgery can cause blood loss and the anaesthetic may affect oxygen transport in the blood. Ideally, the child's haemoglobin should be normal for their age and population. Blood transfusions should be reserved for situations where the anaemia must be corrected quickly.

Children who are anaemic and who are to undergo elective surgery (e.g. hernia repair) should have their anaemia corrected with oral iron before the procedure. Children with haemoglobinopathies (e.g. sickle cell anaemia or thalassaemia) require special preparation for anaesthesia.

Nutrition

Improve the nutritional status of the patient as much as possible before the operation, although this may sometimes be difficult if the surgical problem contributes to poor eating. Good nutrition is essential to support wound healing. Tube feeding may be necessary if the patient cannot take sufficient food orally.

2.1.3 Laboratory studies

Recommended preoperative measurements:

- ▶ infants less than 6 months: haemoglobin
- ▶ children aged 6 months – 12 years: minor surgery (e.g. hernia repair): none; major surgery: haemoglobin
- ▶ other studies suggested by clinical exam (e.g. electrolytes for a patient with a bowel obstruction).

2.1.4 Antibiotics

Preoperative antibiotics can reduce postoperative infections in high-risk patients. They should be given before the incision is made. Preoperative antibiotics are needed for:

- infected and contaminated cases (bowel or bladder): ampicillin, gentamicin and metronidazole; continue for 3–5 days after surgery
- urinary tract procedures: ampicillin and gentamicin
- patients at risk for endocarditis (children with congenital heart disease or valvular disease) – see Table 2.1.

2.1.5 Preparation for general anaesthesia

Warning!

A child's stomach must be empty before general anaesthesia to avoid aspiration of the stomach contents into the lungs.

Table 2.1 Endocarditis prophylaxis for dental, oral, respiratory and oesophageal procedures

Situation	Drug	Dose
Standard general prophylaxis	Amoxicillin	50 mg/kg orally before procedure
Unable to take oral medications	Ampicillin	50 mg/kg IV 30 minutes before the procedure
Allergic to penicillin	Clindamycin	20 mg/kg IV 30 minutes before the procedure

Infants aged 0–6 months

- Formula or breast milk until 4 hours before the procedure.
- Clear liquids (e.g. water or apple juice) until 2 hours before the procedure.
- Nothing by mouth thereafter.

Children aged 7 months and older

- No solids for 6 hours before the procedure.
- Formula or breast milk until 6 hours before the procedure.
- Clear liquids (e.g. water or apple juice) until 2 hours before the procedure.
- Nothing by mouth thereafter.

Remember that preoperative dehydration can be a problem in a hot climate.

▶▶ 2.2 Intraoperative care

Key points

- ◆ Successful procedures require teamwork and careful planning.
- ◆ The operating room staff should function as a team. This includes surgeons, anaesthesia staff, nurses, scrub technicians and others.
- ◆ The key to a successful operation is good planning – have all the necessary supplies and staff available before beginning the procedure.

Intraoperative care of children must consider the unique physiological characteristics of children (Section 1.2).

2.2.1 Preventing hypothermia

Children can very quickly get cold in the operating room. Hypothermia can affect drug metabolism, anaesthesia and blood coagulation. It is important to ensure that the patient does not cool down during anaesthesia induction and preparation.

Warning!

It is easier to keep a patient warm than to warm up a patient.

- ▶ Prevent hypothermia in the operating room by turning off the air conditioning, warming the room (strive for a room temperature of $>28^{\circ}\text{C}$) and covering the patient with a blanket. As a large amount of heat is lost from the head, ensure that the patient's head is covered with a blanket or hat. Alternatively, the patient can be placed on a warm air blanket if available.
- ▶ Use warmed fluids (but not too hot).
- ▶ Avoid long procedures (>1 hour) unless the child can be kept warm.
- ▶ Monitor the child's temperature continuously during surgery and as frequently as possible during recovery.

2.2.2 Avoiding hypoglycaemia (low blood sugar)

Infants and children can become hypoglycaemic during operations. Use glucose infusions during anaesthesia to help maintain the blood sugar level.

- ▶ For most procedures in children, other than minor ones, give 0.45% NaCl / 5% glucose at a rate of 5 mL/kg per hour in addition to replacing the measured fluid losses.
- ▶ For newborns (<3 days old) give 10% dextrose in water at 4 mL/kg per hour in addition to replacement fluids.

2.2.3 Blood loss

Even small amounts of blood loss can be life threatening. Blood loss during the operation should be measured as accurately as possible. Consider blood transfusion if blood loss exceeds 10% of blood volume (Table 2.2). Have blood readily available in the operating room if blood loss is anticipated.

- ▶ Replace blood loss with 10 mL/kg boluses of packed red blood cells. If there is major blood loss, replace blood based on the patient's haemoglobin or haematocrit.

Table 2.2 Blood volume

Age	Blood volume (mL/kg)
Neonate (up to 28 days)	85–90
Children	80
Adults	70

2.2.4 Intra-operative fluid management

Fluid management consists of three parts:

- 1 replacement of the fasting deficit
 - 2 infusion of maintenance fluid
 - 3 monitoring and replacement of ongoing fluid loss.
- ▶ Fasting deficit can be replaced by giving 20 mL/kg isotonic fluid (Ringer's lactate or normal saline) during and after induction of anaesthesia.
 - ▶ Maintenance fluid requirements are given in Section 1.4 and Appendix 2.
 - ▶ For children undergoing large abdominal or thoracic procedures, ongoing losses must be replaced (in addition to maintenance fluids) as follows:
 - ▷ small procedures (hernia, extremity surgery): 1–3 mL/kg per hour
 - ▷ larger procedures (appendectomy, thoracotomy): 4–6 mL/kg per hour
 - ▷ major abdominal procedures (exploratory laparotomy): 7–10 mL/kg per hour
 - ▷ small babies undergoing major abdominal procedures (exploratory laparotomy, gastroschisis): 15–50 mL/kg per hour.
 - ▶ Place a urinary catheter to monitor output during major procedures and the post-operative period.

▶▶ 2.3 Postoperative care

Key points

- ◆ An operation is only one element of surgical care; full recovery from a procedure is only possible when the postoperative period is carefully managed.
- ◆ Good postoperative care requires a plan for patient monitoring, fluid management, pain control, nutritional support and antibiotics.
- ◆ Postoperative complications do best when recognized early and treated promptly.

2.3.1 Monitoring

The initial priority is to ensure that the child awakens safely from anaesthesia. Awakening from anaesthesia is one of the most dangerous periods of the operation and must be done in a closely monitored setting. In the immediate postoperative period, the respiratory rate, pulse and blood pressure should be monitored every 15 minutes until stable. Signs of airway obstruction must be carefully monitored and treated immediately. Postoperative oxygen saturation monitoring can be valuable if available.

- ▶ Investigate and treat abnormal vital signs.

2 Care before, during and after surgery

- ▶ As soon as the child is settled in the recovery room, communicate to the family the outcome of the operation, any problems encountered during the procedure and the expected postoperative course.

Warning!

Avoid placing a postoperative patient in a setting where they are not adequately monitored.

2.3.2 Fluid management

The goal of postoperative fluid management is to maintain a full circulatory volume with an appropriate electrolyte profile. This will maintain perfusion to vital organs as well to the surgical site. An IV line, Foley catheter and nasogastric drain should be available. The key to successful postoperative fluid management is to have diligent nurses who monitor IV fluids and fluid output (urine and other drains).

Children who have undergone abdominal surgery may be unable to tolerate any oral intake in the immediate postoperative period. In many, particularly those with intra-abdominal sepsis in whom postoperative ileus is anticipated, it is wise to consider draining the stomach via a nasogastric tube. Nasogastric aspirates represent a loss of fluid that ultimately comes from the intravascular space and must therefore be replaced on a millilitre-for-millilitre basis with Ringer's lactate or equivalent.

Third-space losses into the peritoneal cavity, bowel lumen, and tissue, etc. are not measurable. Neither are losses from the skin and respiratory tract, but they also come from the circulatory volume and must be replaced. In addition, surgical stress causes fluid retention. Because none of these volumes can be measured directly, the patient's fluid status must be assessed continuously. Clinical signs of a full vascular space include mental alertness, normal skin temperature and turgor, and a normal urine output (0.5–2 mL/kg per hour depending on age – see Appendix 1).

All children need maintenance fluid in addition to the replacement of measured and immeasurable fluid losses. This can be given as a dextrose-containing fluid. However, hyperglycaemia should be avoided as it will stimulate an osmotic diuresis and may result in underestimation of fluid requirements.

- ▶ Postoperatively, patients commonly require more than maintenance fluid. Children who have had abdominal procedures typically require 150% of baseline requirements, and even larger amounts if peritonitis is present.
- ▶ The circulating blood volume of a child is small (approximately 80 mL/kg), so errors in fluid prescription can rapidly become a major clinical problem, as postoperative fluid overload or hypovolaemia. The only way to prevent such errors is to re-assess fluid status frequently – every 4 hours. Record all inputs and outputs (IV fluids, nasogastric drainage, urine, drain outputs).

- ▶ Urine output is the most sensitive indicator of fluid status in a child. If urinary retention is suspected, pass a Foley catheter. A Foley catheter allows for hourly measurement of urine output, which can be invaluable in severely ill patients.

2.3.3 Pain control

Operations are painful no matter what the age of the patient. Pain has many negative effects and should be managed aggressively. A child in pain will not cough, breathe deeply or move in the bed and so will become susceptible to postoperative chest infection. Tachycardia, increased metabolic rate, increased oxygen requirements and catabolism are all improved by pain relief.

- ▶ Ideally, pain control should begin *during* the operative procedure, but this is not always possible. IV opiates offer the best control. IM injections should be avoided, as they are painful and absorption is variable. If possible, opioids should be given as a continuous infusion.
- ▶ IV morphine 0.05–0.1 mg/kg every 4 hours is ideal because it does not cause respiratory suppression in the presence of pain.
- ▶ Mild pain responds to paracetamol 10–15 mg/kg every 4 hours.
- ▶ The role of regional or local anaesthesia should not be forgotten; many blocks are easily learnt. An ilioinguinal nerve block can make recovery from hernia repair painless. Similarly, a penile block can make penile surgery less painful. Caudal blocks are effective for procedures below the umbilicus.
- ▶ Section 1.8 (page 22) provides more information on pain management.

2.3.4 Nutrition

Poor nutrition compromises wound healing and impairs the ability to fight infection. Many children needing surgery are nutritionally depleted before the operation begins. Ideally, total parenteral nutrition would be available to sustain the patient over the operative period, although this is rarely possible.

Patients should be fed nutritious fluids as soon after surgery as possible. Although it may not be possible to meet the total calorie requirements, a little is better than none. Giving even small volumes of enteral fluid prevents the villous atrophy associated with starvation and enhances absorption of nutrients.

The serum albumin can be maintained by alternate-day infusions of plasma where this is available. The use of dextrose-containing fluids as maintenance fluids provides some, but not many, calories.

The patient's weight is an unreliable guide to their state of nutrition, as it may be artificially increased by oedema. Many surgical patients present in a debilitated state. Minimize nutritional problems by feeding patients as soon as possible after surgery. Provide a high-calorie diet containing adequate protein and vitamin supplements. Consider tube feedings for patients whose oral intake is poor.

2.3.5 Antibiotics

Prophylactic antibiotics are often given before surgery. Avoid the temptation to continue these prophylactic antibiotics into the postoperative period. If there is a need for antibiotic therapy after the three prophylactic doses, agents that were not used for prophylaxis should be selected, preferably after a positive culture.

Warning!

Prophylactic antibiotics should be used for prophylaxis and nothing else.

2.3.6 Psychological considerations

Children over the age of 3–4 years are able to appreciate that they are ill, and are often frightened that they might die. Parents must be frankly counselled and involved in the care of their child. A calm parent has a beneficial effect on all aspects of postoperative care, as does a caring nurse. Mobilization adds to a patient's sense of well-being. Sitting a child up out of bed is beneficial as long as care is taken with lines and drains.

2.3.7 Common postoperative problems

Postoperative complications will occur. How well the patient does depends on how quickly the complication is recognized and treated. The following signs and symptoms should alert the clinician to a possible complication.

- ▶ **Restlessness and agitation** in a postoperative patient should be assumed to be hypoxia until proven otherwise. Sedation should never be prescribed unless there is objective evidence that the patient is not hypoxic.
- ▶ **Tachycardia** can be caused by pain, hypovolaemia, hypercapnia, anaemia, fever or infection. Examine the patient!

Warning!

Bradycardia in a child is due to hypoxia until proven otherwise.

- ▶ **Postoperative fever** can be due to tissue injury (immune mediated), wound infection, atelectasis, urinary tract infection (from indwelling catheter), phlebitis (IV catheter site) or other concomitant infections (e.g. malaria). Section 4.2.5 (page 81) provides information on the diagnosis and treatment of wound infections. Fever should not be treated with antibiotics unless there is evidence that the cause is bacterial.
- ▶ **Low urine output** can result from hypovolaemia, urinary retention, renal failure or a blocked urinary catheter. In most instances it is due to inadequate fluid resuscitation. Examine the patient, and catheter if present. Review the patient's fluid record.
 - ▷ Pay special attention to the patient's skin, mucous membranes and abdomen.

- ▷ Falling urine output should be treated by an infusion of 10 mL/kg normal saline or Ringer's Lactate over a 20-minute period.
- ▷ If urinary retention is suspected (the patient is uncomfortable and has a full bladder on physical exam), pass a Foley catheter.
- ▶ **Anaemia:** Blood transfusions are problematic in many areas. The dogma of maintaining the haemoglobin level above 10 gm/dL is an oversimplification. However, it must be recognized that at levels below this the patient's reserves are limited, particularly at altitude.

▶▶ CHAPTER 3: Surgical Problems in Neonates

3.1 Screening newborns for congenital anomalies

- 3.1.1 Diagnosis
- 3.1.2 Advice for parents

3.2 Cleft lip and palate

- 3.2.1 Diagnosis
- 3.2.2 Treatment
- 3.2.3 Advice for parents

3.3 Oesophageal atresia and tracheoesophageal fistula

- 3.3.1 Diagnosis
- 3.3.2 Treatment
- 3.3.3 Advice for parents

3.4 Bowel obstruction

- 3.4.1 Diagnosis
- 3.4.2 Common causes
- 3.4.3 Initial management
- 3.4.4 Surgical treatment
- 3.4.5 Advice for parents

3.5 Abdominal wall defects

- 3.5.1 Gastroschisis
- 3.5.2 Omphalocele (exomphalos)
- 3.5.3 Bladder extrophy
- 3.5.4 Cloacal extrophy (vesico-intestinal fissure)

3.6 Anorectal malformations

- 3.6.1 Diagnosis
- 3.6.2 Initial management
- 3.6.3 Surgical treatment
- 3.6.4 Bowel management
- 3.6.5 Advice for parents

3.7 Spina bifida

- 3.7.1 Diagnosis
- 3.7.2 Treatment
- 3.7.3 Late complications
- 3.7.4 Spina bifida occulta
- 3.7.5 Advice for parents

3.8 Hydrocephalus

- 3.8.1 Causes
- 3.8.2 Diagnosis
- 3.8.3 Treatment
- 3.8.4 Complications
- 3.8.5 Outcome
- 3.8.6 Advice for parents

3.9 Hip dysplasia

- 3.9.1 Diagnosis
- 3.9.2 Treatment

3.10 Clubfoot

- 3.10.1 Diagnosis
- 3.10.2 Treatment

▶▶ 3.1 Screening newborns for congenital anomalies

Key points ◀◀

- ◆ Successful treatment depends on early recognition of the surgical problem.
- ◆ The best way to avoid missing a surgical problem in a newborn is to screen all babies shortly after birth for congenital anomalies.
- ◆ Early recognition makes for better outcomes and allows parents to be informed about treatment options.

3.1.1 Diagnosis

There are many types of congenital anomalies, only a few of which are common. Some congenital anomalies require urgent surgical attention; others can be left alone and repaired when the child is older. All newborns should be examined shortly after birth for congenital anomalies. A head-to-toe exam can be done in a matter of minutes and can make a major difference in the child's care. The presence of more than three anomalies suggests a syndrome and a careful search should be done to identify other anomalies.

Head and neck

Examine the head and neck for any areas of swelling. Upwards slant to the eyes, small ears and a large or protruding tongue suggests Down syndrome. Down syndrome is associated with duodenal atresia and congenital heart disease which may be the first presentation. Inspect the lip and palate for evidence of a cleft. Froth around the mouth suggests the possibility of a tracheoesophageal fistula (see Section 3.3, page 47). Bile-stained vomiting in a newborn is indicative of bowel obstruction until proven otherwise (see Section 3.4, page 49). Inability to pass a nasogastric tube may indicate the presence of a nasal obstruction (choanal atresia). A firm mass in the neck several weeks after birth may be a sternomastoid tumour, which can be caused by a stretch injury during delivery (see Section 5.1.4, page 131).

Chest

If the infant is breathing rapidly, listen to the chest. The presence of bowel sounds in the chest suggests a congenital diaphragmatic hernia. A cardiac murmur can suggest a congenital heart defect.

Abdomen

Inspect the umbilicus for incomplete abdominal wall closure. Examine the groins for hernias.

Back

Look for evidence of scoliosis and myelomeningocele.

Genitalia

Check for normal-appearing genitalia. In boys, check for a hypospadias (abnormal positioned urethral opening) and whether the testicles are located in the scrotum.

Anus

Inspect the bottom for presence of an imperforate anus. In a girl, the anus should be approximately one-third the distance from the posterior vulva to the coccyx. In a boy, the anus should be approximately half the distance from the scrotum to the coccyx.

Extremities

Examine the extremities for evidence of deformities, such as club foot and hip dysplasia. Extra or missing digits should be noted.

3.1.2 Advice for parents

When a congenital anomaly is discovered, reassure the parents that you will do your best to help their baby get the needed treatment.

▶▶ 3.2 Cleft lip and palate

Key points

- ◆ Cleft lip and palate are correctable conditions.
- ◆ Close follow-up is required in infancy to monitor feeding and growth.

Cleft lip and cleft palate are birth defects that affect the upper lip and roof of the mouth. They occur when elements of the face do not fuse properly during development.

3.2.1 Diagnosis

Cleft lip and cleft palate (Figure 3.1) may occur together or separately. The problem can range from a small notch in the upper lip to large bilateral grooves in the upper lip that extend up into the nose and continue into the roof of the mouth.

Early on, cleft lip and palate can cause difficulties in feeding. The baby has difficulty sucking and regurgitates milk through the nose and may aspirate into the lungs. Later there can be problems with middle ear infections and speech development.

3.2.2 Treatment

- ▶ Feed using expressed breast milk via a cup and spoon. A special flanged teat may be used if available and adequate sterility of bottles can be ensured.
- ▶ Close follow-up in infancy is required to monitor feeding and growth.
- ▶ Surgical closure of the cleft lip is usually done at 3–6 months of age (earlier if anaesthetically safe and technically possible), and the palate repaired at 1 year of age.
- ▶ After surgery, children should be monitored closely for problems with hearing and speech development.

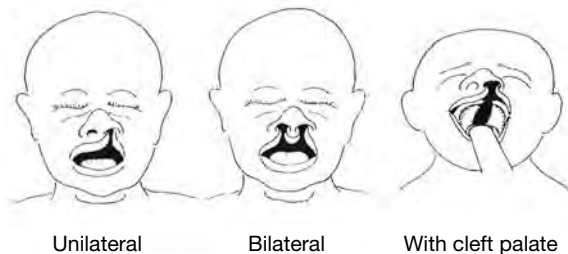


Figure 3.1 Cleft lip and palate. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

Indications for referral

Repair of cleft lip and palate should be done by someone with experience in this type of surgery.

3.2.3 Advice for parents

As there may be concern about the unattractive appearance, reassure the parents that the problem can be corrected.

▶▶ 3.3 Oesophageal atresia and tracheoesophageal fistula

Key points

- ◆ Oesophageal atresia and tracheoesophageal fistula are birth defects where the oesophagus does not develop normally.
- ◆ Babies with oesophageal atresia cannot swallow their saliva. Feeding results in choking, coughing and cyanosis.
- ◆ Oesophageal atresia with tracheoesophageal fistula is a fatal condition if not recognized and treated promptly.
- ◆ Early consultation and referral is required.

Oesophageal atresia is a birth defect in which the oesophagus fails to develop as a continuous passage. Instead, it ends as a blind pouch. Tracheoesophageal fistula represents an abnormal opening between the trachea (windpipe) and oesophagus. Oesophageal atresia and tracheoesophageal fistula can occur separately or, more commonly, together.

3.3.1 Diagnosis

- Oesophageal atresia with a tracheoesophageal fistula (Figure 3.2) should be suspected in a newborn with excessive salivation. With the onset of feeding the infant develops choking, coughing and cyanosis.
- The simplest diagnostic procedure is the passage of a 10 or 12F oral tube into the oesophagus. With oesophageal atresia the tube will always stop about 10 cm from the lips. If the tube passes into the stomach, the child does not have oesophageal atresia. A radiograph of the chest must be obtained to confirm the position of the tube.

Warning!

A contrast study should not be done in an infant with suspected oesophageal atresia because the infant will aspirate into the lungs.

- Up to 50% of babies with oesophageal atresia / tracheoesophageal fistula will have other abnormalities, most commonly those described in the VACTERL association (vertebral, anorectal, cardiac, tracheal, esophageal, renal and limb deformities).

3 Surgical problems in neonates

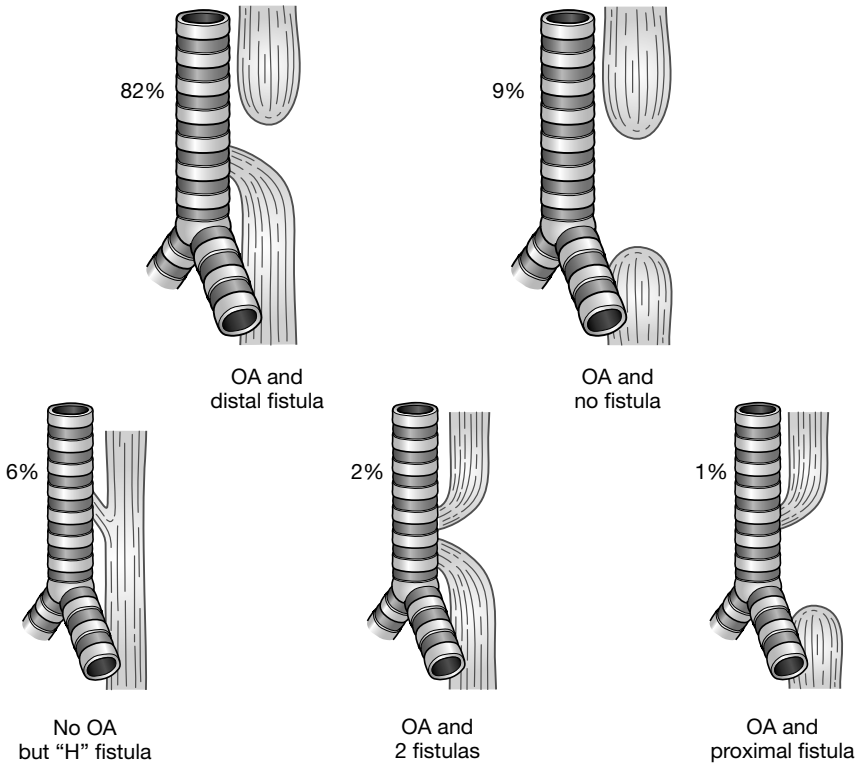


Figure 3.2 Types of oesophageal atresia (OA) and tracheoesophageal fistula

3.3.2 Treatment

- ▶ The patient should be cared for in a head-elevated position. To prevent aspiration, a catheter is inserted into the upper oesophageal pouch and connected to continuous suction. If continuous suction is not available, the catheter can be suctioned manually every 30 minutes.
- ▶ Fluid resuscitation: give 10–20 mL/kg normal saline to correct dehydration. Use dextrose saline solution as maintenance fluid (see Appendix 2).
- ▶ Start antibiotics (penicillin/ampicillin and gentamicin), as neonates are immunocompromised and infants with oesophageal atresia are at risk for pneumonia because of aspiration.
- ▶ Evaluate the baby for other birth defects.
- ▶ Once diagnosed, prompt surgery is required to allow the baby to take in food. The surgeon repairs the fistula by removing the atypical connection between the oesophagus and trachea. Surgery of tracheoesophageal fistula is important to prevent food from entering the lungs, which may cause repeated episodes of pneumonia.

Indications for referral

Repair of tracheoesophageal fistula and oesophageal atresia should be done by someone with experience and preferably training in paediatric surgery.

3.3.3 Advice for parents

Advise the parents of the serious nature of the problem and that you will do your best to treat the problem.

▶▶ 3.4 Bowel obstruction**Key points**

- ◆ Infants with persistent vomiting should be evaluated for a possible bowel obstruction.
- ◆ Bile-stained (green) vomiting should be considered a bowel obstruction until proven otherwise.
- ◆ Bowel obstruction in neonates can be fatal and requires urgent surgical evaluation and treatment.

Mishaps in development of the gastrointestinal tract may occur during early embryonic development. Birth defects of the gastrointestinal tract can take several forms, the most common of which is atresia – failure of part of the system to develop.

3.4.1 Diagnosis

The level of the bowel obstruction determines the clinical presentation.

- Proximal obstruction results in early vomiting with minimal abdominal distension.
- Obstruction in the distal bowel results in abdominal distension, with vomiting occurring later.

Warning!

Bile-stained (green) vomiting is a bowel obstruction until proven otherwise.

Some of the most common causes of bowel obstruction in neonates are described below. Anorectal malformations and Hirschsprung's disease are discussed in Sections 3.6 (page 55) and 6.8 (page 162), respectively.

3.4.2 Common causes***Bowel atresia***

This refers to discontinuity of the bowel (Figure 3.3). Bowel atresias can occur anywhere in the bowel but occur most commonly in the small intestine. The most

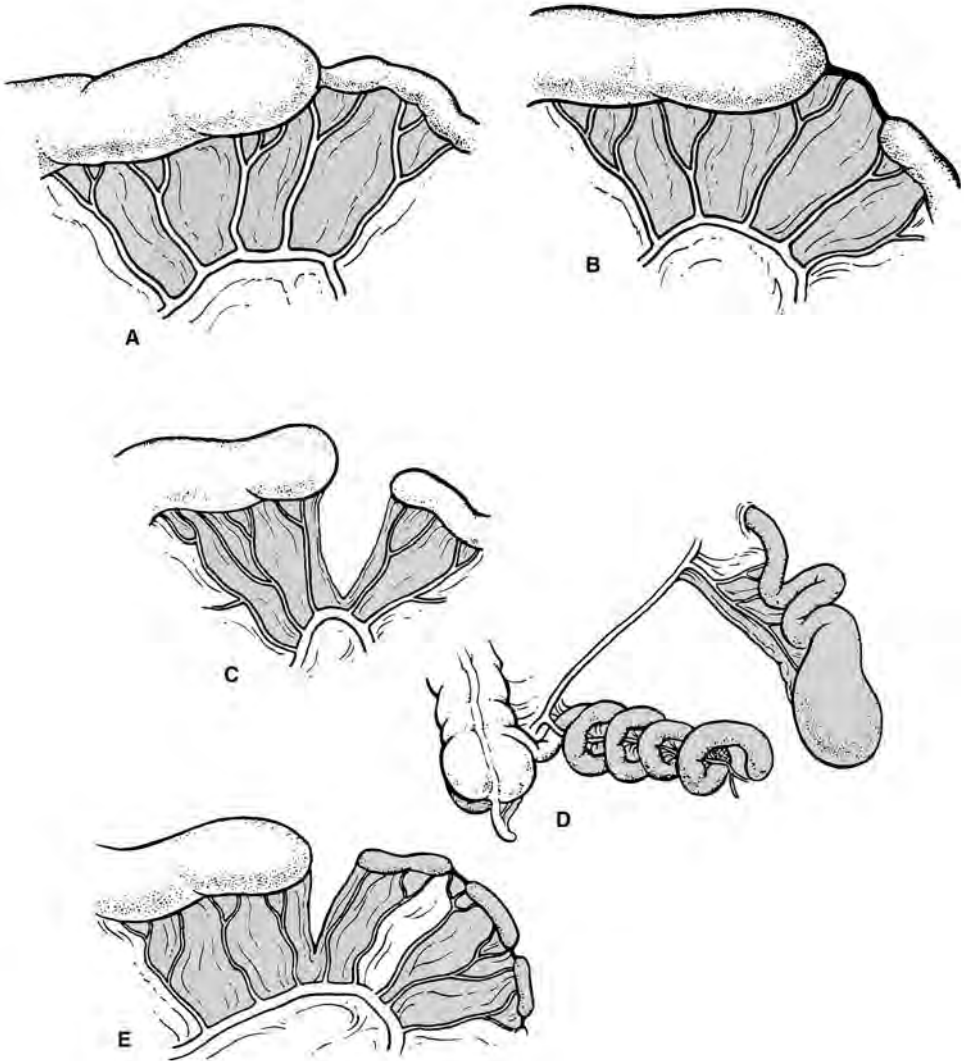


Fig 3.3 Types of small-bowel atresia: (A) obstruction caused by a membrane or web, (B) blind ends joined by a fibrous cord, (C) disconnected blind ends, (D) apple peel deformity, (E) multiple atresias.

common presentation of a small-bowel atresia in an infant is abdominal distension and bilious (green) vomiting shortly after birth. Treatment requires resection of the atretic bowel and reanastomosis to restore continuity of the bowel.

Malrotation with volvulus

This condition results when the bowel does not rotate properly during development. Because portions of the bowel are not fixed in the abdominal cavity, the intestine can twist (volvulus). Twisting of the intestine cuts off the blood flow to the bowel and also results in obstruction. Bile-stained vomiting in a previously well infant suggests this

diagnosis and should be taken very seriously. An emergency upper gastrointestinal contrast study (barium meal) is the study of choice for diagnosing a malrotation with volvulus. These children require urgent resuscitation and surgery to prevent the child from dying. If the diagnosis is suspected and an upper gastrointestinal study cannot be done quickly, consider taking the patient directly to the operating theatre.

Meconium plug syndrome

Meconium plug syndrome is a transient functional disorder of the colon that results from immaturity of the nerve cells in the bowel. This condition should be suspected in a newborn with abdominal distension and failure to pass significant meconium in the first 24 hours after birth. Bilious vomiting may also occur. The treatment is a water-soluble contrast enema, which typically shows retained meconium as a filling defect or plug. The primary differential consideration is Hirschsprung's disease (see Section 6.8, page 162), which is diagnosed eventually in 10–30% of patients with apparent meconium plug syndrome.

Pyloric stenosis

Pyloric stenosis presents as non-bilious vomiting, typically in boys at 3–6 weeks of age. Dehydration and electrolyte abnormalities are common. An olive-like mass (the enlarged pylorus) may be palpated in the upper abdomen. If the enlarged pylorus cannot be palpated, the diagnosis can also be made by ultrasound or a contrast study done under fluoroscopy. Ultrasound is preferred as there is no risk of the infant aspirating the contrast material. The treatment of pyloric stenosis is pyloromyotomy, a surgical procedure in which the thickened pylorus muscle is split. Pyloric stenosis can be confused with gastroesophageal reflux. The condition is rare in many areas of sub-Saharan Africa.

3.4.3 Initial management

Infants do not tolerate bowel obstructions, as they rapidly become dehydrated. Moreover, an untreated bowel obstruction can result in bowel perforation, with death rapidly occurring from sepsis. The following are important principles of managing an infant with a suspected bowel obstruction.

- ▶ **Fluid resuscitation:** Give 10–20 mL/kg normal saline to correct dehydration. Use dextrose saline solution as maintenance fluid (see Appendix 2).
- ▶ **Decompress the bowel.** Keep the baby nil by mouth and pass a nasogastric or orogastric tube to decompress the stomach. This can prevent bowel perforation, reduce respiratory distress and make the infant more comfortable. Nasogastric losses should be replaced with 0.45% normal saline + potassium chloride 20 mmol per litre.
- ▶ **Prevent infection.** Give penicillin/ampicillin, gentamicin and metronidazole.
- ▶ Develop a list of the potential causes for the obstruction. This can usually be done on clinical grounds.

3.4.4 Surgical treatment

All neonates with a suspected bowel obstruction should be reviewed urgently by a surgeon.

Indications for referral

Transfer the patient if the surgical expertise or facilities for caring for the patient are not available at your hospital.

3.4.5 Advice for parents

Describe the problem to the parents and reassure them that you will do your best to get the problem treated.

▶▶ 3.5 Abdominal wall defects

Key points

- ◆ Abdominal wall defects refer to a group of conditions where the abdominal wall fails to close properly during development.
- ◆ If the bowel is exposed the baby likely has a gastroschisis. Babies with gastroschisis are at risk for fluid loss, infection and hypothermia. Surgery must be done urgently.
- ◆ If the bowel is covered with a thin membrane the baby has an exomphalus (omphalocele). Babies with exomphalus often have associated birth defects.

There are several types of abdominal wall defects, each associated with different clinical problems. These are described below.

3.5.1 Gastroschisis (Figure 3.4a)

- This abdominal wall defect occurs next to and usually to the right of the umbilicus. The bowel herniates through the defect, and is exposed prenatally to amniotic fluid. There is no membrane covering the bowel. Because the bowel is exposed, the baby is at immediate risk for fluid loss, infection and heat loss (hypothermia).
- Occasionally the defect is plugged by omentum and the bowel is protected (gastroschisis minor).
- Affected babies are often small but usually do not have other anomalies; 10% will have an associated bowel atresia.

Initial management

Warning!

Babies with gastroschisis require closure of the abdominal wall defect shortly after birth.

- ▶ Do not wrap exposed bowel in saline-soaked gauze as this will increase heat loss.
- ▶ Cover the bowel with a clean or sterile plastic bag. This can be done by placing the whole trunk of the baby in the plastic bag.
- ▶ Keep the patient warm.
- ▶ Do not allow feeding or breastfeeding.
- ▶ Pass an orogastric tube, aspirate the distended stomach and leave on open drainage.
- ▶ Babies with gastroschisis can require a large amount of fluid (see Appendix 2). Maintenance fluid is 5% dextrose or, preferably, 10% dextrose at 150% of normal.
- ▶ Give 10–20 mL/kg normal saline to correct dehydration, repeating as needed.
- ▶ Replace nasogastric losses with normal saline on a millilitre-by-millilitre basis.
- ▶ Start antibiotics (penicillin/ampicillin and gentamicin).
- ▶ Position the baby on its right side to reduce traction on the bowel mesentery.

Indications for referral

Refer for urgent paediatric surgical review. The sooner surgery is performed after birth, the better the outcome.

3.5.2 Omphalocele (exomphalos) (Figure 3.4b)

- The abdominal wall defect is covered with a thin membrane, with the umbilical stump situated centrally. Because the bowel is not exposed, the risk of fluid loss, hypothermia and infection is less than with gastroschisis and the need to surgically correct the defect is less urgent, as long as the bowel is covered.
- A ruptured omphalocele can be difficult to distinguish from gastroschisis.
- In contrast to gastroschisis, omphalocele is commonly associated with other abnormalities (e.g. cardiac and chromosomal abnormalities).

Initial management

Many babies can be treated without surgery.

- ▶ Keep the baby warm.
- ▶ Paint the membrane covering the bowel with gentian violet or mercurochrome solution. The membrane will gradually separate and eventually granulation tissue will form and skin will grow over the defect.

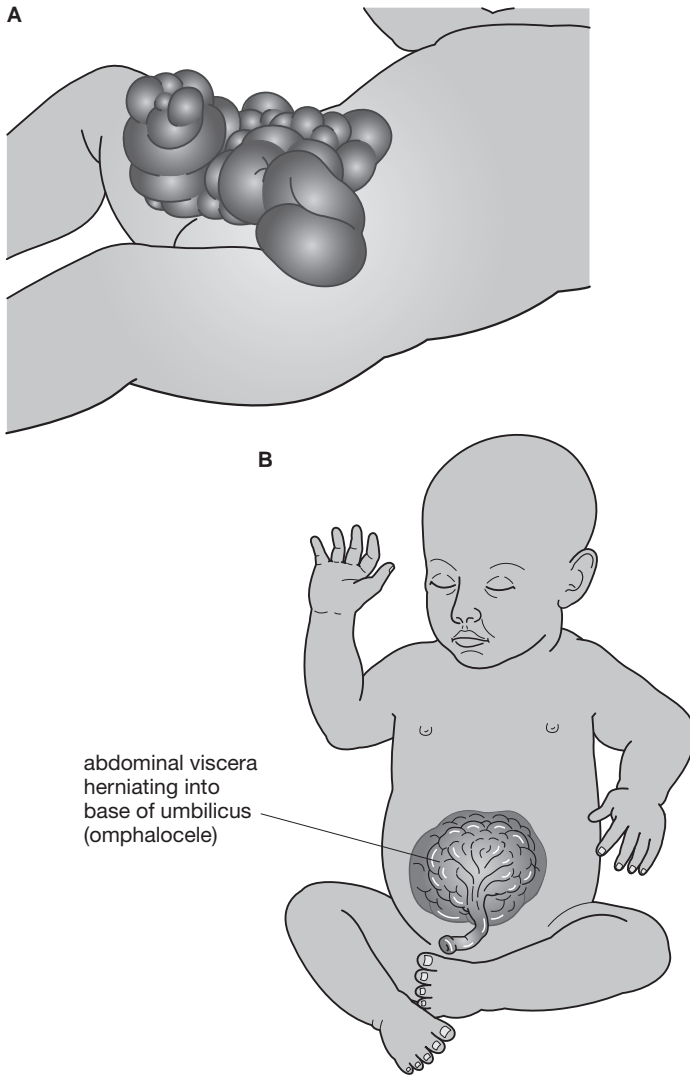


Figure 3.4 Gastroschisis (A) and omphalocele (B). Babies with omphalocele have a thin membrane covering the bowel. The umbilical cord emerges in the centre of the membrane.

- ▶ The residual abdominal wall hernia will need repair before 5 years of age.
- ▶ Surgical repair is necessary if the omphalocele ruptures. Small defects can be repaired surgically if anaesthesia is safe.

Indications for referral

Referral may not be necessary, unless it is required for treatment of other anomalies.

3.5.3 Bladder extrophy

In this condition the abdominal wall defect is below the umbilicus and extends caudally. The bladder is open and everted, as are the genitalia. The ureteric openings drain urine freely. In boys the penis is epispadic. In girls the clitoris is usually split.

Urinary incontinence, sexual dysfunction and psychosocial issues are major long-term problems for these children.

Indications for referral

If the child is seen at birth, he or she should be urgently referred to the paediatric surgeon, as early closure (within 24–48 hours) may reduce the chance of incontinence. If they present later, specialist referral is also essential.

3.5.4 Cloacal extrophy (vesico-intestinal fissure)

This is a more extensive and more serious defect than bladder extrophy because the bowel is involved in addition to the bladder and urethra. There is an imperforate anus, absence of the distal bowel and an opening of bowel alongside the everted bladder. Cloacal extrophy is a complex anomaly and is associated with significant mortality and morbidity.

▶▶ 3.6 Anorectal malformations

Key points ◀◀

- ◆ Anorectal malformations are a spectrum of conditions where the anus and rectum do not develop normally.
- ◆ The major problem at birth is the inability to pass stool, resulting in bowel obstruction.
- ◆ Anorectal malformations are correctable; the type of surgery needed depends on the type of anomaly.
- ◆ All infants should be screened for anorectal malformations at birth.
- ◆ The families must be fully informed of the long-term outcomes and support needed for this group of children.

This is a spectrum of conditions where the anus and rectum do not develop normally (Figures 3.5 and 3.6).

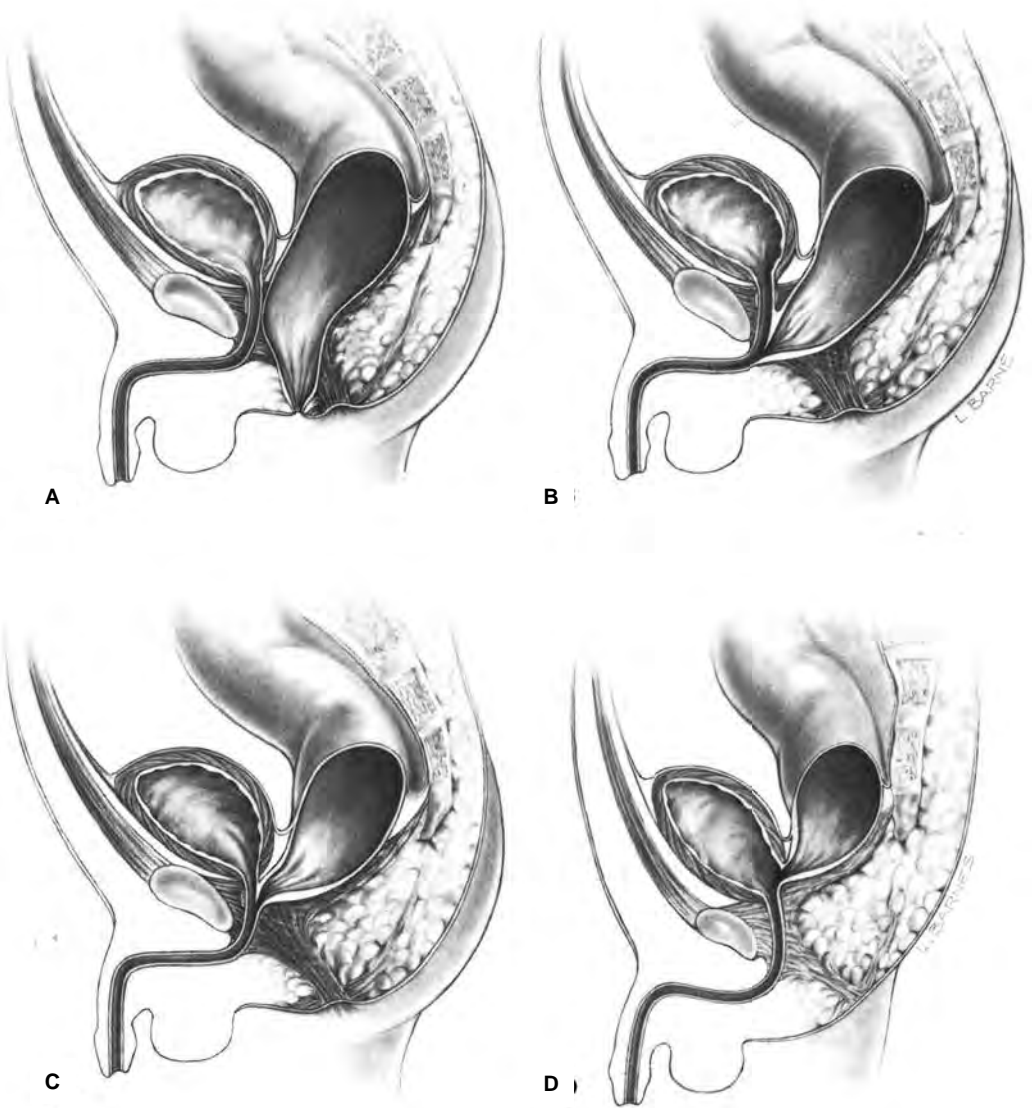


Figure 3.5 Anorectal defects in the male: (A) low-defect perineal fistula; (B) rectourethral bulbar fistula; (C) rectourethral prostatic fistula; (D) rectobladder neck fistula. (Adapted from the *Atlas of Surgical Management of Anorectal Malformations*, A S Peña, Springer-Verlag, 1989.)

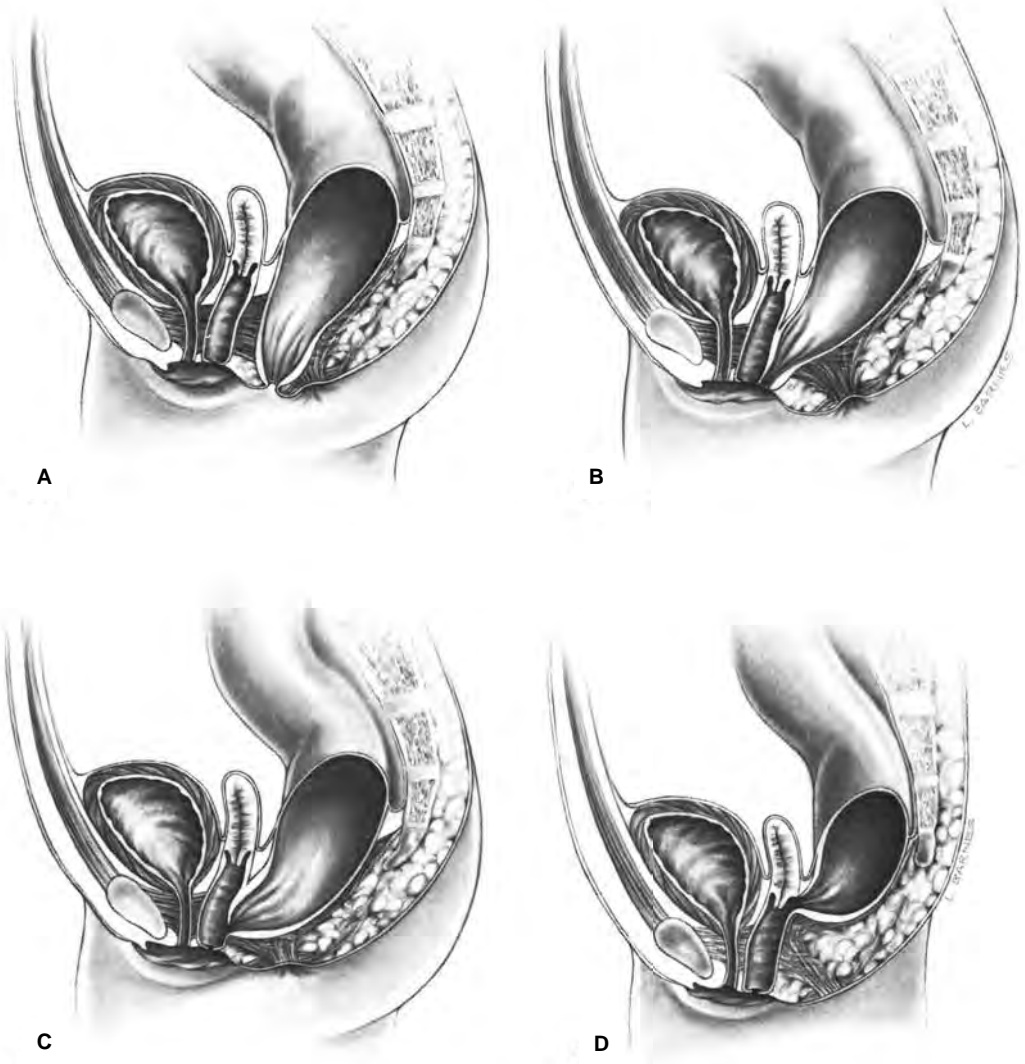


Figure 3.6 Anorectal defects in the female: (A) perineal (cutaneous) fistula; (B) vestibular fistula; (C) low rectovaginal fistula; (D) high rectovaginal fistula. (Adapted from the *Atlas of Surgical Management of Anorectal Malformations*, A S Peña, Springer-Verlag, 1989.)

3.6.1 Diagnosis

Every newborn should be inspected at birth to exclude an anorectal malformation. In a girl, the anus should be approximately one-third the distance from the posterior vulva to the coccyx. In a boy, the anus should be approximately half the distance from the scrotum to the coccyx.

The most common form of imperforate anus in a girl is a vestibular anus, more correctly called a rectovestibular fistula. The fistula is found at the posterior edge of the vulva. In a boy, determine whether there is a perineal fistula (a tract that leads to the skin). The diagnosis is made by inspection, and no further studies are needed. Most of the time the fistula is narrow. The terms 'covered anus', 'anal membrane' and 'bucket-handle deformity' are used to describe the external appearance.

Passing of meconium from the urethra in a boy or from the vagina in a girl indicates a 'high-type' fistula. These children will require a diverting colostomy. A flat bottom ('rocker bottom') results from poor muscle development in the perineal area and is usually associated with a high-type fistula and a poor prognosis.

Warning!

Babies with unrecognized anorectal malformation develop bowel obstruction and abdominal distension, which may lead to intestinal perforation and death within 5–7 days of birth. If there is a perineal fistula that keeps the rectum decompressed, children will present later with abdominal distension related to constipation.

Anorectal malformations are commonly associated with other congenital defects. The acronym VACTERL (vertebral, anorectal, cardiac, tracheal, esophageal, renal and limb deformities) has been used to describe this group of associated anomalies. It is important to identify associated malformations, as they may be the most important factor in determining the baby's outcome. Associated malformations should be identified both clinically and by special investigations. The latter may include blood tests for renal function and electrolytes, full blood count, abdominal and vertebral radiograph, ultrasound of the renal system and cystogram.

3.6.2 Initial management

The most important decision when caring for a newborn with an imperforate anus is whether the infant needs a defunctioning colostomy or if the problem can be fixed with an anoplasty. A decision-making chart for a newborn with anorectal malformations is shown in Figure 3.7.

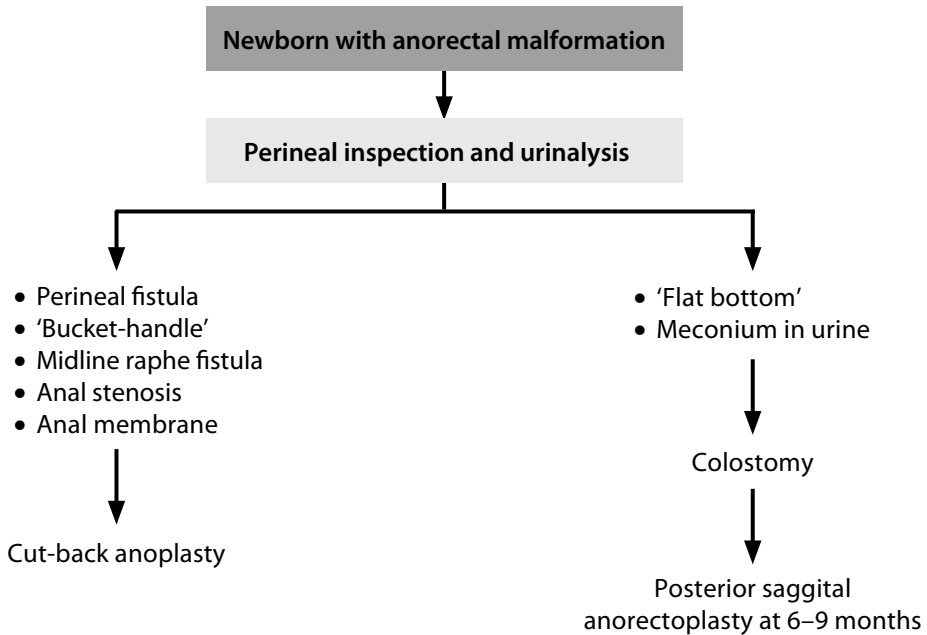


Figure 3.7 Decision-making chart for a newborn with an anorectal malformation.

- ▶ A colostomy is definitely needed for the following patients:
 - ▷ a female baby with:
 - meconium coming from the vagina
 - a single perineal opening (cloaca)
 - ▷ a male baby with meconium coming from the urethra
 - ▷ any infant where a high-type imperforate anus is suspected but cannot be proven.
- ▶ A cut-back anoplasty can definitely be used in a male baby with scrotal or perineal fistula or bucket-handle deformity.
- ▶ Temporary dilation can be carried out in the following patients:
 - ▷ a female baby with a rectovestibular fistula
 - ▷ a male baby with a perineal fistula or a bucket-handle abnormality.
- ▶ Girls with a rectovestibular fistula should be treated with initial dilation and later definitive surgery. A cutback procedure is not suitable for this condition.
- ▶ Infants with missed imperforate anus typically present with severe dehydration and even sepsis. Such infants require aggressive fluid resuscitation before surgery. Adequate resuscitation is indicated by urine output of at least 2 mL/kg per hour. Broad-spectrum antibiotics should be administered. The infant should be kept nil by mouth and a nasogastric tube placed.

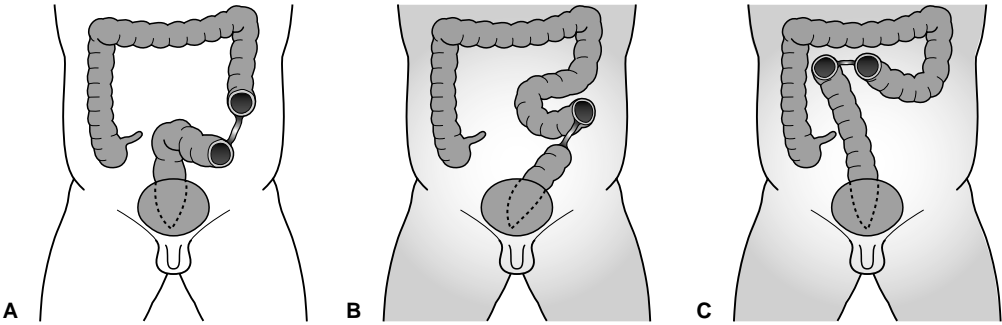


Figure 3.8 (A) Ideal site for location of a colostomy in a newborn with anorectal malformations; (B) too distal; (C) right transverse sigmoidostomy (a frequent technical error). (Adapted from the *Atlas of Surgical Management of Anorectal Malformations*, A S Peña, Springer-Verlag, 1989.)

3.6.3 Surgical treatment

Colostomy

A colostomy decompresses the bowel, prevents contamination of the urinary tract with stool, and allows the child to grow before final repair of the imperforate anus. The preferred method for a colostomy is an oblique left lower quadrant incision with a colostomy and mucous fistula (Figure 3.8). Care must be taken to ensure a proximal sigmoid colostomy so that enough of the distal colon remains for a future pull-through repair. A mucous fistula is important to decompress the distal obstructed segment and also to perform a loopogram (contrast study of the distal bowel) prior to the pull-through procedure. Irrigate and suction the residual meconium from the distal segment before forming the mucous fistula. Divided colostomy ensures that no spillage of stool occurs into distal rectum.

Anoplasty

Anoplasty (Figure 3.9) is appropriate only when it is certain that a minor procedure will solve the problem. An anoplasty is most commonly used for male babies with scrotal or perineal fistulas or bucket-handle deformities.

Reconstructive surgery

The posterior sagittal anorectoplasty (PSARP) has become the gold standard for reconstructing anorectal malformations. PSARP can be done with or without laparoscopic assistance and should be done by surgeons trained to perform this procedure.

Indications for referral

Reconstruction operations for anorectal malformations should be done by someone experienced with these conditions.

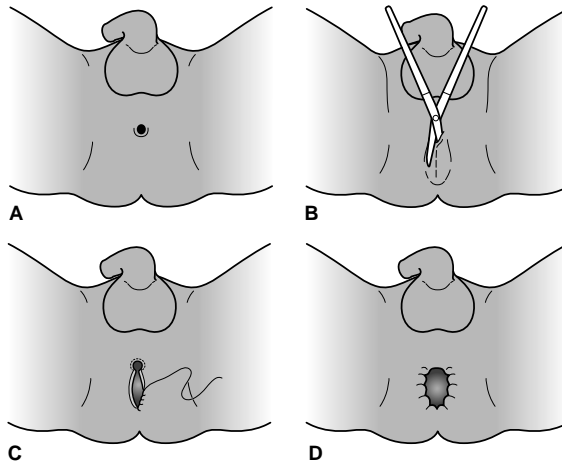


Figure 3.9 The cut-back anoplasty. (A) Small opening of a perineal fistula; (B) Opening being enlarged with a midline cut made with a scissors; (C) Cut layers being re-approximated with absorbable suture; (D) Completed anoplasty showing enlarged opening. The procedure should not be used with more anteriorly placed fistulas.

3.6.4 Bowel management

Even after a successful surgical reconstruction, some patients, particularly those with high-type anomalies or sacral deformities, will have problems with incontinence or constipation. Most of these patients can remain clean provided they have effective bowel management. Although there are a number of reasons for soiling, ranging from diet to short colon, most are due to overflow incontinence following constipation. The majority of these patients respond to daily rectal washouts. Additional information on managing incontinence in children with anorectal malformations is given in Section 6.10.2 (page 170).

3.6.5 Advice for parents

Reassure the parents that anorectal malformations are correctable. Also explain that anorectal problems can be associated with other congenital anomalies (e.g. heart and urinary problems).

▶▶ 3.7 Spina bifida

Key points ◀◀

- ◆ Spina bifida may affect the function of the bladder, bowel, legs and feet.
- ◆ Preventing infection is the first priority when caring for a baby with spina bifida. If the skin is open, apply a sterile dressing and start antibiotics.
- ◆ Surgery to close the defect should be performed as early as possible, ideally within the first few days of life.
- ◆ The family must be fully informed of the potentially complicated long-term outcomes.

Spina bifida refers to a group of neurological defects in the newborn. It is characterized by a swelling in the back which is made of dura with or without part of the spinal cord. The sac protrudes through a bony defect in the vertebrae, the most common site being the lumbar region. The swelling is a meningocele (if the sac contains only cerebrospinal fluid; CSF), a myelomeningocele (if the sac contains nerves and/or the spinal cord), or, more rarely, a lipomeningocele (where the swelling appears to be primarily made of fatty tissue).

Spina bifida is a congenital disorder of unknown cause, although folic acid deficiency is responsible for about half of cases. Folic acid supplements should be offered to all women of child-bearing age.

Spina bifida may be associated with neurological problems (bowel, bladder and motor deficits in the legs/feet) depending on the level of the lesion. About two-thirds of affected children will also have hydrocephalus, either from birth or appearing after closure of the back. Affected children may also have club feet and scoliosis / kyphosis.

3.7.1 Diagnosis

- The diagnosis is usually obvious on inspection, though rarely a tumour (teratoma) can mimic low-lying spina bifida. Meningoceles are skin covered, while myelomeningoceles typically have an open or raw area in the middle and may leak CSF (Figure 3.10). A lipomeningocele may look like a lipoma but is located exactly in the midline.
- On presentation it is important to assess the neurological function in the lower extremities, measure the head circumference and assess the fontanel. Radiography is not necessary but a cranial ultrasound can help in identifying hydrocephalus.

3.7.2 Treatment

- ▶ The immediate management of a baby with spina bifida is focused on preventing infection. If the skin is open, a sterile dressing should be applied and antibiotics started (ceftriaxone or penicillin/ampicillin and gentamicin).

Meningomyelocele

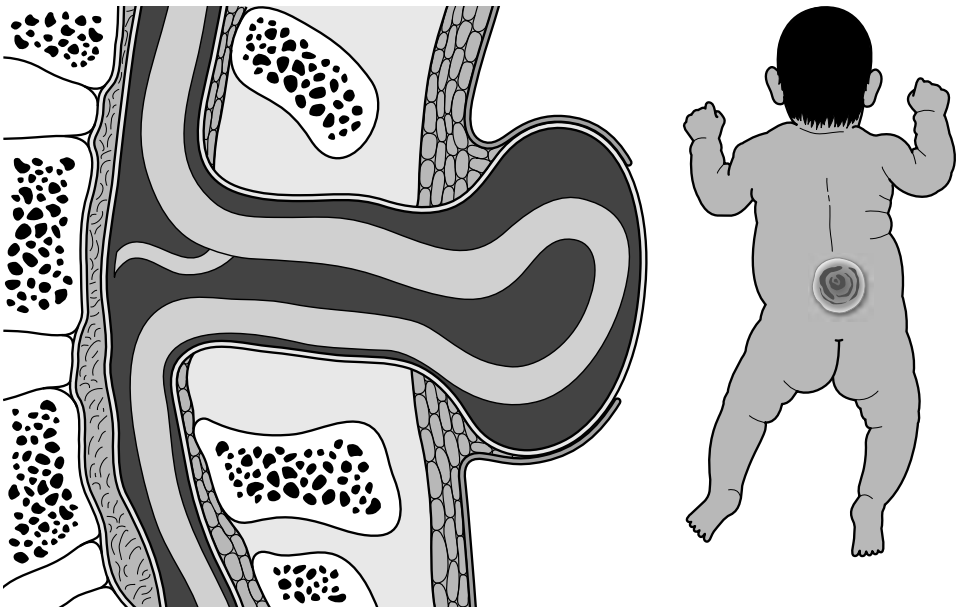


Figure 3.10 Myelomeningocele. (A) Cross section showing spinal cord in sac; (B) Common site on lower back.

- ▶ Surgery to close the defect should be performed as early as possible, to prevent infection and scarring, ideally within the first few days of life.
- ▶ If the baby also has hydrocephalus, insertion of a ventriculo–peritoneal shunt is indicated (see Section 3.8.3, page 66), though never less than 1 week after closure of the back (to prevent shunt infection).

3.7.3 Late complications

Children with spina bifida often have bowel and bladder problems. To prevent renal damage from their neurogenic bladder they will need to be followed up carefully with bladder evaluation; most require clean intermittent catheterization early. Such a bladder evaluation is not difficult but requires some basic training. Children will also benefit later on from bowel regimens to address their constipation or incontinence – this involves dietary changes, manual emptying of the rectum and/or enemas. Occupational therapy and braces are also usually needed for mobility, and for preventing pressure sores.

Regardless of the neurological level, the outcome of children with spina bifida is improving worldwide and can be quite satisfactory. Their care should include social support, and education of public and health care workers. More information on caring for children with spina bifida is available through the International Federation for Spina Bifida and Hydrocephalus (IFSBH; www.IFGlobal.org).

3.7.4 Spina bifida occulta

This is a neurological problem similar to spina bifida but the lesion is not visible on the outside. Children often present at a few years of age with progressive weakness or pain in the lower extremities or new-onset bladder problems. On physical examination a skin marker of the condition is often found – a hairy patch, dimple, birth mark or soft swelling. These children must be referred to a specialist surgeon for release of the tethered (attached) cord, which causes the symptoms.

3.7.5 Advice for parents

It is important to explain to the parents that neurological deficits cannot be corrected by surgery, and that the child may develop hydrocephalus, which may require surgery.

Indications for referral

Spina bifida surgery can be done by a general surgeon if he/she has experience, otherwise the baby should be referred to a paediatric surgeon or neurosurgeon. Because lipomeningoceles contain fatty tissue they are much more challenging to repair than myelomeningoceles; they should therefore be repaired by a specialist surgeon.

▶▶ 3.8 Hydrocephalus

Key points

- ◆ Hydrocephalus – an increased amount of CSF – causes enlargement of the head, and brain damage through compression of the brain.
- ◆ The disability associated with hydrocephalus can be prevented by prompt diagnosis and correct treatment.
- ◆ The treatment of hydrocephalus involves shunting of the CSF from the ventricles to another body cavity, usually the peritoneal cavity, by placement of a ventriculo–peritoneal shunt.

Hydrocephalus is the collection of excessive CSF in the brain. CSF is water-like fluid which fills the ventricles (interior chambers) of the brain and surrounds the brain and spinal cord. In children, hydrocephalus causes enlargement of the head, and brain damage through compression of the brain. It is a relatively common condition throughout the world and is responsible for a large amount of disability; however, such disability can be effectively avoided through prompt diagnosis and correct treatment.

3.8.1 Causes

Hydrocephalus is the result of an imbalance between the rate at which CSF is produced and the rate at which it passes back into the blood through the arachnoid villi. There are two main types of hydrocephalus, obstructive and communicating, which may be congenital or acquired.

- **Obstructive hydrocephalus** refers to obstruction of the CSF pathways within the interior of the brain. Obstructive hydrocephalus can occur as a congenital obstruction in the aqueduct of Sylvius between the third and fourth ventricles. In these children the fourth ventricle will be small. The flow of CSF can also become blocked from infection (meningitis) or from blood (common in premature babies).
- **Communicating hydrocephalus** refers to an inability of the CSF to pass through the arachnoidal villi to get back into the blood stream. This can result when the arachnoidal villi become blocked by inflammation or blood.
- Hydrocephalus that is present at birth is known as **congenital hydrocephalus**.
- Hydrocephalus that arises later in life is termed **acquired hydrocephalus**.
- Congenital hydrocephalus can be due to blockage at the aqueduct (aqueductal stenosis), congenital anomalies such as a Chiari malformation or Dandy–Walker malformation or it can be due to an inflammatory process when premature birth has resulted in bleeding within the brain.

Hydrocephalus can be associated with spina bifida. Between 50% and 75% of children with spina bifida will require shunting for hydrocephalus, primarily because of a malformation in the brain. In Western countries most hydrocephalus is congenital or secondary to prematurity. In sub-Saharan Africa at least half the cases follow infections, and are mostly due to neonatal or infant meningitis.

3.8.2 Diagnosis

- ▶ The typical presentation is gradual head enlargement. If the hydrocephalus is caused by an infection, it will follow a febrile illness, with or without convulsions, and is often misdiagnosed as malaria. Head circumference must be measured and plotted on standard World Health Organization nomograms. In borderline cases, the trend over a few weeks or months is more important than the actual size.
- ▶ Symptoms may include vomiting, seizures and irritability. Signs include a bulging, tense or full fontanel, sunset (down-gazing) eyes and prominent scalp veins.
- ▶ Neglected children with long-standing hydrocephalus are often severely malnourished and may have signs of cerebral palsy (spasticity) and pressure ulcers on the head. Arrested hydrocephalus is a condition where the hydrocephalus has stopped growing, leaving the child with a large head but without any symptoms.
- ▶ Ultrasound examination of the head, when available, is very useful in documenting the ventricular size and ruling out other conditions such as cysts and tumours.
- ▶ A ventricular tap done with a simple syringe and fine needle under aseptic conditions can produce CSF for Gram stain, cell count and bacterial culture to rule out an acute infection. The white cell count in sterile CSF should be less than 50 cells/mm³. Culture is the most sensitive method for establishing the presence or absence of a shunt infection.

3.8.3 Treatment

- ▶ The standard management of hydrocephalus is shunting of the CSF from the ventricles to another body cavity, usually the peritoneal cavity. This is called a ventriculo–peritoneal shunt (Figure 3.11). A shunt is a silastic tube with a one-way valve that prevents back flow into the ventricles. The simplest and cheapest effective shunt is the Indian Chhabra shunt, which is available through the International Federation for Spina Bifida and Hydrocephalus (ISFBH; www.ifglobal.org). In the absence of a commercial shunt, a sterile piece of IV tubing can be used, although this is not recommended because of the rapid decompressions which can be damaging to the brain. Note that placement of a shunt relieves the hydrocephalus but does not address the underlying cause. Shunting is a lifelong treatment.
- ▶ An endoscopic procedure (called endoscopic third ventriculostomy) is slowly growing acceptance as a shuntless alternative, but its availability is limited.
- ▶ Medications have a limited role in the management of hydrocephalus, though acetazolamide can be used to decrease CSF production while waiting for shunt placement. Periodic tapping of the CSF directly through an open fontanel (1 cm away from the midline where the coronal and sagittal sutures meet) can also help but should only be used until a definitive treatment is available.
- ▶ The child who presents with infected hydrocephalus needs to be treated first with IV antibiotics (ceftriaxone or ampicillin/gentamicin). A shunt should not be placed until the CSF is clear of infection.

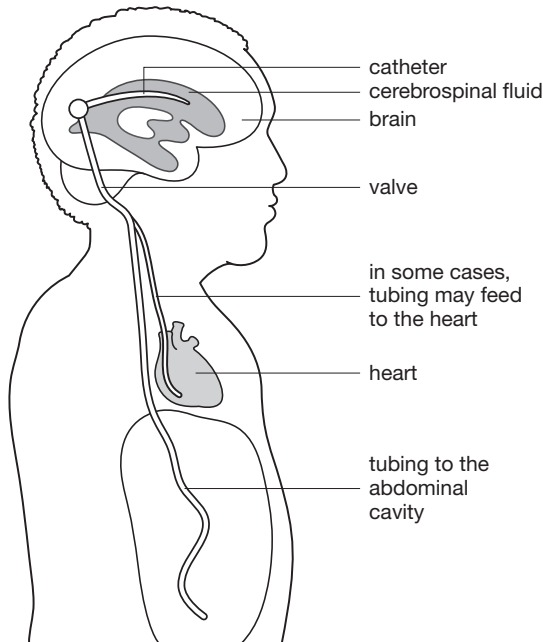


Figure 3.11 Ventriculo–peritoneal shunt for the treatment of hydrocephalus.

3.8.4 Complications

Shunts can cause a number of complications, months or even years after placement. Complications can be infectious (ventriculitis or tunnel infection) or mechanical (erosion through the skin or into the bowel, migration, detachment of the components, bowel obstruction or simple blockage).

Warning!

A change in mental status in a child who has had a shunt placed is due to an infected or obstructed shunt until proven otherwise. A non-functioning shunt in a symptomatic patient needs urgent revision to prevent brain damage. Infected shunts must be removed immediately and IV antibiotics started.

3.8.5 Outcome

The outcome of children with hydrocephalus depends on whether there is a delay in placing the shunt. The earlier the shunt is placed, the better the outcome. Because early diagnosis and treatment are essential, public health care workers should be educated on the diagnosis and treatment of hydrocephalus. The ISFBH provides a wealth of material to help with training.

3.8.6 Advice for parents

It is important to counsel the parents on the potential complications of shunt placement, the condition for which it is required and the long-term care involved.

Indications for referral

Shunts for hydrocephalus should be placed by someone with experience in this type of surgery.

▶▶ 3.9 Hip dysplasia

Key points ◀◀

- ◆ Hip dysplasia refers to a spectrum of abnormalities that occur in the growth and development of the hip joint. The hip may be completely dislocated, partially dislocated (subluxed) or unstable.
- ◆ Most cases of hip dysplasia can be diagnosed by physical examination.
- ◆ If untreated, hip dysplasia may result in leg-length discrepancy and gait disturbance, and/or premature arthritis.

3.9.1 Diagnosis

Risk factors for hip dysplasia include breech presentation, oligohydramnios (low amniotic fluid), female, first born and a family history of hip dysplasia. The presence

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of other orthopaedic abnormalities should prompt a careful examination of the hips to rule out hip dysplasia. The physical exam findings associated with hip dysplasia vary with the age of the patient.

Neonatal period

During the neonatal period, the exam should focus on determining whether the hip joint is stable. Stability of the hip joint is assessed using several manoeuvres.

- ▶ The **Barlow manoeuvre** attempts to sublunate or dislocate a hip that is correctly located (reduced). The thigh is flexed and adducted, and a force is applied from anterior to posterior in an attempt to displace the hip. A Barlow-positive hip is dislocatable with stress.
- ▶ The **Ortolani manoeuvre** attempts to reduce a hip that is dislocated, and is performed by flexing and abducting the hip with gentle traction on the thigh. If the hip can be reduced the Ortolani is positive.

Older infant

Several physical findings may be present in the older infant with hip dysplasia.

- ▶ The **Galleazi sign** is observed when the patient is supine and the hips are flexed up to 90 degrees (knees are also flexed). A positive Galleazi refers to a difference in knee heights. The knee will be lower on the affected side (thigh segment is shorter with a sublunate or dislocated hip).
- ▶ Limited passive abduction of the involved hip indicates an adduction contracture, which may be associated with a sublunate or dislocated hip.

Toddlers and children

In toddlers and children, the typical findings include a limp associated with a leg-length discrepancy (unilateral) or a waddling gait (bilateral). Limited abduction and a positive Galleazi sign are also present in these older patients. Physical findings may be absent in patients with a primary acetabular dysplasia (flattening of the hip socket), which may explain why approximately 10% of cases are missed even with an adequate screening programme.

Diagnostic studies, such as ultrasound and plain radiographs, are useful for confirming the diagnosis and for monitoring the response to treatment. Ultrasound is especially helpful for assessing the hips of infants. Plain radiographs become helpful once the ossific nucleus has formed (3–4 months of age). The common plain radiographic findings in developmental dislocation are shown in Figure 3.12.

3.9.2 Treatment

A host of options are available to treat the spectrum of problems associated with developmental dysplasia of the hip, and the choice for a specific patient depends on both their age and the pathology. In a subset of neonates the hips will stabilize on their own.

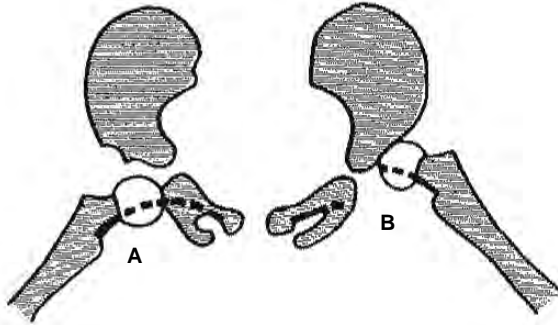


Figure 3.12 Radiological diagnosis of congenital hip dislocation. Positioning the lower limb in 45 degrees abduction demonstrates a break in the continuity of a line drawn along the upper margin of the obturator foramen and the lower aspect of the femoral neck. (a) Normal Shenton's line. (b) The line is broken in dislocation of the hip. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

- ▶ Up until 6 months of age, an unstable or dislocated hip may be treated by a splint such as the Pavlik harness. Correct position of the hip should be confirmed by ultrasonography, if available. Treatment is usually for 6–8 weeks full time, and then only at night for a variable period of time.
- ▶ Hips that are not corrected by splinting will require more complex treatment, and should be referred to higher levels of service. Surgery is usually required in children of walking age, and is generally recommended for bilateral cases of developmental dislocation until 4–5 years of age, and unilateral cases up until 7–8 years of age.

Indications for referral

If possible, have children with a suspected hip dysplasia evaluated and treated by an orthopaedic specialist.

▶▶ 3.10 Clubfoot

Key points

- ◆ Clubfoot (talipes equinovarus; Figure 3.13) is the most common congenital musculoskeletal problem in children.
- ◆ If untreated, the deformity can result in gait disturbance, pain, social stigma and considerable disability.
- ◆ Treatment depends on the age of the patient and the severity of the deformity (flexible versus stiff).
- ◆ The Ponseti method is a simple and effective method for correcting club foot in children less than 8 years of age.

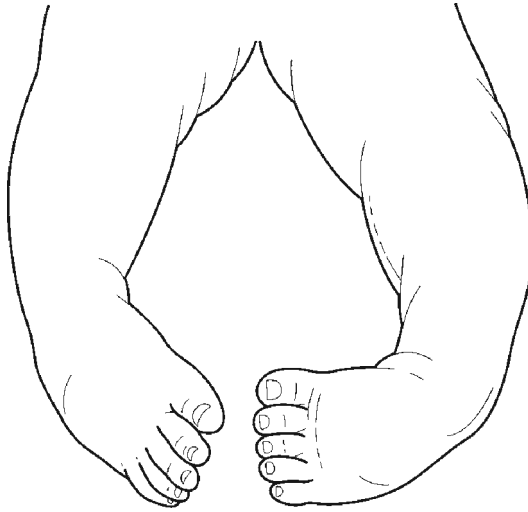


Figure 3.13 Clubfoot. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

Children with clubfoot have abnormalities in both the bone and soft tissue. Bony abnormalities include deformity of the talus (the head and neck of the talus have plantar and medial deviation) and misalignment at the hind foot joints (subtalar, transverse tarsal). The soft tissues (ligaments, joint capsules and muscles) are contracted along the posterior, medial and plantar surfaces of the foot and ankle. The degree of flexibility varies between patients.

3.10.1 Diagnosis

- A complete physical exam should be done to rule out other congenital or neuromuscular conditions. In particular, examine the hips for evidence of dysplasia, and the spine for skin changes (midline dimple, skin tag, hair patch or skin lesion) that might suggest an underlying spinal dysraphic condition.
- The diagnosis of clubfoot is made on physical examination, and radiographs are not routinely required. Components of the deformity include cavus and adductus at the midfoot, and hindfoot varus and equinus. In the older child, atrophy of the calf muscles is a common finding with or without treatment, and a leg-length discrepancy may be observed as well (the clubfoot side is shorter).

3.10.2 Treatment

Treatment depends on the age of the patient and the severity of the deformity (flexible versus stiff). A positional clubfoot (due to intrauterine moulding) will be flexible and easily corrected with stretching or a few casts. Idiopathic clubfoot varies in the degree of stiffness. Clubfoot associated with neuromuscular conditions or syndromes tends to be rigid, more difficult to correct and more prone to recurrence.

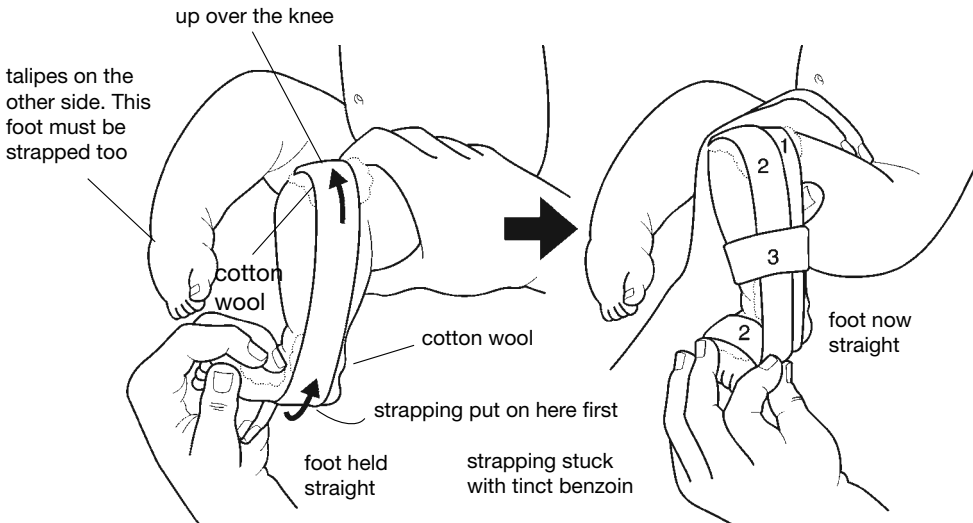


Figure 3.14 Treatment of clubfoot by strapping. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

- ▶ **Non-surgical methods** include taping/strapping (Figure 3.14) and ‘functional’ treatment (daily physical therapy, taping and continuous passive motion).
- ▶ **The minimally invasive Ponseti method** (Figure 3.15) involves a specific sequence of corrections (cavus, adductus, varus, equinus – ‘CAVE’). Long leg casts using plaster of Paris are applied every 5–7 days.
 - ▷ The first series of casts are applied with the hindfoot in equinus. The goal is to simultaneously correct the cavus, adductus and hindfoot varus, by abducting the forepart of the foot around the head of the talus (fulcrum). In the first cast, the first ray is dorsiflexed to correct the midfoot cavus and the foot is progressively abducted (while stabilizing the head of the talus).
 - ▷ During the next few casts, the foot is progressively abducted, resulting in a three-dimensional realignment of the hindfoot joints.
 - ▷ Once 70 degrees of passive abduction is achieved, the last step involves correcting the hindfoot equinus by progressive dorsiflexion.

Approximately 90% of patients treated with the Ponseti method will require a percutaneous tenotomy of the Achilles tendon. After the tenotomy, the foot is casted in 70 degrees of abduction and 10–15 degrees of dorsiflexion. The final cast is worn for 3 weeks, after which a foot abduction orthosis is worn full time for 3 months, and then at night until 5 years of age. Recurrence is common if the abduction brace is not worn. Recurrence is treated by repeat casting, with or without a percutaneous Achilles tendon release. A small subset of patients with recurrence and a dynamic equinovarus foot may require lateral transfer of the tibialis anterior to the middle cuneiform to balance the muscular forces.

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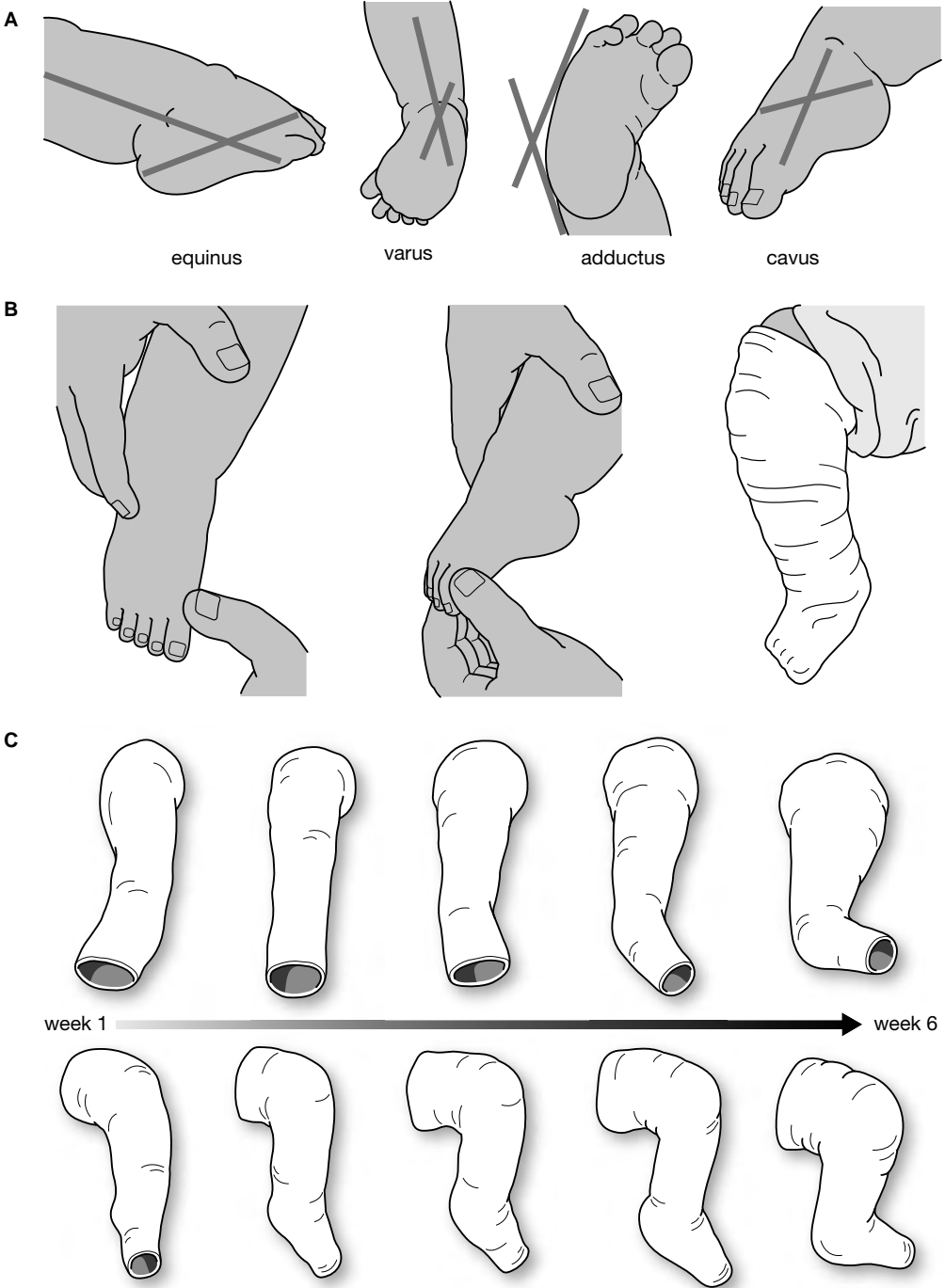


Figure 3.15 The Ponseti method for treatment of clubfoot. (A) Components of a clubfoot deformity. (B) Applying the first cast in the in equines position enables simultaneous correction of the cavus adductus and varus deformities. (C) Examples of serial casts; anterior and lateral views of the casts are shown.

The Ponseti method can be used for children up to 8 years of age and has eliminated the need for extensive soft-tissue release in more than 90% of patients less than 2 years of age with idiopathic clubfoot.

In the older child (older than about 8 years) with a rigid clubfoot, options include a triple arthrodesis (fusion of talocalcaneal, calcaneocuboid and talonavicular joints) or gradual correction with a hinged distractor (Ilizarov, Joshi) with or without osteotomies.

More information on the management of children with clubfoot can be found in *Clubfoot: Ponseti Management*, third edition (available from Global Help; www.global-help.org).

Indications for referral

More extensive surgery may be required if non-surgical and minimally invasive methods fail. Severe deformities may require realignment osteotomies, hindfoot fusion (triple arthrodesis) or gradual correction with an external fixator. This surgery should be done by someone with training in paediatric orthopaedic surgery.

▶▶ CHAPTER 4: Injuries

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▶▶ 4.1 Principles of paediatric trauma care

Key points

- ◆ Injuries are a leading cause of death in children, and also a major cause of disabilities.
- ◆ The ABC of trauma management (airway, breathing, circulation) applies equally to the injured child and adult.
- ◆ Every injured child with hypotension or inadequate perfusion must be evaluated by a surgeon as soon as possible.

Childhood injuries are common and, compared with adults, vary in their mechanism of injury, treatment and outcome.

4.1.1 Differences between children and adults

- The child has a smaller body mass and so traumatic energy (e.g. bumps or falls) generates a greater force per unit body area, resulting in a high frequency of multiple organ injuries.
- The child's skeleton is incompletely calcified and is more pliable than that of an adult. This frequently results in internal organ damage without overlying bony fractures. Examples include pulmonary contusion or splenic rupture without rib fractures. When ribs are fractured, a massive amount of energy transfer has to be assumed and serious organ injuries suspected.
- Hypothermia develops much more quickly in the child because of the higher ratio of body surface area to body volume.
- The greater physiological reserve of the child often allows maintenance of normal vital signs in the presence of severe shock. Unlike the adult who may deteriorate gradually with haemorrhagic shock, the child can often 'crashes' suddenly.
- In adults, closed head injury is not considered a source of massive blood loss. Infants, however, may become hypotensive from blood loss into either the subgaleal or epidural space.

4.1.2 Initial assessment and treatment

The priorities for managing an injured child are:

- **A**irway
- **B**reathing
- **C**irculation (ABC).

Airway with cervical spine control

A crying or speaking child has a patent airway. If unclear, look, listen and feel for air exchange at the mouth or nostrils. The infant's airway should be protected in the neutral position; a child's airway should be protected in a slightly superior and anterior position of the midface, known as the 'sniffing position' (Figure 4.1). The mouth and the oropharynx should be cleared of secretions, foreign bodies and debris. A chin lift or jaw thrust may be necessary to support the airway in a spontaneously breathing child.

If the decision is made to intubate a child, they should first be oxygenated. Orotracheal intubation under direct vision, with adequate cervical spine protection, is the preferred method of obtaining initial airway control in a child incapable of

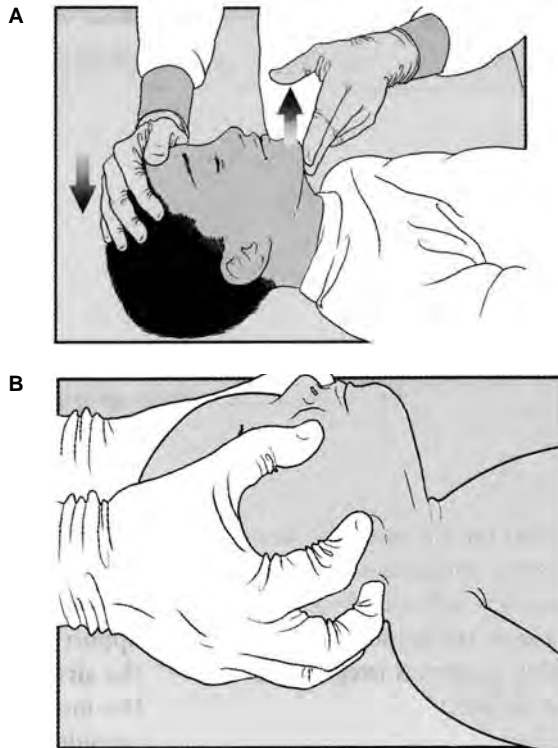


Figure 4.1 Proper positioning of the airway: (A) the chin lift in a small child; (B) the jaw thrust in a small baby.

spontaneous breathing. The size of the endotracheal tube can be estimated from the diameter of the child's little (fifth) finger (see Table 1.1, page 10). Children should be ventilated at approximately 20 breaths per minute; infants require 40 breaths per minute (see Sections 1.5 [page 10] and 5.3.6 [page 137]).

Breathing

Adequate ventilation involves more than airway patency, and includes adequate function of the lungs, chest wall and diaphragm. Auscultation should confirm air exchange in both lungs. Right main stem intubation is all too common in emergency situations. Visual inspection and palpation may reveal injuries to the chest wall that may compromise ventilation. Injuries that acutely impair ventilation, such as tension pneumothorax or massive haemothorax, should be identified and treated promptly (see Section 4.8 [page 109]).

Circulation

Warning!

Every injured child with hypotension or inadequate perfusion must be evaluated by a surgeon as soon as possible.

- Tachycardia (increased heart rate) is a common finding in an injured child and may be caused by bleeding, pain and/or fear. Tachycardia associated with poor skin perfusion (cold extremities, mottling) is haemorrhagic shock until proven otherwise.
- Hypotension in an injured child indicates severe blood loss, inadequate resuscitation and uncompensated shock. Remember that children often 'crash' suddenly, rather than decompensating gradually as an adult would.
- Information on establishing IV access and fluid resuscitation is provided in Sections 1.6 (page 11) and 1.4.3 (page 7), respectively.

Indications for referral

If a surgeon is unavailable at the primary referral hospital, the child should be stabilized and transferred to a facility that can provide the needed care.

▶▶ 4.2 Principles of wound care

Key points

- ◆ The goals of caring for any wound are to stop bleeding, prevent infection, assess damage to underlying structures and promote wound healing.
- ◆ The signs of a wound infection are pain, swelling, redness, increased warmth and drainage.

4.2.1 Control of bleeding

- ▶ Direct pressure will stop any bleeding (Figure 4.2).
- ▶ Bleeding from extremities can be controlled for short periods of time (< 10 minutes) using a blood pressure cuff inflated above the systolic blood pressure. However, prolonged use of a tourniquet risks damage to the extremities. Tourniquets should never be used in a patient with sickle cell anaemia, or when a patient is being transferred to another facility.
- ▶ The best way to control bleeding in an emergency situation is to apply pressure. Do not attempt to control bleeding by clamping structures within a wound, as this risks damage to other important structures such as nerves and blood vessels.

4.2.2 Preventing infection

Cleaning the wound is the most important factor in preventing wound infection. Most wounds are contaminated when first seen: they may contain blood clots, dirt, dead or dying tissue and possibly foreign bodies such as grass, metal or glass.

- ▶ Clean the skin around the wound thoroughly with soap and water or antiseptic.
- ▶ Irrigate the wound with large amounts of water and antiseptic. Dilute antiseptic solution can be poured directly into the wound.

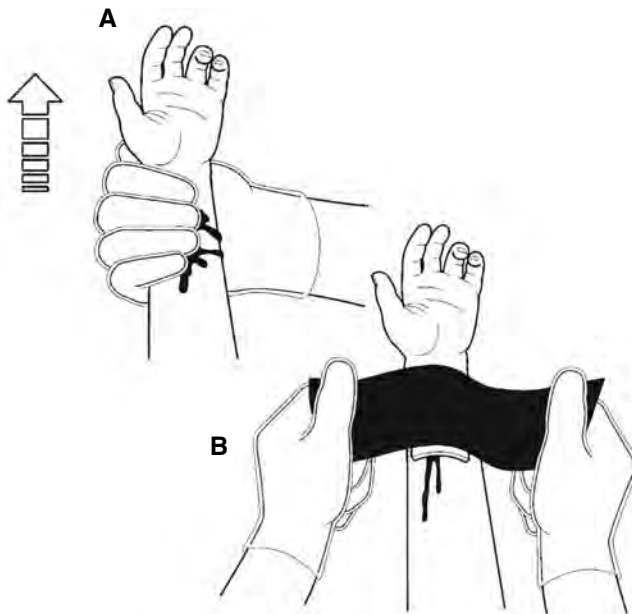


Figure 4.2 Controlling external bleeding. (A) Elevate the limb and apply direct pressure. (B) Apply a pressure bandage. Give tetanus prophylaxis if appropriate. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

- ▶ After giving a local anaesthetic (lidocaine 1%, not to exceed 0.45 mL/kg), search carefully for foreign material and carefully excise any dead tissue.
- ▶ Determine what damage may have been done.

When a wound cannot be adequately explored under local anaesthesia, consider general anaesthesia. Most major wounds in children require exploration under general anaesthesia. If the bone is fractured, splint the extremity after applying the dressing.

Warning!

**Do not attempt to repair nerves, arteries or tendons without expertise available.
The goal is to secure haemostasis and clean the wound.**

Antibiotics are not usually necessary if wounds are cleaned carefully. However, the following should be treated with oral antibiotics:

- untreated wounds older than 12 hours (these are likely to be already infected)
- wounds penetrating deep into tissue (e.g. a wound made by a dirty stick or knife)
- wounds that already showing signs of infection (cellulitis or pus is present).

Patients with serious wound infections – as evidenced by cellulitis or fever – should be treated with IV antibiotics.

4.2.3 Tetanus prophylaxis

Although any open wound is a potential source for tetanus infection, wounds contaminated with dirt, faeces or saliva are at the greatest risk. Punctures, wounds containing devitalized tissue, crush and avulsion injuries, and burns are particularly vulnerable to infection with *Clostridium tetani*.

- ▶ The use of tetanus vaccine boosters and tetanus immunoglobulin (TIG) is based on the vaccination history and the type of wound (Table 4.1).
- ▶ For infants younger than 6 months of age who have not received a full three-dose primary series of tetanus-containing vaccines, the need for TIG depends on the mother's tetanus immunization history and type of wound:
 - ▷ non-vaccinated mother: give TIG to infant
 - ▷ vaccinated mother, infant with clean minor wound: no further treatment required
 - ▷ vaccinated mother, infant with dirty wound: give TIG to infant.
- ▶ TIG contains antibodies that bind to tetanus toxin. If a tetanus booster is to be given at the same time as TIG, use separate syringes, and inject each at different sites.
- ▶ TIG comes in several forms.
 - ▷ Human TIG is given IM at a dose of 250 units (regardless of age or weight).
 - ▷ In countries where TIG is not available, equine tetanus antitoxin (1500 units

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for a child < 30 kg) can be used after appropriate testing for sensitivity, and desensitization if necessary.

- ▷ Immunoglobulin IV (IGIV) can also be used, as it contains antibodies to tetanus.
- ▶ HIV-positive children should receive TIG regardless of tetanus vaccination history.
- ▶ Regardless of vaccination status, wounds should be cleaned, disinfected and treated surgically if appropriate. It is not necessary to debride puncture wounds extensively.

Table 4.1 Management of tetanus-prone wounds

History of tetanus vaccination		Type of wound	Tetanus vaccine booster*	Tetanus immunoglobulin
3 or more doses**	< 5 years since last dose	All wounds	No	No
	5–10 years since last dose	Clean minor wounds	No	No
		All other wounds	Yes	No
> 10 years since last dose	All wounds	Yes	No	
< 3 doses or uncertain		Clean minor wounds	Yes	No
		All other wounds	Yes	Yes

*Tetanus booster doses may be with either DTP or Td vaccines, depending on the child's age. Td should be used for tetanus and diphtheria booster doses after 7 years of age.

**Three doses should be given in the first year of life. In areas where pertussis is a particular risk to young infants, DTP should be started at 6 weeks of age, with two subsequent doses at least 4 weeks apart.

4.2.4 Wound closure

An important decision is whether to close a wound. In general, if the wound is less than a day old and has been cleaned satisfactorily, the wound can be closed (called primary closure).

Warning!

A wound should not be closed if it is more than 24 hours old, contaminated with dirt or other foreign material, or caused by a human or animal bite. Closing a wound under these circumstances risks serious wound infection.

Wounds not treated with primary closure should be packed lightly with saline-soaked gauze. If the wound is clean 48 hours later, it can then be closed (delayed primary closure). If the wound is infected, clean and repack the wound lightly every day and let the wound heal on its own. If a wound is closed, this should be done in such a way that no cavities are left behind. Subcuticular skin sutures are preferred in children to avoid the need for subsequent removal of sutures.

4.2.5 Wound infections

The signs of a wound infection are pain, swelling, redness, increased warmth and drainage of fluid from the wound.

- ▶ If pus is suspected, remove some sutures and open the wound.
- ▶ Clean the wound with disinfectant and pack it lightly with saline-soaked gauze. Change the dressing every day, or more frequently if needed.
- ▶ Give antibiotics until the surrounding cellulitis resolves (usually 5 days). Cloxacillin is a good choice for most wounds to cover *Staphylococcus* species. Ampicillin, gentamicin and metronidazole may be needed if bowel flora are suspected.

4.2.6 Bite wounds

Bites from humans and animals can lead to serious infections.

- ▶ Surgical intervention is frequently necessary, ranging from simple wound exploration and debridement to repair of complex structures. Indications for surgical intervention include:
 - ▷ severe soft-tissue infection
 - ▷ abscess
 - ▷ joint penetration
 - ▷ underlying fracture
 - ▷ tendon laceration
 - ▷ osteomyelitis
 - ▷ tenosynovitis
 - ▷ septic arthritis
 - ▷ neurovascular compromise or injury to a complex structure
 - ▷ foreign body.
- ▶ Prophylactic antibiotics (amoxicillin/clavulanate 10 mg/kg orally every 8 hours or clindamycin plus trimethoprim/sulfamethoxazole orally for 3–5 days) should be used for:
 - ▷ moderate or severe bite wounds, especially if oedema or crush injury is present
 - ▷ puncture wounds, especially if penetration of bone, tendon sheath or joint has occurred

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- ▷ bites to the face, hands, feet or genital areas
- ▷ wounds in immunocompromised and asplenic children.
- ▶ Consider IV antibiotics (clindamycin and gentamicin) for infected bite wounds, especially to the hand or foot.
- ▶ Tetanus prophylaxis may be required (see Section 4.2.3 [page 79]).
- ▶ Assess the risk of rabies, HIV, hepatitis B and C and syphilis.

Warning!

Be particularly cautious with bites to the hand. Infection can spread along tendon sheaths and into the deep spaces of the hand. Surgical incision and drainage may be needed.

▶▶ 4.3 Birth injuries

Key points

- ◆ The birth process can be traumatic and may result in a number of injuries.
- ◆ Recognizing birth injuries early and initiating proper therapy will ensure the best possible outcome.

4.3.1 Types of injuries

Some of the most common birth injuries are described below.

Head injuries

A spectrum of head injuries are associated with vaginal delivery. They occur more commonly with forceps delivery, vacuum extraction or malpresentation.

- ▶ **Caput succedaneum** is a diffuse, sometimes ecchymotic, oedematous swelling of the soft tissues of the scalp. The oedema disappears in the first few days of life. No specific treatment is needed.
- ▶ A **cephalohaematoma** is a collection of blood under the outside lining of the skull (periosteum). It is always limited to the surface of one cranial bone; there may be an associated linear skull fracture. Most cephalohaematomas are reabsorbed by 2 weeks to 3 months.
- ▶ **Subgaleal haematoma** is bleeding in the potential space between the skull periosteum and the scalp galea aponeurosis. A fluctuant boggy mass gradually develops over the scalp (especially over the occiput). Infants with subgaleal haematoma may develop haemorrhagic shock. The swelling may obscure the fontanelle and cross suture lines (distinguishing it from cephalohaematoma). Watch for significant hyperbilirubinaemia. In the absence of shock or intracranial injury, the long-term prognosis is generally good.

The management of head injuries is described in Section 4.6 (page 101).

Facial paralysis

The neck can become stretched during delivery, injuring the nerves to the face. This can occur when forceps have been used. The side of the face is paralysed. This problem typically resolves in a few weeks.

Erb's palsy

Sometimes the large nerves under a baby's arm are injured during birth, so that the arm is weak. The weakness in the arm does not heal as quickly as weakness in the face. Unfortunately, there is no specific treatment. Instruct the mother to move the arm to the position shown in Figure 4.3 several times every day to prevent contracture.

Clavicle fractures

A baby's collar bone sometimes breaks during delivery. As it heals there is a hard swelling over the fracture site, which can take several months to resolve.

Limb fractures

An arm or leg may be fractured during a traumatic birth. Bandage the arm as shown in Figure 4.4. Leg fractures can be treated by applying an ace wrap to stabilize the fracture.

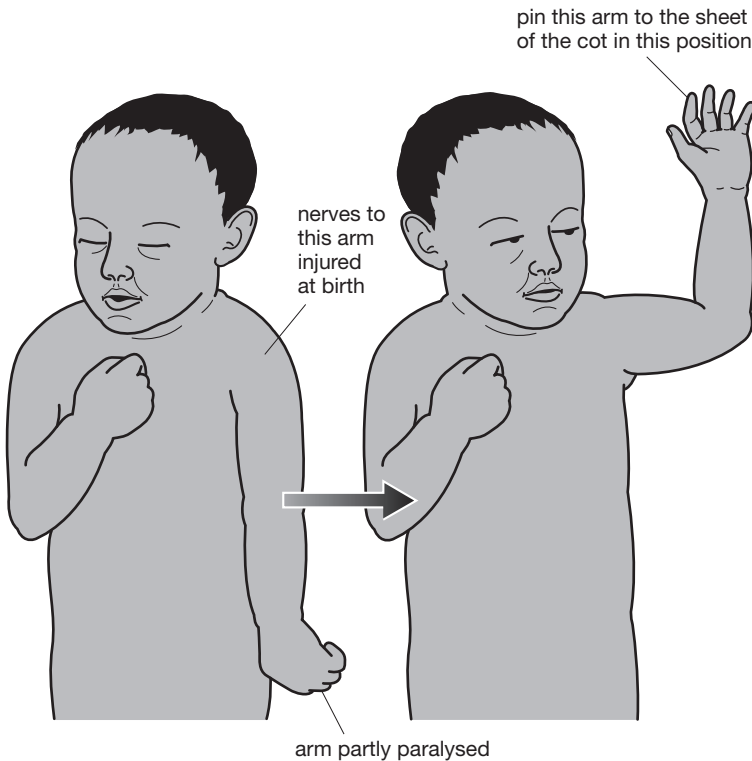


Figure 4.3 Treatment of Erb's palsy. The arm should be moved to the position shown several times a day, to prevent contracture.

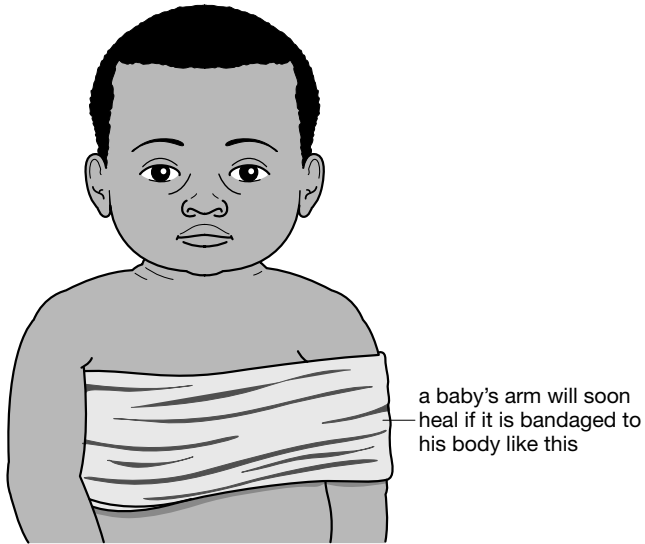


Figure 4.4 Treatment of an arm fractured during birth.

4.3.2 Advice for parents

Describe the problem to the parents and reassure them that you will do your best to treat the problem.

▶▶ 4.4 Burns

Key points ◀◀

- ◆ Burn injuries are a common health threat to children and may result in serious suffering, disfigurement and psychosocial trauma.
- ◆ Inadequate fluid resuscitation is a common cause of death in burns patients in low- and middle-income countries.
- ◆ Many burns patients can be treated successfully, although reconstruction and rehabilitation can take 10–15 years.

Scalds are common amongst infants and toddlers. In older children, burns caused by flames, hot objects and electricity are the most common types.

4.4.1 Diagnosis

Burn wounds are classified according to the depth of tissue injury.

- **Superficial partial-thickness burns** destroy only the superficial layers of the skin. They are painful, red in colour with blister formation and blanch readily. They usually heal within 3 weeks and rarely cause hypertrophic scars.

- **Deep dermal burns** (indeterminate depth) involve destruction of the epidermis and various amounts of dermis. Pain is less than with a superficial burn; the wound has a mottled pink or white dry surface and may blister. These wounds are difficult to assess during the first 3 days. Scarring is common and skin grafting is often required.
- **Full-thickness burns** represent total destruction of all elements of the skin. They have a white, red or charred and dry appearance and are insensitive to pain. Functional and cosmetic results of healing are usually unsatisfactory, and skin grafting is inevitably required.

4.4.2 Initial management

- ▶ Proper management early on can make a major difference. At the scene, remove smouldering hot clothing and cool the burn wound with tap water (15–18°C) for 20–30 minutes. Do not apply any oily substances. Chemical burns should be washed with copious volumes of water. The wounds can be covered with plastic wrap or a clean cloth.
- ▶ Tar, asphalt and melted plastics can be very difficult to remove. These materials can retain heat for a very time, so the wounds should be cooled with tap water as quickly as possible. Liquid paraffin is useful for dissolving the foreign material out of the burn wound.
- ▶ Consider whether the patient may also have a respiratory injury. If there is evidence of respiratory distress (stridor or tachypnoea), provide supplemental oxygen.

Warning!

Severe facial burns and inhalational injuries may require intubation or tracheostomy (rarely). Intubation is better done early rather than later.

- ▶ Protect the wound, maintain the body temperature and start IV fluids if required.
- ▶ Admit any child with burns affecting more than 10% of their body surface or that involve the face, hands, feet or perineum or across joints. Children with burns that are circumferential, neonatal burns, inhalation injury, the result of abuse, electrical and chemical burns and those that cannot be managed as out-patients should also be admitted.

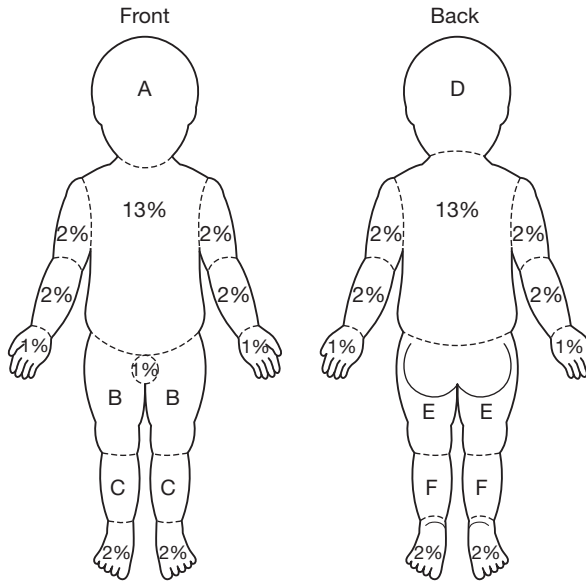
Warning!

Urgent escharotomy should be considered if the circulation distal to the burn (extremities) is compromised (see Section 4.4.4).

4.4.3 Fluid resuscitation

Inadequate fluid resuscitation is a common cause of death in burns patients in low- and middle-income countries. Fluid requirements are estimated according to the percent burn and the child’s weight. The percent body surface burned can be estimated using Figure 4.5. Alternatively, the patient’s open hand represents approximately 1% of the total body surface area.

Fluid resuscitation is required for burns that affect more than 15% of the total body surface area. The fluid required should be calculated from the time of the burn. The initial resuscitation should occur over the first 48 hours.



Area (front/back)	Age in years			
	0	1	5	10
Head (A / D)	10%	9%	7%	6%
Thigh (B / E)	3%	3%	4%	5%
Leg (C / F)	2%	3%	3%	3%

Figure 4.5 Estimation of percentage of body surface area in children of different ages. Add the percentages of body areas A–F affected, noting the different contributions that these body zones make to surface area at different ages. (Adapted from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

First 24 hours

- ▶ Resuscitation fluid is determined as 4 mL/kg per % burn. For example, the resuscitation fluid for a 20 kg child with a 30% burn would be: $4 \times 20 \times 30 = 2400$ mL.
- ▶ Administer half of the total fluid in the first 8 hours following the burn and the remainder in the next 16 hours. The resuscitation fluid should be a balanced salt solution (Ringer's lactate or equivalent).
- ▶ If the patient is in shock, give 10 mL/kg boluses until haemodynamically stable and producing adequate urine.
- ▶ Maintenance fluid should be calculated separately and be given in addition to the resuscitation fluid (see Appendix 2).

Second 24 hours

- ▶ Give half to three-quarters of the fluid required during the first day.
- ▶ Monitor the patient closely during resuscitation (pulse, respiratory rate, blood pressure and urine output). Urine output is the best indicator of response to fluid therapy and should be at least 1 mL/kg per hour (1.5–2 mL/kg per hour in small children; see Appendix 1). Blood may be given to correct anaemia or for deep burns to replace blood loss.

4.4.4 Decompression incision (escharotomy)

Circumferential burns to the extremities and chest may compromise blood flow to the extremities and impair respiration. Oedema accumulates under the rigid burned skin and acts as a tourniquet, obstructing normal circulation and restricting respiration.

An escharotomy is a longitudinal incision of full-thickness burned tissue to permit expansion of the underlying viable tissue. It should be considered part of the resuscitation and should be performed as soon as possible to avoid irreversible ischaemic damage to tissue, and/or to permit adequate chest excursion and ventilation. Escharotomy should be considered in the following situations:

- a circumferential full-thickness burn of any limb, finger or the chest
- rigidity of the chest wall that compromises ventilation
- diagnosis of compartment syndrome
- deep pain of the affected area at rest
- pain on passive movement
- loss of distal circulation (pallor, delayed capillary refill, loss of palpable pulses)
- numbness in an extremity
- decreased oxygen saturation on pulse oximetry in an isolated extremity.

Recommended escharotomy incisions are shown in Figure 4.6. The decompression incision must be deep enough to release the tight tissue but not so deep as to cause extensive bleeding or injury to vital structures (e.g. nerves and blood vessels).

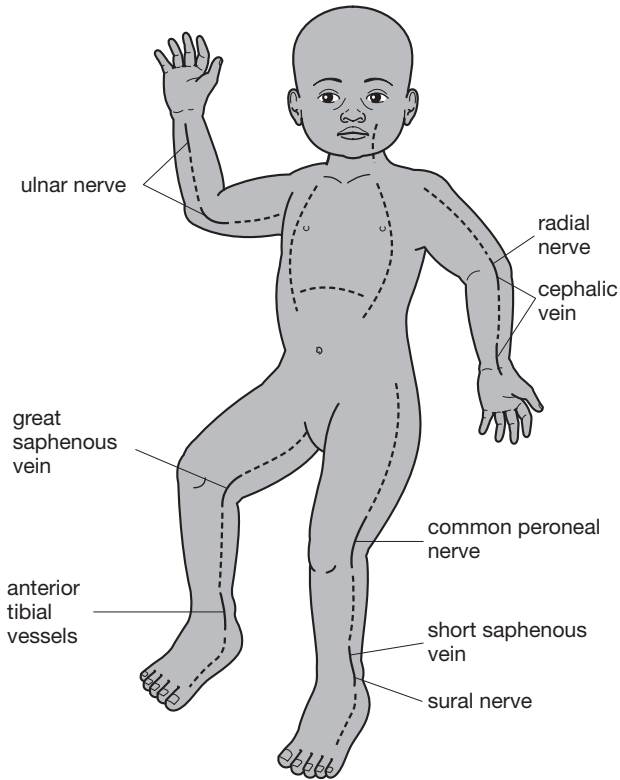


Figure 4.6 Incision sites for emergency escharotomy. Be careful to avoid the labelled structures.

4.4.5 Preventing infection

It is important to use clean/sterile methods to prevent contamination and subsequent colonization and invasion of the burn wound by bacteria.

- ▶ The patient should be showered or washed daily and appropriate topical antiseptic applied. Smaller wounds can be treated in a ward environment; for larger burn wounds, dressings should be changed under general anaesthesia.
- ▶ Check tetanus vaccination status. If the child has not been immunized, give tetanus immunoglobulin. If immunized, give tetanus toxoid booster if due.
- ▶ Infection in the burn wound is suggested by pus, foul odour or presence of cellulitis. If the infection is localized to the burn wound, treat with oral antibiotics.
- ▶ If septicaemia is suspected, use IM/IV antibiotics according to bacterial sensitivity pattern.
- ▶ If infection is suspected beneath an eschar, remove it.

4.4.6 Pain control

This is of great importance and should be given on a regular basis for the acute injury, during dressing changes and for chronic pain. See Section 1.8 (page 22) for suggestions on pain management.

4.4.7 Nutrition

Begin feeding after the period of resuscitation is completed. Children should receive a high-calorie diet containing adequate protein, vitamins and iron supplements. Extensively burned children require about 1.5 times the normal calories and 2–3 times the normal protein requirements. Children with burns of more than 20% body surface require aggressive nutritional support (see Section 1.7 [page 19]).

4.4.8 Methods for managing burns

Small superficial burns

Administer analgesia. Initial management consists of gentle and thorough cleansing of the wound and removal of any debris left by combustion and the accident, debridement of loose non-viable tissue, and application of a sterile dressing or topical therapy to prevent infection. Carefully debride the burn wound if the skin is not intact. Blisters should be pricked and dead skin removed. Apply topical antiseptic; several options depending on resources are available: silver sulfadiazine, gentian violet, betadine and even papaya can be used. Clean and dress the wound daily.

In hot and humid areas, burns can also be treated using the exposure method shown in Figure 4.7. The burn wound is cleaned and then left open to the air to dry out.



Figure 4.7 The exposure method for managing burns. (Adapted from *Primary Surgery Volume 2: Trauma*, MH King, Oxford University Press, 1987.)

4 Injuries

The room should be warm and moist (40°C and 40% relative humidity is ideal). The child's temperature must be monitored to ensure they do not become cold. If necessary, close the windows and put a heater beside the patient (electric fan heaters are the best). Leave the burn alone. Do not prick the blisters unless they are tense and painful. By the seventh day you should be able to determine if the burns are superficial or full thickness.

Full-thickness burns

These are best managed with early excision and grafting once the patient has been stabilized. The status of the patient, burn size, availability of donor skin and anticipated blood loss should determine the size of the excision. Alternatively, if resources are not available for early excision, the wound can be allowed to develop a surface of granulation tissue, which may take 3–4 weeks, and can then be grafted.

4.4.9 Burn contracture

Burn scars across flexor surfaces contract as they heal. This happens even with the best treatment, and is almost inevitable with poor treatment.

- ▶ Prevent contractures by passive mobilization of the involved areas and by splinting flexor surfaces. Splints can be made of plaster of Paris. Splints should be worn at night. Figure 4.8 shows some of the splinting positions to prevent contractures.

Section 9.3 (page 231) describes the treatment of burn contractures.

4.4.10 Physiotherapy and rehabilitation

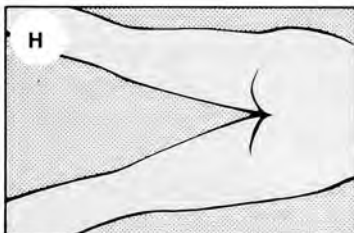
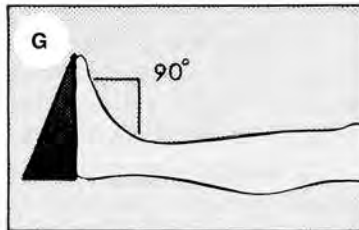
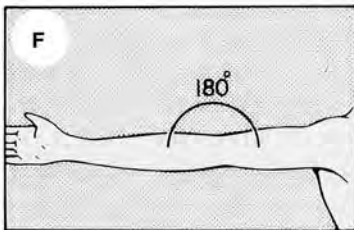
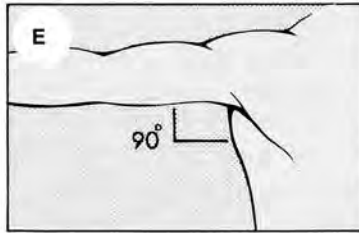
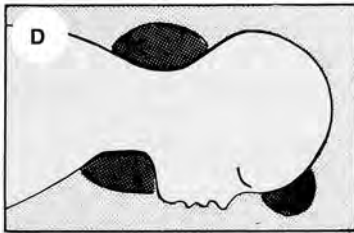
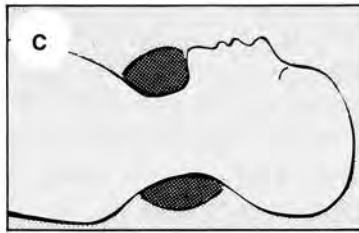
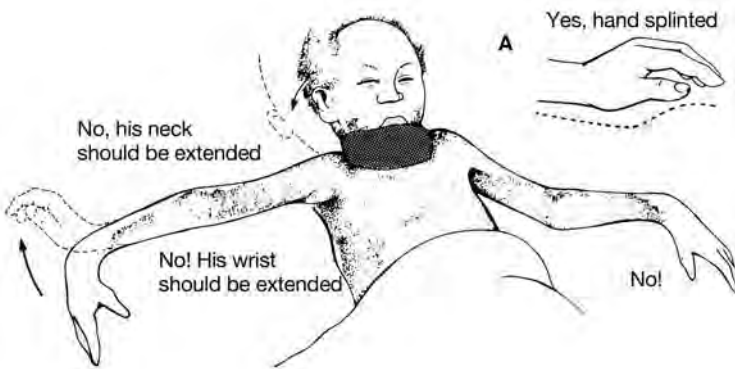
Physiotherapy should begin early and continue throughout the course of burn care. If the child is admitted for a prolonged period, ensure they have access to toys and encourage them to play.

4.4.11 Advice for parents

Inform the parents about the severity of the burns and the plan for care. If the burns are severe, be realistic about the expected outcome.

Indications for referral

Burns are usually stable immediately after an injury. If transfer is anticipated, do it as soon as possible.



(B–D) Nurse a burnt neck in extension either on a pillow or with a collar in place. (E) If the axilla is burnt, abduct the arm to 90 degrees. (F) If the antecubital fossa is burnt, extend the elbow. (G) Keep a burnt ankle at 90 degrees. (H, I) Keep burnt hips and knees straight. If the popliteal space is burnt, the patient should keep their knee straight for several months after discharge. (Adapted from *Primary Surgery Volume 2: Trauma*, MH King, Oxford University Press, 1987.)

Figure 4.8 (A) Nursing positions to prevent burn contractures. Failure to follow these simple procedures is one of the most common errors in treating burns.

▶▶ 4.5 Fractures

Key points ◀◀

- ◆ Fractures are common in children. Proper management can make the difference between complete recovery and lifelong disability.
- ◆ Displaced fractures, open fractures and those involving the growth plate are most likely to have a complication.
- ◆ Always check for a pulse and do a neurological examination in an injured extremity to exclude vascular and nerve injury.

There are a number of differences between fractures in the immature skeleton compared with that of the adult, which have implications for the pattern of fractures, ability to remodel, healing time and risk of growth disturbance.

4.5.1 Fracture patterns in children

Children's bones are less brittle than adult bones, resulting in several unique fracture patterns (Figure 4.9).

- The **torus** (buckle) fracture involves 'wrinkling' of the bone on one side, and is a stable injury.
- A **greenstick** fracture represents an incomplete fracture.
- The '**compression**' **greenstick** pattern occurs when only one cortex is broken and the other cortex is intact. These fractures tend to have rotational

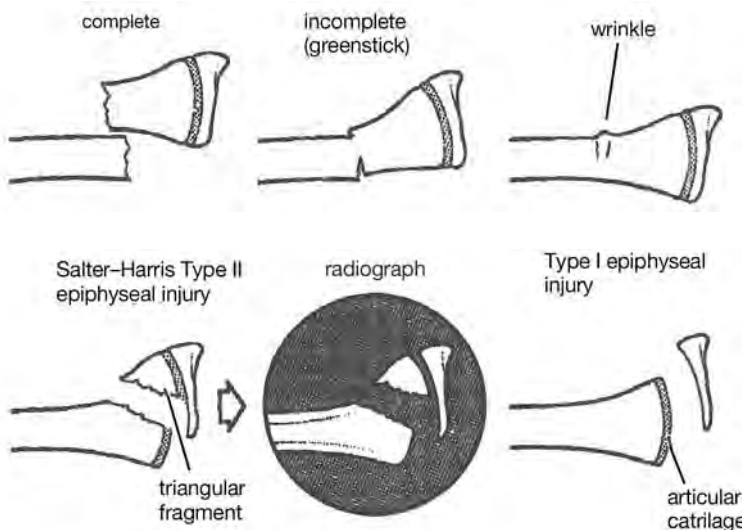


Figure 4.9 Common types of childhood fractures.

misalignment and/or angulation, without displacement. They are generally stable once reduced.

- The **'tension' greenstick** fracture includes a non-displaced fracture of the opposite cortex and is prone to angulation during treatment.
- In a **plastic deformation** injury, the bones have angulation with or without rotational misalignment, but there is no fracture line.
- **Physeal fractures** involve the growth plate; variations are described in the Salter–Harris classification (Figure 4.10). The risk of growth disturbance is highest with Types III, IV and V injuries.

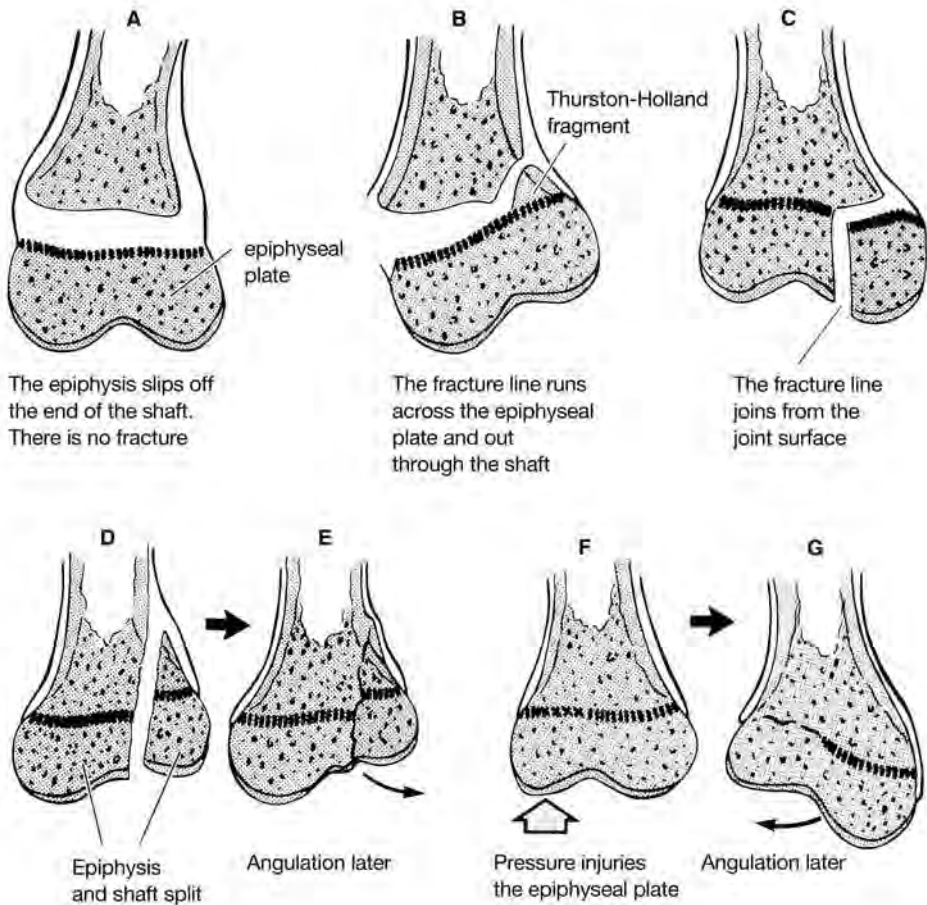


Figure 4.10 The Salter–Harris classification of growth plate injuries. (A) Type I injuries extend through the physis. (B) Type II fractures course through the physis and exit the metaphysis, resulting in a triangular wedge of bone (Thurston–Holland fragment). (C) Type III fractures extend along the physis and then into the joint. (D and E) Type IV fractures extend from along the physis and then into the joint. (F and G) Type V injuries, in which the end of the bone is crushed and the growth plate compressed, are rare; premature stunting of growth is almost inevitable.

4.5.2 Diagnosis

- When assessing a child for a possible fracture, ask three questions:
 - Which bone may be broken?
 - Is the fracture open?
 - Is there an associated nerve or vascular injury?
- Findings suggestive of a fracture include pain, soft-tissue swelling, deformity and crepitus. A careful neurovascular examination is mandatory. Plain radiographs provide detailed information on the site and nature of the fracture. Two views of the fracture (anteroposterior and lateral) should be obtained. Always include the joints proximal and distal to the fracture.
- Growth plates can be confused with fractures. If there is a question about the timing of growth plate closure, take a radiograph of both the injured and uninjured extremities to compare the injured side with the normal side.
- Fractures can be closed (where the skin is intact) or open (where there is a wound to the skin). Suspect an open fracture if there is an associated wound. Open fractures require antibiotics (cloxacillin and gentamicin) and meticulous cleaning to prevent osteomyelitis.

Warning!

Open fractures may lead to serious bone infection.

- Always examine the involved extremity for evidence of a vascular or neurological injury. Compare the extremity pulse with the opposite side. Even with a fracture it should be possible to assess whether sensation and motor function are intact. Children are particularly prone to vascular spasm. When a vascular injury is suspected, reassess the patient once the fracture has been reduced.
- Fractures with the highest risk for complications include displaced fractures, open fractures and those involving growth plates.

4.5.3 Closed fractures

Most closed fractures in children can be managed without surgery. The periosteum is well developed in children, allowing a closed reduction to be performed in the majority of cases. The remodelling potential is greatest when the fracture is close to a joint and if the deformity is in the plane of motion of that joint. Rotational deformities do not remodel, so any rotational misalignment must be corrected at the time of injury.

- ▶ A well-padded splint should be the initial treatment, especially when significant swelling is present. Apply soft roll, followed by plaster slabs, extending one joint above and one joint below the fracture. The splint will decrease the risk of complications from soft-tissue swelling that may occur if a full cast is applied, and provides stability and comfort until it is safe to proceed with definitive treatment.

- ▶ Fractures with significant displacement or angulation will require a closed reduction for the best outcome. This may be performed after a haematoma block (local anaesthetic injected into the fracture site), regional anaesthesia (nerve block), IV sedation (ketamine or other agents) or under general anaesthesia. The acceptable limits for reduction are based on remodelling potential (age and other variables) and have been outlined for the majority of fractures.
- ▶ After the swelling has subsided the fracture can be stabilized with a circumferential plaster-of-Paris cast. Fractures of the growth plate with unacceptable alignment should be reduced within 7–10 days to limit the possibility of growth disturbance from manipulation.
- ▶ Indications for surgical treatment include an open fracture, unstable or irreducible fractures, certain physeal fractures, and some fractures associated with neurovascular injury. Physeal fractures that extend into the joint (Salter–Harris Types III and IV) must be reduced anatomically to achieve the best outcome – an open reduction and internal fixation are usually required.
- ▶ Fractures heal more quickly in children than in adults, so a shorter period of immobilization is required. Either skin (smaller children) or skeletal traction may be used to treat selected fractures, most commonly of the femur. A traction wire may be inserted under local anaesthesia supplemented by sedation. Surgical fixation with implants is required when the fracture cannot be held in an adequate position using other means. If the fracture can be reduced by manipulation but remains unstable, percutaneous fixation with simple and inexpensive implants such as Kirschner wires or Steinmann pins may provide adequate stability when supplemented by a cast. Open reduction and internal fixation, especially with plates and screws, should be avoided if possible, given the higher risk of infection at the primary referral hospital.

Figures 4.11–4.15 describe simple methods for treating some of the most common closed fractures of childhood.

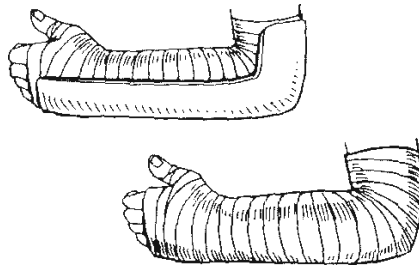


Figure 4.11 Splints. The limb is first wrapped with a soft padding (e.g. cotton), and then a plaster-of-Paris splint is placed to maintain a neutral position. The posterior splint is held in place with an elastic bandage. These can be used for injuries to the arms or legs. Monitor the fingers or toes for capillary refill and temperature to ensure that the splint is not too tight. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

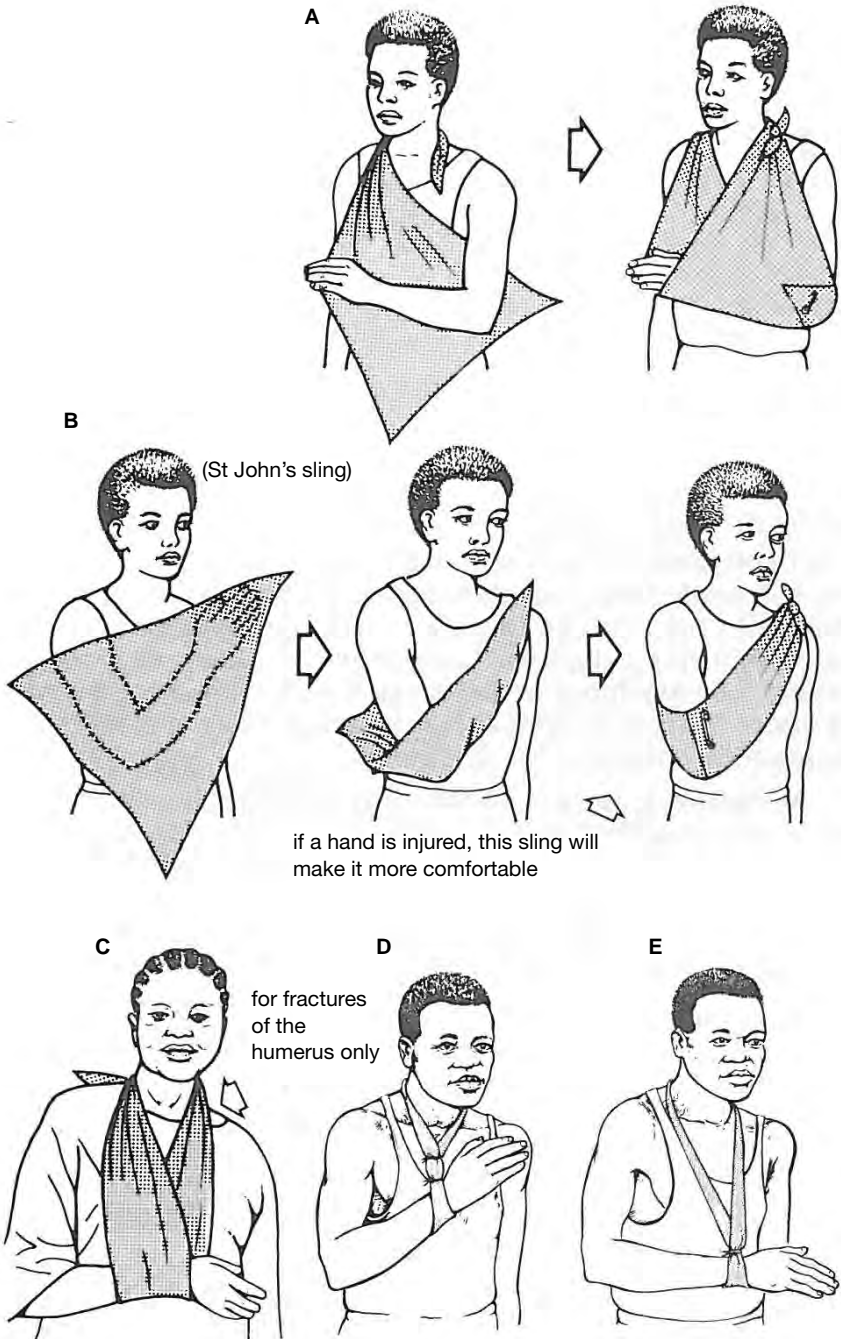


Figure 4.12 Slings for supporting an injured arm. (A) Standard sling for an injured arm; (B) St John's sling for an injured hand – note that the hand is elevated; (C) sling for a fractured humerus, with the elbow hanging free; (D and E) sling for a supracondylar fracture to keep the elbow fixed. (Adapted from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

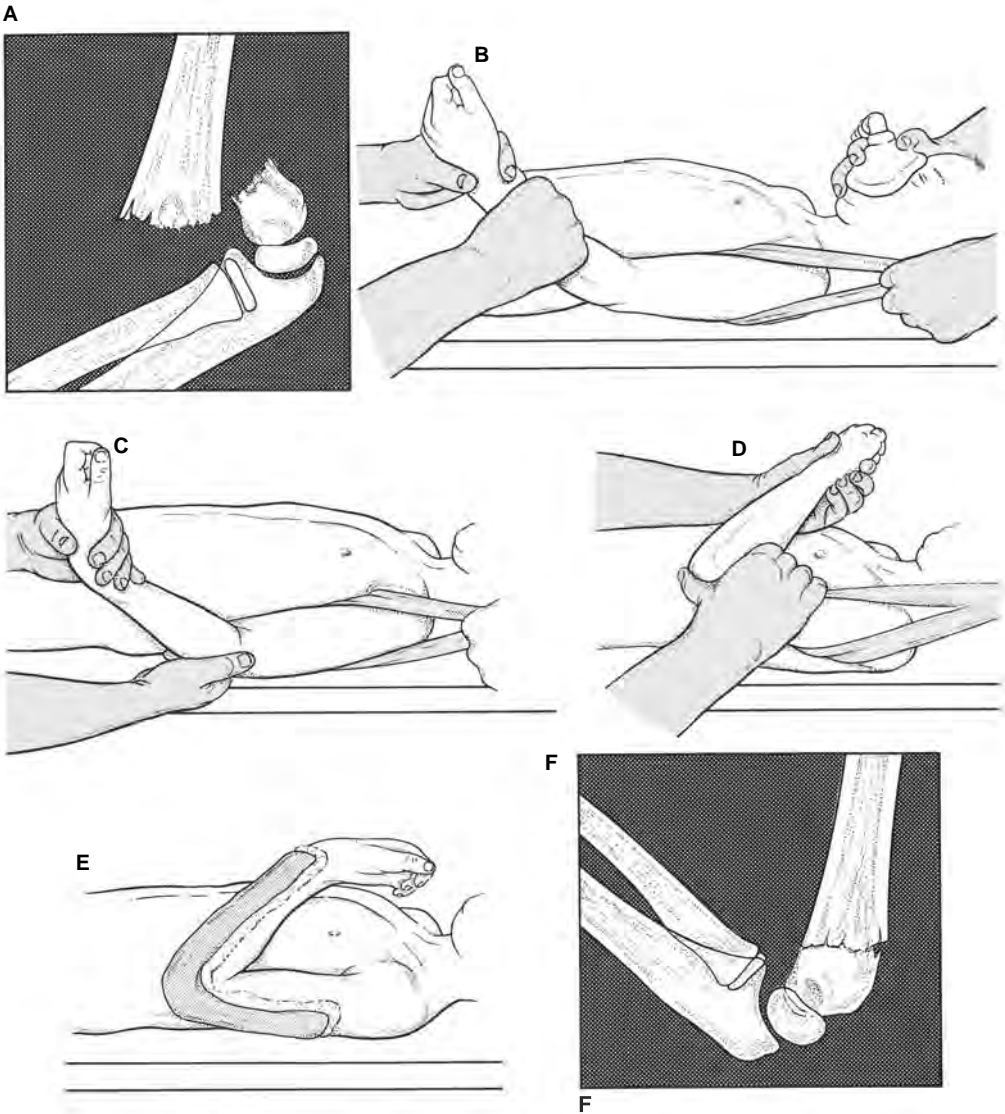


Figure 4.13 Principles of reducing a supracondylar fracture: (A) Radiograph showing a supracondylar fracture; (B) Exert traction on the child's elbow, (C) Correcting the sideways displacement of the distal fragment; (D) When reduced, flex the arm while still exerting traction; (E) Apply a posterior splint; (F) Radiograph of a reduced supracondylar fracture. An important complication of this fracture is constriction of the artery at the elbow, where it can become entrapped. If the artery is obstructed the hand will be cool, capillary refill will be slow and the radial pulse will be absent. If the artery is obstructed, reduction needs to be done urgently. Always confirm that a pulse is present after the fracture is reduced. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

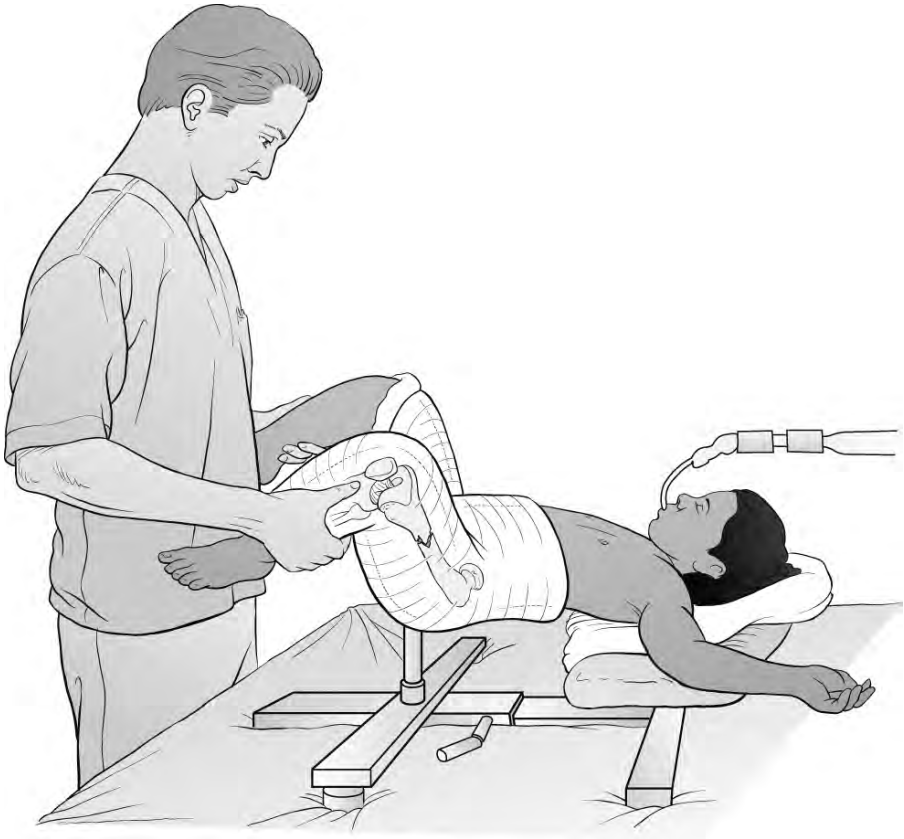


Figure 4.14 Spica casting is the treatment of choice for nearly all femur fractures in children less than 6 years of age. Skin traction (Figure 4.15) is an acceptable alternative if casting material is not available.

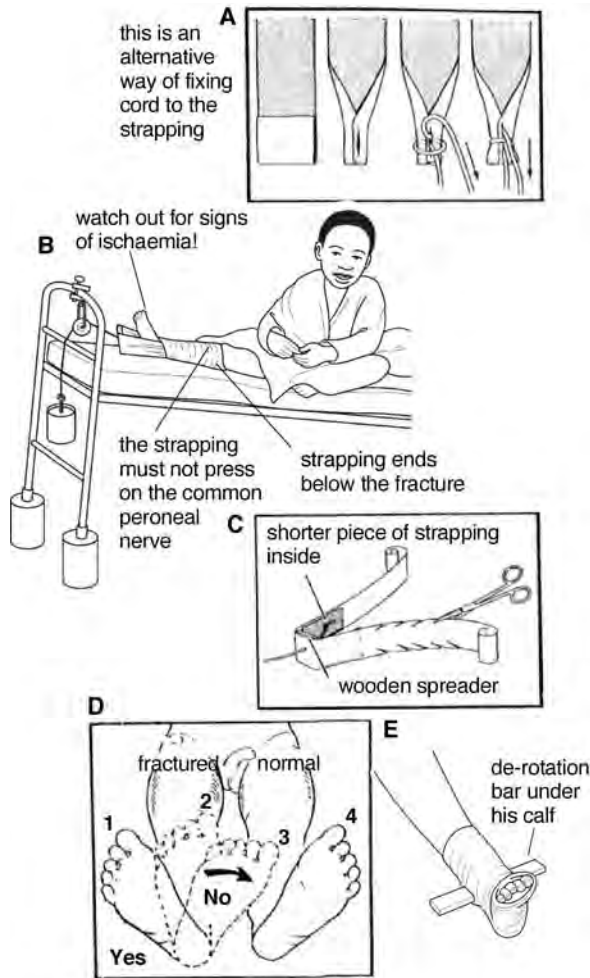


Figure 4.15 Lower-extremity traction for fractures of the femur. (A) Skin traction may be applied with weights up to 4–5 pounds, and is useful in smaller children with fractures of the femur. Skeletal traction is used when greater weights are required; a smooth or threaded wire is first placed through the distal femur (proximal to the physis, parallel to the joint line). (B) Balanced skeletal traction is most commonly used. If the child can raise his or leg off the bed, the fracture has united and the patient is ready for ambulation on crutches (usually after about 3 weeks). (C) Fixing a wooden spreader to the strapping. (D, E) Try to make the patient's injured leg match the normal one. Sometimes, a de-rotation bar is needed; note that the de-rotation bar lies under the ankle not on the heel. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

4.5.4 Open fractures

- ▶ Open fractures require prophylactic antibiotics, typically a first-generation cephalosporin or cloxacillin for 24 hours. Additional antibiotic treatment is given only in the presence of established infection. The risk of infection depends on the wound contamination, the time between injury and treatment, and the amount of damage to the bone and surrounding tissues. Open fractures from high-energy injuries in which there has been fragmentation of bone and soft-tissue damage have the highest risk of infection.
- ▶ A thorough wound exploration, with irrigation and debridement of any devitalized tissue, is essential to prevent infection. Several litres of fluid should be used if available to enhance the mechanical cleansing of the tissues. Effective irrigation solutions include sterile saline, distilled water and even boiled water. For small wounds that have no gross contamination, exploration is performed by surgically extending the wound by 1–2 centimetres on each side and removing any bone/debris or dead tissue. The wound is left open to drain.

Warning!

All open fractures require wound exploration with irrigation and debridement of devitalized tissue to prevent serious bone infection.

- ▶ On many occasions the patient should be brought back to the operating room after 24–48 hours for a second irrigation and debridement, especially if there are concerns regarding the viability of the soft tissues at the margins of the wound. Fracture stabilization is often delayed until this ‘second look’. When the soft-tissue damage is more extensive and the wound is grossly contaminated, more than one irrigation and debridement is suggested, and patients often require additional surgical procedures to achieve wound coverage and to stabilize the fracture. In severe cases additional surgery is also required to treat bony defects or other complications of the injury.
- ▶ An external fixator may be applied to temporarily (or definitively) stabilize fractures with significant soft-tissue injury and to allow access to the wound for dressing changes. Open fractures associated with vascular injury are particularly difficult to manage; if facilities for revascularization are not available, a primary amputation must be considered. The most effective strategy for many open fractures (especially the most severe) at the primary referral hospital is to perform an emergent and thorough irrigation and debridement, and then to refer the patient to a higher level of service.

4.5.5 Compartment syndrome

This occurs when the soft-tissue swelling in a muscle compartment is so severe that it impairs the blood supply to the muscle.

- Compartment syndrome should be suspected when there is increasing pain despite appropriate immobilization or definitive fracture stabilization, or pain that is out of proportion to what would be expected for a given injury. The muscle compartments are tense to palpation, and there is pain with passive stretch of the muscles in the compartment.

Warning!

Compartment syndrome requires emergency surgery to prevent irreversible muscle damage.

- Findings such as neurologic dysfunction (tingling, decreased sensation) or evidence of decreased vascular flow (decreased pulse/capillary refill) occur late in the process, after irreversible damage has occurred. The most common sites for a compartment syndrome are in the lower leg (tibia) and the forearm.
- ▶ The treatment is emergency surgical release of the involved compartments, as permanent damage to muscle (necrosis) can occur after 4–6 hours. For the lower leg, longitudinal incisions on both the medial and lateral side are used to decompress all four compartments, and the wounds are left open. The patient returns to the operating room for further inspection/irrigation, and a skin graft is usually required to achieve coverage. Any dead tissue must be debrided. Amputation may be required to salvage the limb, particularly if a coexisting infection occurs.

Indications for referral

If possible, have children with high-risk fractures (displaced fractures, open fractures and those involving the growth plate) evaluated by someone with orthopaedic experience.

▶▶ 4.6 Head injuries

Key points

- ◆ The priority for managing a child with a head injury is to resuscitate the patient to prevent further brain injury.
- ◆ Every child with a head injury should have their Glasgow coma scale (GCS) score calculated.
- ◆ A decrease in the patient's GCS, change in pupil size or weakness on one side of the body suggests increasing brain swelling that may require emergency surgery.

Head injuries are common in children. The basic principles of managing head injuries in adults also apply to children. However, there are some important differences.

4.6.1 Differences between children and adults

- Children with severe head injuries generally do better than adults. However, children less than 3 years old have a poorer outcome than older children.
- Unlike adults, it is possible for young infants to become hypotensive from a head injury. This can occur because a large amount of the child's blood volume can collect in the subgaleal, epidural or subdural spaces.
- Young children have an open fontanelle and mobile cranial sutures and can therefore tolerate a greater increase in intracranial pressure. A bulging fontanelle in a child with open sutures after head injury suggests a serious head injury.
- Children commonly develop vomiting and memory loss after head injury, but this does not necessarily imply a severe injury. Seizures following head injuries in children are usually self-limiting. Children also tend to have fewer focal mass lesions than adults.

4.6.2 Types of head injuries

When a child injures the head, a number of structures can be damaged.

- **Skull fractures** can be closed, depressed or open. An open skull fracture needs to be excluded in any patient with a scalp laceration. The simplest way to exclude a skull fracture is to explore the wound carefully with a gloved finger. A depressed fracture (Figure 4.16) occurs when the fracture is pushed inwards; the bone fragments may compress the brain.

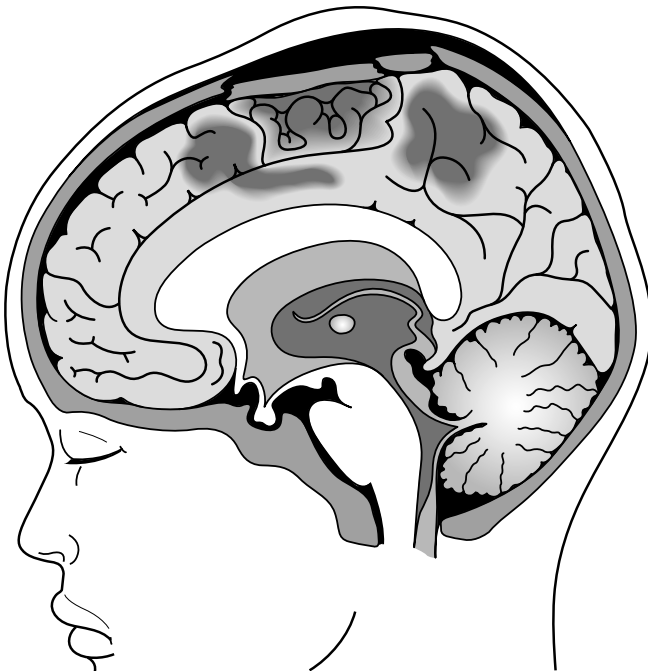


Figure 4.16 Depressed skull fracture. The fragments of bone may cause pressure on the brain.

- **Brain injuries** fall into three categories (3 Cs):
 - **Concussion** – the mildest injury where loss of brain function is temporary.
 - **Contusion** – the brain is bruised; brain function may be affected for hours to days, or even weeks.
 - **Compression** (Figure 4.17) may result from generalized swelling of the brain or from an enlarging collection of blood; there is loss of brain function as the pressure inside the head increases.
- Two types of bleeding can occur inside the head – arterial and venous. Arterial bleeding results in a rapid rise in intracranial pressure whereas the increase is more gradual with a venous bleed. Urgent surgery may be required if blood is compressing the brain.
- Increasing intracranial pressure should be suspected when there is deterioration in the patient’s neurological status, change in pupil size or weakness on one side of the body.

Warning!

An enlarging collection of blood in the head compresses the brain and can be fatal.

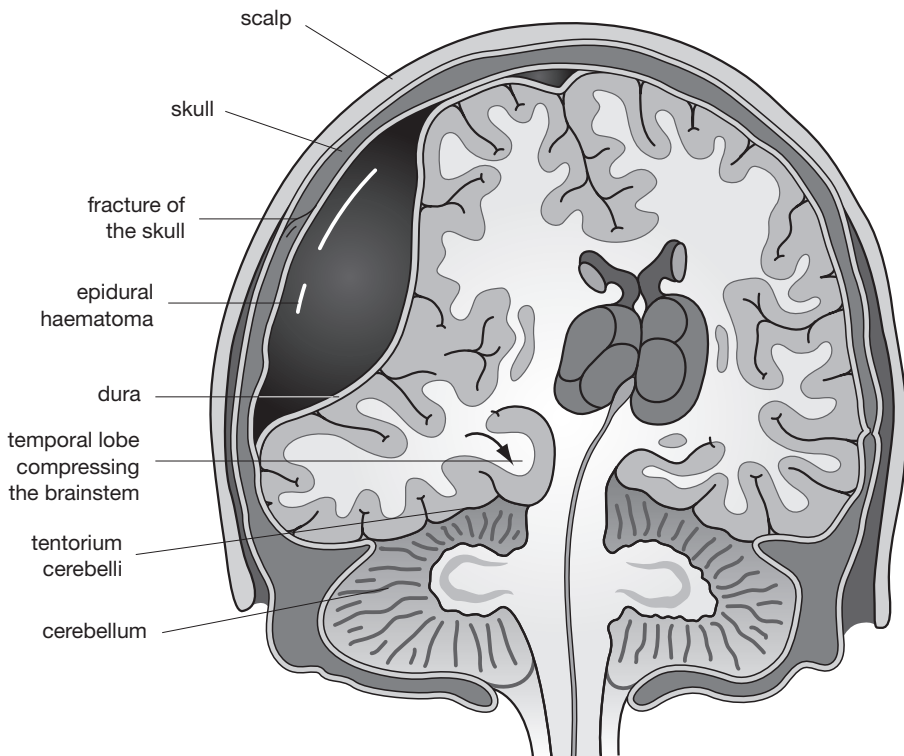


Figure 4.17 Epidural haematoma. The expanding collection of blood compresses the brain.

4.6.3 Diagnosis

- The history of the injury is important. Ask about the mechanism of injury and whether there was loss of consciousness, confusion and/or seizures. Remember that loss of consciousness can be caused by problems other than head injuries (e.g. cerebral malaria, meningitis).
- With respect to the head, look for signs of external injury (abrasions and haematoma). Palpate for skull fractures. Look in the ears, eyes and mouth.
- Calculate the GCS (Table 4.2) The GCS is a simple but valuable method for assessing and following the severity of a head injury.
- In an infant with an open fontanelle, ultrasound can be useful to determine whether a collection of blood is present.

4.6.4 Treatment

- ▶ The priority for managing a child with a head injury is to resuscitate and prevent further brain injury. This is done by ensuring an adequate airway and resuscitating the patient properly.
- ▶ Make the patient nil by mouth.
- ▶ Protect the airway.
- ▶ Use maintenance fluid unless the child requires more fluid for resuscitation because of other injuries.
- ▶ Elevate the head of the bed to 30 degrees.
- ▶ Diagnose and treat other injuries.
- ▶ In selected cases (patients with epidural or subdural collections), creation of burr holes may be a life-saving intervention. The decompression afforded by burr holes may provide the time required to transfer the patient for definitive management. The person doing the burr holes must have the necessary equipment and expertise.

4.6.5 Advice for parents

Explain to the parents that it is often difficult to know the outcome of head injuries shortly after the injury.

Indications for referral

Severe head injuries require specialized care. Consider transfer if the patient can be cared for better at another facility.

Table 4.2 The Glasgow coma scale (GCS)

Add the scores for the best eye response, best verbal response and best motor response. A GCS score of 15 is normal. A score below 8 indicates a severe head injury.

Eye opening score			
Score	Under 1 year		Over 1 year
4	Open spontaneously		Open spontaneously
3	Open to verbal stimuli		Open to verbal stimuli
2	Open in response to pain		Open in response to pain
1	No response		No response
Motor score			
Score	Under 1 year		Over 1 year
6	Spontaneous movement		Obeys commands
5	Localizes painful stimulus		Localizes painful stimulus
4	Flexion/withdrawal to painful stimulus		Flexion/withdrawal to painful stimulus
3	Abnormal flexion to painful stimulus		Abnormal flexion to painful stimulus
2	Extension to painful stimulus		Extension to painful stimulus
1	No response		No response
Verbal score			
Score	0–23 months	2–5 years	Over 5 years
5	Smiles or coos appropriately	Appropriate words or phrases	Oriented and conversive
4	Cries but consolable	Inappropriate words	Disoriented and conversive
3	Persistent inappropriate crying and/or screaming	Persistent cries and screams	Inappropriate words
2	Grunts, agitated or restless	Grunts	Incomprehensible sounds
1	No response	No response	No response

▶▶ 4.7 Eye injuries

Key points ◀◀

- ◆ Although many eye injuries are minor, if not treated quickly and appropriately they can lead to blindness.
- ◆ Examine the eye and the area around the eye in a systematic manner. The examination should include a careful assessment of vision, eye movement, pupillary reactions, conjunctiva, sclera, cornea, anterior chamber, lens and retina.

Trauma to the eye is common and often associated with other injuries.

4.7.1 Diagnosis

- A basic examination of the eye can be done with relatively little equipment. A basic eye examination kit should include:
 - a bright penlight torch with convergent beam and blue filter
 - units of sterile single-dose preservative-free eye drops
 - fluorescein (a specialized dye that stains the cornea and highlights any irregularities of its epithelial surface)
 - local anaesthetic (Minims benoxinate (oxybuprocaine) HCl 0.4%)
 - a short-acting mydriatic (tropicamide) to dilate the pupil
 - magnifier (preferably ×8 magnification factor)
 - hand-held ophthalmoscope
 - bent paperclip to retract the eyelids.
- Document the time and mechanism of the eye injury.
- Examine the area surrounding the eye. Are there facial fractures, eyelid involvement, fractures of the orbital rim, lacerations, or abnormalities in ocular movement? Abnormalities in eye movement suggest muscle entrapment or paralysis.
- Examine the eye. If the eyelid is swollen it will be necessary to instill local anaesthetic (Minims benoxinate HCl 0.4%); use a bent paperclip to expose the globe (Figure 4.18).
 - **Vision:** ask an older child to count fingers.
 - **Eye movement:** observe how the eye moves when the child looks up, down and to the sides.
 - **Pupillary reactions:** compare with the normal eye for size and shape.
 - **Conjunctiva:** check for haemorrhage and lacerations.
 - **Sclera:** look for dark-brown areas indicating prolapsed uveal tissue.

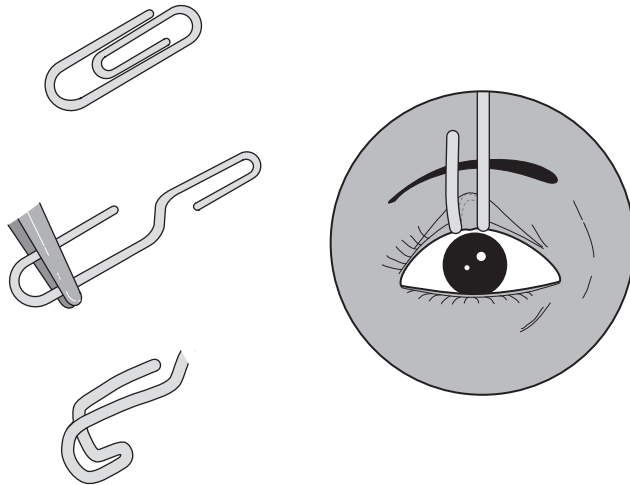


Figure 4.18 Use of a bent paperclip to retract the eyelid.

- ❑ **Cornea:** check for lacerations and ulcers. Examine the eye with a blue light after a drop of fluorescein has been placed into the eye. A corneal abrasion will appear as a roughened area on the surface of the cornea.
- ❑ **Anterior chamber:** the anterior chamber should be clear. Blood and pus in the anterior chamber can make this area appear cloudy.
- ❑ **Lens:** cloudiness of the lens suggests a cataract.
- ❑ **Retina:** inspect the optic disc and blood vessels. Inability to see the optic disc suggests intraocular bleeding or other damage.

4.7.2 Treatment

The following describes the treatment for the most common types of eye injuries.

Foreign body

- ▶ Apply topical anaesthesia. Remove the foreign body gently using magnification under good lighting.
- ▶ Foreign bodies of the cornea should be removed as soon as possible, as the cornea will quickly grow over the foreign body.
- ▶ Apply antibiotic eye ointment.
- ▶ Examine the eye on the following day to ensure that the problem has resolved.

Corneal scratch

- ▶ Examine the eye with fluorescein to determine whether the cornea has been damaged.

4 Injuries

- ▶ If there is damage to the surface of the cornea, apply antibiotic eye ointment three times a day for 3 days.
- ▶ Minor corneal abrasions should heal within 24–48 hours. More extensive or deeper abrasions may take up to a week to heal.

Blood inside the eyeball (hyphema)

- ▶ Ensure there are no other eye injuries.
- ▶ Patch both eyes.
- ▶ The child should stay in bed for 5 days.
- ▶ Refer if the eye is not clear after this time.

Lid laceration

- ▶ Check the eye for other injuries.
- ▶ Apply a sterile dressing and shield.
- ▶ Give intravenous antibiotics (cloxacillin and gentamicin).
- ▶ Refer immediately to an eye specialist.

Burns (chemical or thermal)

Burns to the eye may affect the eyelids, conjunctiva or cornea. It is important to keep the cornea moist and free from exposure.

- ▶ The priority for managing a burn of the eye is immediate and profuse irrigation with clean water after instilling local anaesthetic drops. Pour water into the eye.
- ▶ Apply antibiotic eye ointment generously all over the conjunctiva, cornea and burned eyelids.
- ▶ Acid injuries have a better prognosis than alkali injuries.
- ▶ Avoid using an eye pad, as it might ulcerate the cornea.
- ▶ Refer immediately to an eye specialist.

Warning!

Alkalis (e.g. household ammonia) can seriously damage the eye. Children with alkali injuries should be referred immediately to an eye specialist.

Perforation of the eye

- ▶ Do not use drops or ointments.
- ▶ Cover the eye with a protective shield. Do not use eye pads, to avoid any pressure on the eye.
- ▶ Give intravenous antibiotics (cloxacillin and gentamicin).

- ▶ Do not attempt to remove a penetrating foreign body.
- ▶ Refer immediately to an eye specialist.

Indications for referral

- Refer any minor eye problem that does not respond to treatment to an eye specialist.
- Children with burns to the eye, suspected perforation or lid lacerations should be referred to an eye specialist.

▶▶ 4.8 Chest injuries

Key points

- ◆ The most common chest injuries in children are rib fractures, pneumothorax, haemothorax and pulmonary contusion.
- ◆ Chest injuries are frequently associated with other injuries. Approximately two-thirds of children with a chest injury will have another organ injury.
- ◆ Most chest injuries in children can be treated with simple procedures.

4.8.1 Differences between children and adults

The majority of chest injuries in children are due to blunt trauma, including falls, assault and road traffic accidents. The following are some of the differences in chest injuries in children compared with adults.

- Because a child's chest is more pliable than that of an adult, it is possible to have a major lung injury (e.g. pulmonary contusion or intrapulmonary haemorrhage) or a mediastinal injury without rib fractures.
- Rib fractures in children suggest that a major force has been transferred to the chest wall and more severe associated injuries should be expected.
- Children are more vulnerable to tension pneumothorax and haemothorax because of the mobility of the mediastinal structures.

4.8.2 Initial management

The priorities for initial evaluation and management are the ABC principles that apply to all trauma patients (see Section 4.1.2, page 76). Thus, establishing and maintaining a clear airway (with cervical spine control) takes priority over all other considerations. Injuries to the chest that directly affect breathing (e.g. tension pneumothorax) must be addressed once the airway is secured.

Whenever possible and following initial resuscitation, a supine chest radiograph should be obtained. This will help to identify common injuries such as simple pneumothorax, haemothorax and rib fractures. If tubes have been inserted (endotracheal tube, chest

tube, nasogastric tube), the chest radiograph is useful to check correct placement. The film may also reveal ominous signs of more severe injuries that may require greater skill and equipment than is readily available at the primary referral hospital.

Warning!

Signs of more serious injuries on chest radiograph include mediastinal air (suggesting oesophageal or tracheobronchial disruption), widened mediastinum (suggesting aortic injury) and bowel contents in the chest (diaphragm injury).

4.8.3 Rib fractures

Rib fractures are relatively uncommon in children, as the ribs are pliable and quite resilient. Rib fractures in children suggest that a major force has been transferred to the chest wall and more severe associated injuries should be expected. Rib fractures in infants and toddlers should raise the suspicion of non-accidental injury.

- ▶ The treatment of rib fractures is to provide adequate rest and analgesia. Attempts to mechanically splint the chest are counterproductive and can increase the risk of pneumonia.

4.8.4 Pneumothorax

Pneumothorax is caused by a blunt or penetrating injury that disrupts the respiratory system, allowing air to escape from the lung tissue or the airway tract into the pleural space. The air collection produces a mass effect that collapses the underlying lung. Pneumothorax should be suspected in a child with breathing difficulty or decreased breath sounds. A chest radiograph can confirm the diagnosis.

- ▶ Place an intercostal drain and attach it to a simple underwater seal bottle (see Section 4.8.8, page 112).

4.8.5 Tension pneumothorax

A tension pneumothorax occurs when accumulation of air in the pleural space is so severe that it pushes the mediastinum and heart to the opposite side of the chest. Signs of tension pneumothorax include diminished breath sounds, tympanic percussion on the involved side, deviation of the trachea and distended neck veins. In addition, the child is often tachycardic and hypotensive because of cardiac compression and impaired venous return. Not all components will be present, however. Immediate treatment is warranted if there is moderate or high suspicion. This problem is relatively simple to treat and often leads to immediate and dramatic improvement.

Warning!

A tension pneumothorax must be decompressed immediately as it can cause cardiac arrest.

- ▶ Treatment of a suspected tension pneumothorax is immediate needle decompression, a simple procedure that can be life-saving. It can be performed with any over-the-needle catheter, such as regular IV catheters. The largest bore catheter available is preferred (18-gauge or larger). However, any catheter size will do and whatever is available should be used.
- ▶ The catheter should be inserted into the pleural cavity through the second intercostal space (just below the middle of the clavicle). A rush of air from the needle is a sign that the tension pneumothorax has been relieved. The needle is then removed but the catheter is left in place and attached to a simple underwater seal bottle.
- ▶ This procedure converts the tension pneumothorax into a simple pneumothorax, which will require placement of chest tube (see below).

4.8.6 Open pneumothorax

This injury is rare in children but can be fatal. It is caused by a chest wound that extends directly into the lung tissue to cause a pneumothorax with direct communication to the skin. Because the intrapleural pressure is lower than the outside (atmospheric) pressure, with each breath the child sucks more air into the pleural space. This produces the characteristic ‘sucking’ chest wound that creates a spiral of increasing intrapleural pressure and lung collapse with each breath. If untreated, a tension pneumothorax can develop.

- ▶ The sucking effect is treated by covering the wound with square gauze taped on only three sides. This creates a flutter valve that allows air to escape with each breath and prevents air entering the chest.
- ▶ A chest tube is inserted to treat the pneumothorax and attached to a simple underwater seal bottle.

4.8.7 Haemothorax

A haemothorax is caused by bleeding into the pleural space from a laceration of the lung, intercostal vessels or mediastinal vessels. It creates a space-occupying lesion with clinical effects similar to pneumothorax. Breath sounds may be diminished and a pleural opacity is seen on chest radiograph.

- ▶ Place a chest tube to drain the blood, and connect to an underwater seal bottle. In most cases the bleeding stops spontaneously.

Warning!

A haemothorax is considered massive when blood loss is severe enough to cause shock. Such patients may need a thoracotomy to control bleeding.

4.8.8 Insertion of an intercostal drain (chest tube)

An intercostal drain is used to drain blood (haemothorax) or air (pneumothorax) from the chest. The procedure requires only basic skills and little specialized equipment, but can be life-saving. Have a pre-prepared chest tube pack ready, or collect together the following before starting the procedure:

- skin cleansing solution
- local anaesthetic (see Section 1.8.5 [page 26])
- sterile instruments (scalpel, tissue forceps, scissors)
- silk suture (or other strong suture)
- gauze and tape
- chest tube
- underwater seal drainage system.

Chest tubes are available in sizes 12–36F. The smallest tubes are suitable for infants; sizes 28F and higher for children 12 years and above. Smaller tubes are adequate for draining air but a larger bore tube is needed to adequately evacuate blood. For safety, if the chest tube comes with a metal trocar, the trocar should be discarded and only the plastic tube used. When a regular chest tube is not available, any sterile tube will suffice in an emergency; for example, a nasogastric tube or urinary catheter may be substituted. In these cases, extra holes should be cut near the tip of the tube to create additional drainage outlets.

- ▶ Select the site where the intercostal drain will be inserted. This should be at the mid axillary line at the level of the nipple (Figure 4.19).

Warning!

An intercostal drain should never be placed lower than the nipple.

- ▶ Inject the local anaesthetic to infiltrate the skin and soft tissue overlying the rib.
- ▶ Make a 2–3 cm transverse skin incision on top of the rib. Do not attempt to perform this procedure through a pinhole incision.
- ▶ Use an artery forceps to bluntly dissect the intercostal muscles and pleura just above the rib. If this step is omitted, the subsequent steps will be difficult to accomplish.
- ▶ Continue deeper by applying pressure as the forceps enters the pleural space. When the pleural space is entered there is a gush of air or blood.
- ▶ Insert the tube (without trocar) through the hole into the pleural cavity. The forceps may be used to guide the tip of the tube into the pleural cavity. Correct placement in a pneumothorax is marked by rush of air or fogging of the tube. With a haemothorax, blood drains from the tube.

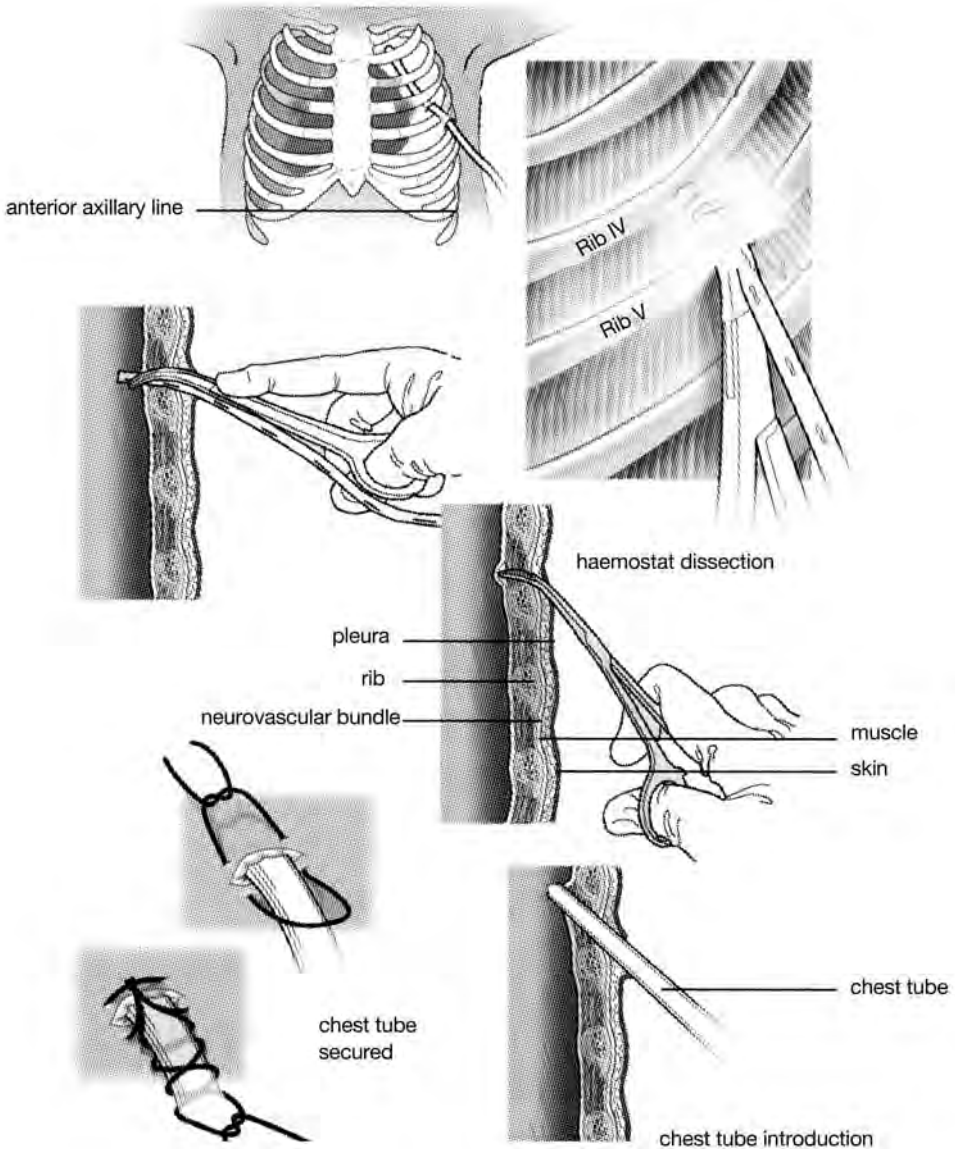


Figure 4.19 Technique for placing a chest drain. Following injection of a local anaesthetic, a small transverse incision is made on the mid-axillary line at the level of the nipple. The chest is entered bluntly with a curved clamp over the top of a rib. If the chest tube is being placed for a pneumothorax, there is typically a gush of air (pus if being placed for an empyema). The chest tube is inserted through the tract and anchored in place by suturing it to the skin. It is then taped in place and connected to a collection system. (Reproduced with permission from *Paediatric Trauma and Child Abuse*, S Van As, S Naidoo (eds), Oxford University Press, 2006.)

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- ▶ Advance the tube until the side holes are well within the chest.
- ▶ Secure the tube to the skin with suture.
- ▶ Connect the end of the tube to an underwater seal drainage device (Figure 4.20). If available, connect the water seal to low wall suction.
- ▶ Obtain a chest radiograph to check placement.

Indications for referral

Severe chest injuries require specialized care. If a patient is to be transferred to another facility, ensure that life-threatening conditions such as pneumothorax are treated first.

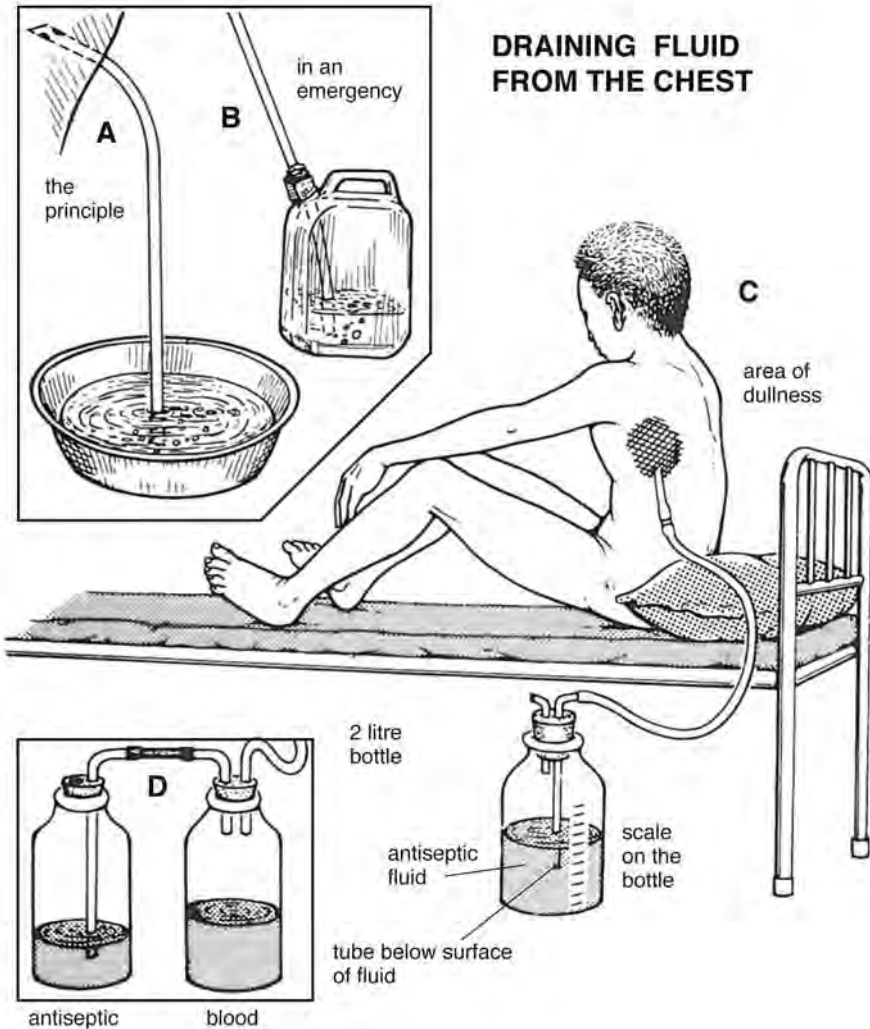


Figure 4.20 Methods for underwater drainage of fluid from the chest. (A) The principle is to place the tube from the patient underwater; (B) any bottle can be used in an emergency situation; (C) the one-bottle method; (D) the two-bottle method, used when there is a large amount of drainage.

▶▶ 4.9 Abdominal injuries

Key points ◀◀

- ◆ Most abdominal injuries in children occur as the result of blunt trauma.
- ◆ The spleen is the most commonly injured organ during blunt abdominal trauma.
- ◆ Bleeding from an injured spleen usually stops spontaneously.

Abdominal injuries may result from blunt or penetrating injuries. Abdominal trauma is commonly associated with head injuries and long-bone fractures.

4.9.1 Diagnosis

- Determining whether a child has an abdominal injury can be challenging. Most infants and children involved in an accident are frightened by the events and this may influence the abdominal examination.
- Almost all infants and young children who are stressed and crying will swallow large amounts of air. Decompression of the stomach by inserting a nasogastric tube should be part of the resuscitation phase in a child with altered mental status or a suspected abdominal injury. An orogastric tube is preferred in infants and older children with facial injuries. Decompression of the stomach often allows a much better exam. Decompression of the urinary bladder with a Foley catheter also improves the accuracy of the abdominal exam.
- Clinical signs will not be obscured by pain medication, although symptoms will be decreased in severity. Pain medication should be given IV, in small and frequent doses. This makes assessment easier and physical signs more reliable.

4.9.2 Blunt abdominal injuries

Splenic injuries

The spleen is the most common organ injured in blunt abdominal trauma. Bleeding from an injured spleen usually stops spontaneously, and splenectomy is rarely required. Splenectomy in children is not a benign procedure. Overwhelming post-splenectomy sepsis caused by encapsulated organisms such as the *Pneumococcus* is a real danger, with a high fatality rate. The spleen can be sutured or placed in a Vicryl bag (absorbable suture material) to oppose the wound margins, or the splenic artery can be ligated to arrest bleeding, or both. Such manoeuvres should always be tried before considering splenectomy. Remember that splenic injuries are commonly associated with other injuries.

Liver injuries

Liver injuries are best treated non-surgically whenever possible. If an operation becomes necessary, consider simple packing of the liver with a view to later definitive surgery.

Warning!

Attempted emergency liver resection has a high mortality.

Bowel injuries

Blunt abdominal trauma may also result in a duodenal haematoma. Treatment is nasogastric suction and parenteral nutrition, if available. Small bowel perforation at or near the ligament of Trietz is more common in children than in adults, as are mesenteric small bowel avulsion injuries.

Diaphragmatic injury

Diaphragmatic rupture can occur following either blunt or penetrating trauma. If clear diaphragmatic outlines cannot be seen on an erect chest radiograph then diaphragmatic injury should be suspected. Herniation of abdominal viscera into the chest may result in strangulation of the bowel. When a diaphragmatic injury is recognized, immediate repair through a laparotomy should be planned. Patients who present late with missed injuries are best treated through a thoracotomy. Diaphragmatic injury should be considered before a chest tube is placed to drain an apparent haemothorax or pneumothorax.

Pelvic fractures

It takes a lot of force to fracture the pelvis, and most pelvic fractures are therefore associated with significant soft-tissue injury. Whilst injury to the urethra, bladder or rectum can usually be clinically detected, injury to the pelvic veins may be missed. If a contained haematoma is discovered in the pelvis at the time of laparotomy, it should not be opened because bleeding may be difficult, if not impossible, to stop.

Urethral/bladder injuries

Do not attempt to pass a urinary catheter if there is bleeding from the urethral meatus or bruising of the perineum – to do so may convert a partial urethral laceration into a complete disruption. It is safer simply to drain the bladder suprapubically. Bladder injuries are often missed. Children with an intraperitoneal bladder rupture may pass urine normally, especially if a catheter is in place. A slowly accumulating ascites and unexplained uraemia in a trauma patient should arouse suspicion of a bladder injury.

4.9.3 Non-surgical management of blunt abdominal injuries

There is a trend towards managing solid-organ injuries in children non-surgically. This management is based on the fact that bleeding from most blunt injuries to the liver, spleen and kidney in children is self-limiting. If the patient is haemodynamically stable there is no reason to operate. Peritoneal lavage and abdominal paracentesis in children are unhelpful, as the finding of blood in the peritoneal cavity does not, of itself, constitute an indication for surgery.

Management involves resuscitation with isotonic crystalloid fluid, analgesia, stabilization of fractures and supplemental oxygen. Surgery should be considered when

40 mL/kg crystalloid fluid fails to restore hemodynamic stability and the abdominal examination demonstrates increasing distension. This is infrequent.

Warning!

If non-surgical management is chosen as the treatment modality, bear in mind the possibility of sudden deterioration. Thus, the patient must be closely monitored, including pulse, blood pressure and urine output. This approach requires continuous coverage by nursing staff to monitor vital signs and immediate availability of surgical personnel.

It is often argued that non-surgical management is too labour intensive to be a real option in settings of limited resources; however, it requires no more resources than surgical management, is safer and leaves the abdomen unscarred. The key to managing such patients is frequent and repeated examination.

4.9.4 Penetrating abdominal injuries

Assume that a penetrating wound to the abdominal wall has entered the abdominal cavity and that there are injuries to the intra-abdominal organs. Remember that the abdominal cavity can be penetrated by injuries to the back. Penetrating abdominal injuries require prompt surgical treatment. Laparotomy for penetrating trauma should include careful inspection of the diaphragm and retroperitoneal structures.

Warning!

Be particularly cautious of penetrating injuries that occur around the anus, as rectal injuries are easily missed.

Sadly, gunshot injuries in children are no longer rare. Survivors have usually been injured by a low-velocity weapon. It is unwise to assume that the bullet has passed in a straight line between entry and exit wounds, as it can ricochet off bones, ligaments etc. Abdominal gunshot injuries mandate a thorough laparotomy. There is no need to perform radical excision of the bullet track, but all necrotic tissue should be removed. The entry and exit wounds should be excised and dressed.

Indications for referral

Consider transfer if your facility does not have the necessary resources to treat or monitor a child with an abdominal injury.

▶▶ 4.10 Spinal cord injuries

Key points

- ◆ Compared with adults, children have more flexible interspinous ligaments and joint capsules. This flexibility makes it possible to have a spinal cord injury without a fracture.
- ◆ A cervical spine injury should be suspected when there is tenderness or swelling in the area of question, a step-off deformity or neurological deficits on physical exam.

Fortunately, spinal cord injuries are rare in children, but can be devastating when they do occur. Knowledge of important anatomical and radiological differences between children and adults can help with diagnosis and management of these injuries.

4.10.1 Anatomical differences between children and adults

Compared with adults, children have more flexible interspinous ligaments and joint capsules, which means that it is possible to have a spinal cord injury without a fracture. Indeed ‘spinal cord injury without radiological abnormality’ (SCIWRA) injuries are much more common in children than adults. A normal spine series can be found in up to two-thirds of children suffering spinal cord injury.

Warning!

When in doubt about the presence of a spinal cord injury, assume that an unstable injury exists, and keep the child’s head and neck immobilized. A normal radiograph in a child does not exclude a spinal cord injury.

4.10.2 Diagnosis

Normal anatomical variations in the cervical spine can be easily confused with injuries. These variations relate to ossification centres (where the bone forms) and the laxity of the vertebrae. For this reason it is important to know what is normal for age, and to always correlate the radiological findings with the clinical exam (see Figure 4.21).

- A cervical spine injury should be suspected when there is tenderness or swelling, a step-off deformity or neurological deficits on physical exam.

Hypermobility

In children, pseudosubluxation (laxity of the joint) of the vertebral bodies C2 on C3, and C3 on C4 is normal. About 40% of children younger than 7 years of age show anterior displacement of C2 on C3, and 20% up to 16 years of age. The phenomena can also be observed at C3 to C4 but is less common.

- To differentiate normal pseudosubluxation from an injury, compare the spina lamina junctions (the posterior cervical line). In normal hypermobility (no injury),

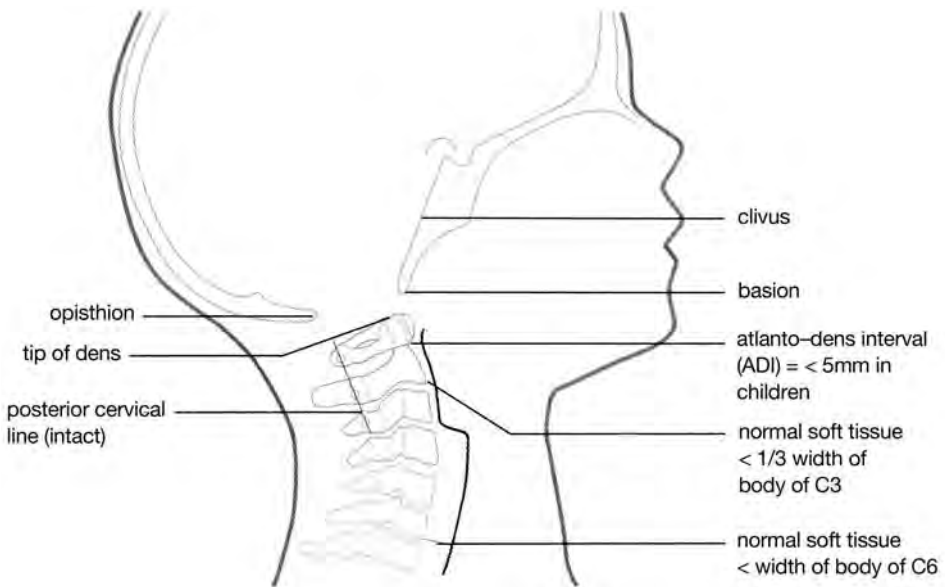


Figure 4.21 Radiology of the normal paediatric cervical spine.

this line remains intact. In about 20% of children there is an increased distance between the dens and anterior arch of C1.

- Measure the atlanto–dens interval (ADI). This is the distance from the posterior inferior corner of the arch of the atlas to the adjacent anterior border of the odontoid. Maximum normal ADI in a child on a flexion view is 5 mm. Maximum normal adult ADI is 3 mm.
- Skeletal growth centres can be confused with fractures. Embryologically, the odontoid represents the body of C1. Its apical epiphysis, the ossiculum terminale, appears at 3 years of age and fuses at 12 years. A synchondrosis exists between the odontoid and the body of C2. This fuses by 3–6 years. The growth centre of the spinous process may resemble fractures of the tip of the spinous process.
- Anterior wedging of vertebral bodies is normal in children less than 7 years of age. After this age, the vertebrae assume an adult appearance and become square.
- The normal retropharyngeal soft tissue of a child should measure one-third the width of the body of C3 at the inferior border of C2 and the width of the body of C6 at C6. Increased retropharyngeal soft tissue at C2 and C3 can be due to forced expiration in the crying child.

4.10.3 Treatment

Care of a child with spinal cord injury is the same as for an adult.

- ▶ Splint or protect the cervical spine with formal splints or home-made splints fashioned from towels or sheets.

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- ▶ Keep the spine aligned when rolling or turning the patient. Use the ‘log roll’ technique.
- ▶ Use tongs for cervical spine and upper thorax injuries.
- ▶ Apply a body cast if necessary for torso splinting.
- ▶ Prevent bedsores by providing good nutrition, skin care and frequent turning.
- ▶ Begin physical therapy to maintain joint and muscle tone.
- ▶ Provide counselling.
- ▶ Consider ulcer prophylaxis and antidepressant medications.
- ▶ Encourage good nutrition early.

4.10.4 Advice for parents

Reassure the parents that you will do your best to treat their child, but that spinal cord injuries are difficult to treat and do not always improve or that improvement is likely to be slow.

Indications for referral

If possible, consult an orthopaedic or neurosurgical expert for help in managing a child with a spinal cord injury.

▶▶ 4.11 War-related injuries

Key points

- ◆ Following basic resuscitation, inspect the patient’s entire body to ensure that all entrance and exit sites are identified.
- ◆ Treatment of gunshot wounds depends on the type of weapon involved.
- ◆ Blasts can cause a wide spectrum of injuries, including rupture of the eardrums, pulmonary damage and bowel perforation.

4.11.1 Gunshot wounds

Tissue injury from a gunshot wound is related to the mass and shape of the bullet and the square of the speed at which it travels. The greater the energy transferred to the tissue, the greater the tissue injury. Heavier bullets have more momentum and release more energy when they hit tissue. The external shape of the bullet also determines whether the bullet will penetrate smoothly or result in major tissue damage. Mine fragments are irregular in shape and are designed to tear their way through tissue.

Diagnosis

- Inspect the entire body of the patient to ensure that all entrance and exit sites are identified. Gun shot wounds to the head, chest and abdomen may be life-threatening. The size of the entrance or exit wound does not reliably predict the underlying tissue damage.
- Carefully check the sensation, muscle power and circulation of the injured extremities and record your findings. Radiographs are not essential, but will help you to evaluate the type of fracture and ascertain if any missile fragments are retained within a joint. If present, these must be removed.

Treatment

Treatment of gunshot wound depends on the type of weapon involved. Rifles and military assault weapons produce high-velocity injuries (> 1500 feet/second; approx. 450 metres/second) and are usually associated with much greater tissue injury than handgun injuries.

Low-velocity injuries

- ▶ Wash the wound with soap and water or other disinfectant.
- ▶ Do not close the skin.
- ▶ Administer IV antibiotics for 3 days.
- ▶ Give tetanus prophylaxis.
- ▶ Treat fractures by closed means with a cast, traction or external fixation.
- ▶ If bullet fragments remain in a joint cavity, arrange to have them removed within a few weeks.

High-velocity injuries

The tissue damage is usually much greater.

- ▶ Debride the wounds in the operating theatre, using adequate anaesthesia.
- ▶ Lavage each wound, after removing all dead tissue and foreign material.
- ▶ Lavage between the entrance and exit wounds, passing gauze through the tract if necessary.
- ▶ Do not close the wound.
- ▶ Re-debride the wounds in 2–5 days, and close or skin graft when clean.
- ▶ Administer antibiotics and tetanus prophylaxis as above.
- ▶ Treat fractures with a cast or, preferably, external fixation or traction.

4.11.2 Blast injuries

The effects of blasts fall into four categories (Table 4.3). Each category is associated with different types of injuries.

Table 4.3 Effects of blasts

Effect	Types of injury
Primary: direct effects of pressure	Rupture of tympanic membranes Lung damage Rupture of the bowel
Secondary: effects of projectiles	Penetrating trauma Fragmentation injuries
Tertiary: effects of structural collapse and of persons being thrown by the blast wind	Crush injuries and blunt trauma Penetrating or blunt trauma Fractures and traumatic amputation Open or closed brain injuries
Quaternary	Burns Asphyxia Exposure to toxic inhalants

Treatment

- ▶ After evaluation for life-threatening penetrating or blunt injuries, examine the eardrum with an otoscope, as rupture of the eardrum suggests that there may also be barotrauma to the lung. If the tympanic membranes are intact and there are no respiratory or abdominal symptoms, a primary blast injury is unlikely. If the tympanic membranes are not intact, obtain a chest radiograph and observe the patient for a minimum of 8 hours.
- ▶ If possible, monitor the patient’s oxygen saturation with a pulse oximeter. Low oxygen saturation is an early indicator of ‘blast lung’, and may occur before respiratory symptoms begin.

Warning!

Primary blast injuries are notorious for their delayed onset.

- ▶ Gross deformities of the extremities should be gently realigned and splinted. Open fractures must be immobilized and covered with bulky sterile dressings, and therapy with systemic broad-spectrum antibiotics should be started.
- ▶ Tetanus prophylaxis should be given during initial treatment.
- ▶ When the ear canal contains debris, remove the foreign material under direct vision or wash out gently with antibiotic-containing fluid. Small perforations typically

heal within a few weeks. During this time the child should avoid swimming or immersing the head under water, and should take antibiotic-containing eardrops. Refer the patient for repair if the eardrum does not heal within a few weeks.

- ▶ Do not forget to examine the eyes, as many blast survivors have a serious eye injury (see Section 4.7).

4.11.3 Landmine injuries

The type of injury depends on whether the child stepped on the mine or gripped the device with their hand. Children who step on mines typically lose their foot and part of the leg. The blast shreds skin and muscle, and the bone becomes secondary missiles which can injure the abdomen and perineum. Picking up a landmine can cause the hand to be blown off, and damage the eyes and face. Fragmentation mines result in puncture wounds all over the body.

Treatment

- ▶ Following basic resuscitation, inspect the patient's entire body to determine the location of all wounds and to evaluate injuries to the head, chest, abdomen and perineum. If a portion of the leg or arm is missing, examine the remaining portion of the extremity to determine which tissue might be salvageable.
- ▶ Cover the wounds with sterile dressings.
- ▶ Splint fractures temporarily until the patient is transported to the operating room.
- ▶ Administer IV antibiotics and tetanus prophylaxis, as with open fractures.
- ▶ Provide pain medication (see Section 1.8 [page 22]).
- ▶ Debride the wounds, removing all dead and foreign material. During this initial debridement it can be difficult to determine which tissues have an adequate blood supply. If in doubt, save the tissue and re-evaluate it on the next debridement. Muscle is judged on colour, bleeding and ability to contract. Remove bone fragments with no soft-tissue attachment. Save all bleeding skin for coverage of the stump. Skin from amputated parts should be saved for use as a split-thickness skin graft.
- ▶ Debride the wounds in the operating theatre every 2–5 days until the wounds are either closed or skin grafted.
- ▶ Treat fractures with splints, traction or external fixation. It is not always necessary to amputate the limb at the most proximal fracture. Try to save as much limb as possible. External fixation is particularly useful for patients with extensive soft-tissue wounds.
- ▶ Coverage of the weight-bearing portion of an amputation stump with full-thickness skin will provide a better prosthetic fit.
- ▶ Begin range-of-motion exercises of the remaining joints as soon as possible, as the extensive scarring from mine injuries can lead to severe contractures.

4.11.4 Crush syndrome

Crush syndrome (also called traumatic rhabdomyolysis) is characterized by major shock and renal failure following a crushing injury to skeletal muscle. It occurs most frequently during war and earthquakes where victims have been trapped under fallen masonry.

- Crush syndrome should be suspected in any child who has been trapped under rubble.
- Crush syndrome results from release of muscle breakdown products into the bloodstream (notably myoglobin, potassium and phosphorus) which are the products of rhabdomyolysis – the breakdown of skeletal muscle damaged by diminished blood flow.
- The most serious complications of crush syndrome are hypovolaemic shock, hyperkalaemia leading to cardiac arrest, compartment syndrome (see Section 4.5.5, page 100) and acute renal failure.
- Finding on physical exam include presence of skin trauma or local signs of compression (redness, bruising, blisters, abrasion, etc.) over a muscle mass. The absence of a pulse or a weak thready pulse to the distal limb may be an indicator of muscle swelling or compromised circulation.
- Aggressive and early hydration is important to prevent acute renal failure.
 - ▷ If possible, begin IV fluids during extrication. For young children, use normal saline 20 mL/kg per hour (1–2 L/h for adolescents). Once the patient is haemodynamically stable, the IV fluid can be switched to 0.45% NaCl/5% glucose at 2–3 times maintenance (see Appendix 2).
 - ▷ Insert a Foley catheter to allow careful monitoring of urine output.
 - ▷ Obtain an ECG to monitor the effects of hyperkalaemia and other electrolyte disturbances.
 - ▷ Treat hyperkalaemia by administering insulin and glucose, a nebulized beta agonist and a potassium-exchange resin. These measures transiently shift potassium from extracellular to intracellular compartments.
 - ▷ Correct hypocalcaemia only if the patient has cardiac dysrhythmias or seizures.
 - ▷ If urine output is not adequate (i.e. 2 mL/kg per hour), consider the use of diuretics such as oral or IV furosemide (frusemide), 1–2 mg/kg every 12 hours.
 - ▷ Dialysis may be required for patients with low-output renal failure, persistent hyperkalaemia, pulmonary oedema, congestive heart failure or persistent metabolic acidosis.
- ▶ Early amputation of a crushed limb does not improve outcome, although it may help with extrication. Amputation of a trapped limb in the field should be a procedure of last choice.

4.11.5 Advice for parents

Inform the parents about the nature and severity of the injuries. Explain the care plan and inform them that multiple operations may be needed.

Indications for referral

Complex wounds are labour intensive to treat and can consume large amounts of resources. Consider transferring the patient if another facility can provide better care for the patient.

▶▶ 4.12 Injuries from child abuse

Key points

- ◆ Children are vulnerable and an easy target for abuse.
- ◆ The smaller the child, the greater the chance that an injury associated with abuse will be fatal.
- ◆ Children who die within the first year of life from injury usually do so as the result of abuse or neglect.

Child abuse and neglect is defined as the maltreatment of children and adolescents by parents, guardian or acquaintances.

4.12.1 Diagnosis

- Suspect child abuse when:
 - there is a discrepancy between the history and the degree of physical injury
 - there is a delay in seeking medical care
 - there is a history of repeat trauma
 - parents respond inappropriately or do not comply with medical advice
 - the history of the injury changes.
- Certain physical findings should also raise suspicion of child abuse:
 - trauma to the genital or perianal area
 - evidence of frequent injuries typified by old scars or healed fractures on radiographs
 - fractures of long bones in children younger than 3 years of age
 - bizarre injuries such as bites, cigarette burns or rope marks
 - sharply demarcated second- and third-degree burns in unusual areas
 - multiple subdural haematomas, especially without a fresh skull fracture
 - retinal haemorrhage
 - ruptured bowel without a history of major blunt trauma.

4.12.2 Treatment

Every effort must be made to protect the child and prevent future injuries from occurring – half of abused children who return to the hospital dead are victims of previous episodes of abuse that were not reported or taken seriously.

Warning!

Abused children are at risk for repeat injuries.

- Carefully document the history and physical exam and make the appropriate referral so the suspected child abuse can be properly investigated.
- Child abuse is a family problem. Effective treatment should involve a multi-disciplinary child abuse team with representation from authorities that are available in your locality, such as child protective services, the courts, police department, rape crisis centres and mental health services.

▶▶ 4.13 Injury prevention

Key points ◀◀

- ◆ Approximately two-thirds of children die from their injuries before arriving at hospital; injury prevention is therefore the single most important strategy for reducing the burden of paediatric trauma.
- ◆ We all have a responsibility to be an advocate for injury prevention.

Anyone caring for injured children is strategically positioned to help with injury prevention. The role and responsibilities of the healthcare provider in this regard are outlined below.

4.13.1 Generating epidemiological data

Irrespective of the level of practice, anyone treating injured children should maintain a careful record of each patient. Information should include basic demographic information, mechanisms of injury, and details of management and outcome. Community- or population-based data are usually more valuable as they can provide insight into the overall burden of injuries. However, hospital-based data are still useful as they reflect the most common injuries in the community.

Epidemiology data can be used to generate community support and to get the attention of local authorities. The data will also help determine the best injury preventive measures.

4.13.2 Public education

In addition to educating the community, the family of each injured child should be counselled on how to prevent future injuries. This helps raise awareness in the local population and also makes the implementation of preventive programmes easier. The emphasis should be placed on preventing the most common childhood injuries in your community. The aim is to modify attitudes and practices that promote the likelihood of injuries.

4.13.3 Advising local authorities

Healthcare providers are in a unique position to convince authorities and policy makers on the importance of childhood injuries. Advice should be based on available epidemiological data, even if it is hospital based. Consider inviting the local authorities to visit your healthcare facility so they can appreciate the scope and magnitude of the problem.

4.13.4 Development of injury-prevention measures

Preventive measures must be tailored towards the needs of each environment, and will depend on the type and mechanism of injury as well as other contributing factors. Example of injury-prevention strategies include changes in traffic regulations (e.g. speed limits, placing of stop signs or cross walks), structural modifications of susceptible buildings, legislation against child abuse, and protection of children during conflicts.

To maximize your success in developing injury-prevention measures, planning should be done in conjunction with other healthcare personnel and community leaders.

Implementation of prevention measures

Inadequately implemented prevention measures are ineffective and without impact. For any implementation to be effective, careful attention should be given to the target community with regard to language of communication, level of education and commonly used sources of information in that community. A well-planned public enlightenment programme is important before starting implementation, and this should be backed by policy legislation by relevant authorities. The paediatric healthcare provider is an important intermediary in this regard because of their closeness to community and families through patient care.

Programme evaluation

Continuous and ongoing evaluation is required to monitor the effectiveness of any prevention measures. This should be in the areas of injury prevalence, changes in mechanisms of injury, as well as morbidity and disabilities. Based on this information, there may be a need to modify the prevention measures periodically.

▶▶ CHAPTER 5: Head and Neck Problems

5.1 Neck swellings

5.1.1 Cervical lymphadenopathy

5.1.2 Residual embryonic structures

5.1.3 Salivary gland swelling

5.1.4 Torticollis (sternocleidomastoid tumour)

5.1.5 Burkitt's lymphoma

5.2 Foreign bodies in the ears, nose and throat

5.2.1 Foreign body in the ear

5.2.2 Foreign body in the nose

5.2.3 Foreign body in the throat

5.2.4 Swallowed foreign body

5.3 Airway obstruction

5.3.1 Diagnosis

5.3.2 Initial management

5.3.3 Epiglottitis

5.3.4 Laryngotracheobronchitis (croup)

5.3.5 Aspirated (inhaled) foreign body

5.3.6 Establishing a surgical airway

▶▶ 5.1 Neck swellings

Key points

- ◆ Most swellings in the neck can be diagnosed by physical examination using knowledge of the common conditions.
- ◆ Swollen lymph nodes are the most common cause of neck swelling in a child.
- ◆ Less common conditions relate to embryological structures that did not reabsorb during development or to enlarged salivary glands.
- ◆ Burkitt's lymphoma should be considered in any child from an endemic area who presents with a jaw mass.

5.1.1 Cervical lymphadenopathy

Lymph nodes in the neck drain the face, mouth, pharynx and trachea. Thus, any infection in these areas will result in enlargement of the lymph nodes draining the specific area. Common causes of enlarged lymph nodes in the neck of children include upper respiratory tract infection, dental abscess and scabies infection in the hair. In the latter condition, the posterior neck lymph nodes are typically involved. Enlarged lymph nodes in the neck can also be part of a systemic illness such as HIV/AIDS, tuberculosis or toxoplasmosis.

- An important question is when to biopsy a lymph node in the neck. Lymph node biopsy should be reserved for nodes where the results will influence the treatment, or when there is a suspicion for a malignancy (hard nodes, increasing in size). Our

practice is to observe most enlarged lymph nodes for a minimum of 3 weeks before making a decision about biopsy. Most lymph nodes related to a treated infection will begin to resolve over this time period.

Warning!

When performing a cervical lymph node biopsy, be careful to not damage the accessory nerve. Review the anatomy before performing any procedure in the neck.

- Occasionally, a child will develop an abscess in a cervical lymph node. These patients usually present with fever, chills and general constitutional symptoms. The involved gland is tender, enlarged and has an area of fluctuance. The treatment is incision and drainage of the abscess followed by antibiotic treatment.

5.1.2 Residual embryonic structures

Abnormal development of embryonic structures or failure of them to completely resolve can result in several types of neck swelling.

Cystic hygromas (lymphangioma)

These are multilocular cystic malformations of the lymphatic system. About half are present at birth, and 80–90% are detected by 2 years of age. They appear as soft, cystic, discrete, non-tender masses that transilluminate. Infection or haemorrhage may cause tenderness and colour change of the overlying skin. Infection can also cause rapid enlargement with cellulitis and slow response to antibiotic therapy.

- ▶ Spontaneous remission is extremely rare. Surgical excision and sclerotherapy offer the best opportunities for cure. These are complex lesions and rarely require emergency intervention unless the airway is involved. It is best to seek advice on the options for treatment before embarking on what may be mutilating surgery. Incision and drainage is inappropriate treatment.

Thyroglossal duct cysts

These arise from thyroglossal ectodermal remnants that develop along the line of descent of the thyroid from the posterior third of the tongue to its final position anterior to the trachea. They present most commonly in toddlers and older children as a painless midline cystic swelling that occurs most commonly in the infrahyoid region. The key diagnostic features of these cysts are their movement on tongue protrusion and swallowing. About 10% arise under the chin as submental swellings and may be confused with midline dermoid cysts; 70% of midline cervical lumps are thyroglossal cysts.

Secondary infection of thyroglossal cysts is common. Infections should be treated early and, if required, incision and drainage should be performed. Most infected thyroglossal cysts evolve into a chronic draining sinus.

5 Head and neck problems

- ▶ The treatment of thyroglossal duct cysts is to surgically excise the cyst and tract. The middle third of the hyoid bone is removed along with the sinus leading to the cyst, to prevent the problem from recurring.
- ▶ Excision of thyroglossal duct cysts should be done by an experienced person.

Branchial cleft cysts and sinuses

These are remnants of abnormal fetal development. Abnormal development of the branchial arches may leave remnants near the mandible and ear (first arch), hyoid region (second arch) or thyroid region (third arch). The spectrum of abnormalities includes sinuses, cysts and remnants of cartilage. Preauricular (just in front of the ear) sinuses and cartilage remnants from the first arch are the most common. Preauricular sinuses may be blind but occasionally extend deeper into the ear. A true sinus or fistula from the first branchial arch is rare and has an opening just below the angle of the jaw along the uppermost border of the sternocleidomastoid. A communication with the external auditory canal may be identified during dissection.

- ▶ Because branchial cleft cysts and sinuses may extend deep into the neck, they should be operated on by someone with proper training. Infected cysts or sinuses should be treated with antibiotics and, if necessary, aspirated or surgically drained.

Dermoid remnants

These are remnants of skin that become embedded as the elements of the face fuse. The most common sites for dermoid remnants are the lateral aspect of the eyebrow and along the midline of the face and neck.

- ▶ Dermoid cysts should be treated by surgical excision.

5.1.3 Salivary gland swellings

Swelling may be due to acute or chronic inflammation, retention of secretions, or neoplasm.

- Mumps is the most common cause of acute salivary-gland swelling.
- HIV/AIDS can cause salivary-gland enlargement, especially the parotid gland (see Section 8.10, page 219).
- Chronic swellings of the salivary glands are usually due to chronic non-suppurative infections.
- Acute bacterial sialoadenitis (infection of the salivary gland) is also a common problem. The infection ascends from the mouth into the salivary gland. Risk factors include poor oral hygiene, obstruction of the salivary duct and dryness of the mouth from dehydration. The main presenting symptoms are fever and painful swelling on the side of face. The salivary duct is red and swollen and discharges pus when pressure is applied to the affected gland.

- ▶ Early cases respond to warm packs and antibiotics. Late cases may require incision and drainage.

Warning!

If an abscess on the face is drained, be careful not to damage the facial nerve.

- ▶ Sialiectasis refers to recurrent pain and swelling of one or both parotid glands due to accumulation and stasis of secretions. Sialograms are not necessary if the diagnosis is clear. Commonly associated with eating, the discomfort can be managed by massaging the parotid area forwards along the line of the duct and simple analgesia. Rarely does this become infected or require antibiotics or drainage. This condition is self-limiting over 12 months or more and does not require surgical resection.

5.1.4 Torticollis (sternocleidomastoid tumour)

Sternocleidomastoid tumour usually results from injury to the sternocleidomastoid muscle due to overstretching during a difficult delivery. The result is fibrosis and swelling of the muscle. Such lumps are often detected some weeks after birth as a firm swelling at the middle part of the sternocleidomastoid muscle. As the muscle contracts, the head is tilted toward the side of the lesion, with the face to the opposite side.

- ▶ The treatment of torticollis is physiotherapy to gently stretch the involved muscle. The parents should be taught to do these stretching exercises.

5.1.5 Burkitt's lymphoma

Although Burkitt's lymphoma can involve a number of different sites (distal ileum, caecum, ovaries, kidney or the breast), in young children it characteristically presents as a jaw tumour. The distribution of Burkitt's lymphoma correlates with the prevalence and intensity of malaria – the immunosuppression from malaria in combination with infection with Epstein–Barr virus infection is thought to explain the high prevalence of Burkitt's lymphoma in sub-Saharan Africa. In children presenting with a jaw tumour in an endemic area, clinical suspicion of Burkitt's lymphoma will nearly always be confirmed by biopsy. Burkitt's lymphoma is often curable with chemotherapy.

Indications for referral

There are many important structures in the head and neck, and this type of surgery should be done by someone with proper training.

▶▶ 5.2 Foreign bodies in the ears, nose and throat

Key points

- ◆ Young children have a propensity to stick objects in their ear, nose and mouth. These objects will occasionally become lodged or will be swallowed.
- ◆ Foreign bodies should be removed, as they may erode into other structure, and cause serious infection.
- ◆ The narrowest parts the gastrointestinal tract are the upper oesophagus and just above the stomach (gastroesophageal junction). Once in the stomach, most foreign bodies will pass spontaneously.

5.2.1 Foreign body in the ear

- ▶ These can usually be removed with gentle ear syringing. Alternatively, remove them in the operating theatre under general anaesthesia using good light and suction. A chronic ear infection or cholesteatoma may be difficult to differentiate from the presence of a foreign body, so careful suctioning is essential.

5.2.2 Foreign body in the nose

These can be difficult to remove in a child that is not sedated.

- ▶ Remove in theatre using good light and sedation or general anaesthesia, depending on age.
- ▶ Beware of pushing the foreign body into the pharynx and causing aspiration.

5.2.3 Foreign body in the throat

- ▶ Impacted fish (or chicken) bones require removal with a laryngoscope under general anaesthesia.

5.2.4 Swallowed foreign body

The narrowest parts of the gastrointestinal tract are the cricopharyngeal area of the upper oesophagus and the gastroesophageal junction. These are the two sites where swallowed foreign bodies are most likely to lodge. Once in the stomach, most foreign bodies will pass spontaneously. Wait and watch the stools.

- ▶ Coins and other impacted foreign bodies in the oesophagus usually require removal with a rigid oesophagoscope under general anaesthesia.
- ▶ Watch batteries should be removed as soon as possible, as the electrical current can cause oesophageal perforation.

Warning!

A radiograph should be taken immediately before taking the patient to theatre, as the foreign body may have moved.

Indications for referral

If you do not have a scope to remove a foreign body from the airway, or are unable to remove the foreign body even with a proper scope, refer the patient. Occasionally, a foreign body becomes so stuck in the airway that it must be removed via a chest incision.

▶▶ 5.3 Airway obstruction

Key points

- ◆ The most common cause of airway obstruction in a child is the tongue falling backwards in an unconscious patient.
- ◆ Other causes include laryngospasm, oedema, foreign bodies in the airway, infection (e.g. croup, epiglottitis, tracheitis and diphtheria), tumours, subglottic stenosis, webs, granulations and strictures.
- ◆ The key to managing airway obstruction in a child is to recognize the problem early and intervene as quickly as possible.

5.3.1 Diagnosis

Airway obstruction should be considered in any child with respiratory distress. The following are signs of respiratory distress in a child:

- coughing, gagging, expiratory grunting
- increase in respiratory rate for age (> 80 per minute in an infant, > 30 per minute in a child)
- tachycardia
- sweating
- flaring of the nose and use of the accessory muscles of inspiration (intercostal and subcostal retractions)
- stridor (a harsh high-pitched, sound produced by turbulent airflow through a partially obstructed airway)
- prolonged expiratory wheeze is usually a sign of small airways obstruction as occurs in bronchiolitis or asthma but can occur in large airway obstruction because of a foreign body
- unequal breath sounds suggests that a major bronchus is obstructed

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- restlessness
- impaired ability to feed in a conscious patient
- cyanosis
- ‘silent chest’ (obstruction so severe that no air flow is occurring).

5.3.2 Initial management

The key to managing airway obstruction in a child is to recognize the problem early and intervene as quickly as possible.

- ▶ Check for clinical signs (blue lips, delayed capillary refill in the fingers or toes).
- ▶ Check the patient’s oxygen saturation if a pulse oximeter is available.
- ▶ Provide supplemental oxygen as needed.
- ▶ Obtain a radiograph of the neck and chest. The chest radiograph may reveal a radiopaque foreign body. Signs of air trapping in one lung are suggestive of impaction of a foreign body in a main bronchus with partial occlusion. If a main bronchus is fully occluded, the lung on the involved side collapses. With a longer history and incomplete occlusion, signs of pneumonia may develop.
- ▶ A lateral neck radiograph can be helpful in making the diagnosis of epiglottitis (see Section 5.3.3 below) or laryngotracheobronchitis (croup), as it will show soft-tissue swelling at the level of the larynx. It may also show displacement of the airway associated with a retropharyngeal abscess.

5.3.3 Epiglottitis

This is usually due to a bacterial infection, classically by *Haemophilus influenzae* B. The child has a fever of short duration, inability to swallow, and drooling. The child typically assumes an open-mouthed sitting position. All ages can be affected by epiglottitis but it is most common in 3–6 year olds.

Warning!

If epiglottitis is suspected, DO NOT lay the child down, remove him from his or her parents or try to start a drip, as disturbing the child may provoke life-threatening complete airway obstruction.

- ▶ The treatment of choice is urgent intubation.
- ▶ Halothane in oxygen is the safest anaesthetic to use in the presence of airway obstruction and should be started with the child in the sitting position.
- ▶ The main risk is complete airway obstruction, which may develop at a light stage of anaesthesia (too light to tolerate an airway or endotracheal tube). Thus, the surgeon should be ready do an emergency tracheostomy if needed.

- ▶ Once the child is asleep, anaesthesia should be deepened.
- ▶ IV access should then be secured and blood cultures taken if possible.
- ▶ The child should be intubated with an oral endotracheal tube under direct vision without the use of muscle relaxants. The epiglottis has the appearance of a red cherry. Small bubbles are often seen bubbling through the nearly obstructed airway.
- ▶ Use an endotracheal tube much smaller than that predicted from age (see Table 1.1, page 10).
- ▶ The child should be given antibiotics (third-generation cephalosporin and/or erythromycin).
- ▶ Keep the child intubated until an audible leak around the endotracheal tube is heard and the temperature has settled, usually within 24–36 hours.

5.3.4 Laryngotracheobronchitis (croup)

Croup is usually of viral origin, mainly parainfluenza type 1. The clinical course is usually longer than with epiglottitis. Croup typically presents during the second year of life and a preceding upper respiratory tract infection is common. There is usually inspiratory and expiratory stridor with the classic ‘barking’ cough.

Treatment

- ▶ Give one dose of oral dexamethasone (0.6 mg/kg) or equivalent dose of another steroid
- ▶ Give humidified oxygen.
- ▶ Give a trial of nebulized epinephrine (adrenaline; 1:1000 solution). If this is effective, repeat as often as every hour, with careful monitoring. While this can lead to improvement within 30 minutes in some children, it is often temporary and may last only about 2 hours.
- ▶ Intubate if there are signs of incipient airway obstruction (severe indrawing of the lower chest and restlessness). Management of anaesthesia is the same as for epiglottitis, although an IV line will usually already be in place. Extubate once there is an audible leak around the endotracheal tube, usually after 4–5 days.
- ▶ Antibiotics are only indicated in the presence of secondary bacterial infection.

5.3.5 Aspirated (inhaled) foreign body

An aspirated foreign body should be considered in any child with shortness of breath and stridor preceded by an episode of coughing and choking, especially while eating. Remember that the history is **always** correct. Upper airway obstruction in a child can be rapidly fatal and requires urgent attention.

Warning!

Sudden onset of shortness of breath in a child under 3 years of age is an inhaled foreign body until proven otherwise.

Symptoms depend on the size and position of the foreign body. If the foreign body is in the larynx or trachea, stridor and shortness of breath are the predominate symptoms. Smaller objects will sometimes get stuck in smaller airways (e.g. the distal bronchi) and lead to more chronic symptoms. Occlusion of a main bronchus can lead to air trapping and overinflation of a lung. Infectious causes (viral or bacterial) do not usually have such rapid onset and are accompanied by systemic signs such as fever and mucus secretion.

If there is severe respiratory distress, the first priority is airway control by intubation. Subsequently bronchoscopy can both confirm the diagnosis and relieve the obstruction by removal of the foreign body.

Anaesthesia

- ▶ Avoid all sedative premedication in the presence of upper airway obstruction.
- ▶ Atropine premedication, 20 micrograms/kg should be given *IM*, as this will ensure that the airway mucosa is sufficiently dry for topical lidocaine to work (topical lidocaine will not anaesthetize wet mucosa).
- ▶ Induce anaesthesia with halothane in oxygen and aim for deep anaesthesia.
- ▶ Apply topical lidocaine (4 mg/kg maximum) to anaesthetize the airway, including the vallecula to prevent coughing/laryngospasm upon surgical instrumentation.
- ▶ Maintain spontaneous ventilation with an Ayre's T-piece connected to the side arm of the ventilating bronchoscope, although assisted ventilation may be necessary if the procedure is long.
- ▶ The biggest danger comes when the foreign body is withdrawn into the trachea – it may fall out of the forceps, lodging just below the cords and totally obstructing the airway.
- ▶ Good communication between the surgeon and anaesthetist is vital.

Post-operative care

- ▶ Administer dexamethasone (0.25 mg/kg IV and then three doses of 0.1 mg/kg IV at 6 hour intervals).
- ▶ Air with or without oxygen should be humidified.
- ▶ Regular postoperative chest physiotherapy is essential.
- ▶ Antibiotics should be administered if infection is present.

5.3.6 Establishing a surgical airway

Sometimes it is impossible to intubate a child and a surgical airway is required to save the patient's life. The options for establishing a surgical airway in a child are:

- needle cricothyroidotomy
- surgical cricothyroidotomy
- emergency tracheostomy.

Needle cricothyroidotomy

Jet insufflation through a needle cricothyroidotomy can provide a temporary means of oxygenating a child with complete or partial airway obstruction. This procedure may be required in an emergency setting when an endotracheal tube cannot be passed. Needle cricothyroidotomy can be difficult in infants because the cricoid cartilage overlaps the thyroid cartilage and obscures the cricothyroid membrane.

Jet insufflation does not provide adequate pulmonary ventilation, so carbon dioxide retention can result. Complete airway obstruction is a contraindication to jet insufflation, as injury to the lung will result. The equipment and staff required for an emergency tracheostomy should be assembled while needle cricothyroidotomy is being done.

Procedure for needle cricothyroidotomy

- ▶ Assemble the required equipment: 14G catheter over needle, 10 mL syringe and a Y-connector connected to oxygen tubing.
- ▶ Place the patient in the supine position, with in-line immobilization of the neck.
- ▶ Identify landmarks of the cricothyroid membrane (Figure 5.1).
- ▶ Attach a syringe to the catheter over needle.
- ▶ Clean the area with alcohol swab or cleaning solution.
- ▶ Hold the plastic base of the catheter over needle between the thumb and index finger of the instrumentation hand.
- ▶ Pull tight the skin across the cricothyroid membrane between the thumb and index finger of the other hand.
- ▶ Hold the catheter over needle with the bevel facing upwards and place the needle tip in the midline of the cricothyroid membrane. Aim the needle in a caudal direction at a 45-degree angle relative to the trachea. Insert the needle through the skin and advance while drawing back on the syringe. Air returning into the syringe suggests tracheal placement.
- ▶ Advance the plastic cannula into the trachea and withdraw the metal needle.
- ▶ Attach the Y-connector to the end of the cannula and connect it to the oxygen tubing.
- ▶ Insufflate in a 1:4-second ratio using high-flow oxygen (8–10 litres/minute): occlude the side hole of the adaptor for 1 second, allowing 100% oxygen to enter



Figure 5.1 Landmarks of the cricothyroid membrane. The best way to find the cricothyroid membrane is to run a finger down the front of the neck in mid-line and find the notch in the upper border of the thyroid cartilage. Below this is a depression between the thyroid and cricoid cartilages – the cricothyroid membrane. (Reproduced with permission from *Paediatric Trauma and Child Abuse*, S Van As, S Naidoo (eds), Oxford University Press. 2006.)

the trachea, then uncover the side hole for 4 seconds to prevent airflow into the trachea.

- ▶ Repeat the cycle of 1 second ‘insufflation’ and 4 seconds’ ‘exhalation’ until an emergency tracheostomy is completed.

The risks of needle cricothyroidotomy include inadequate ventilation, leading to hypoxia and death, aspiration of blood, oesophageal laceration, haematoma, posterior tracheal wall perforation, subcutaneous and/or mediastinal emphysema and perforation of the thyroid gland.

Surgical cricothyroidotomy

Warning!

Surgical cricothyroidotomy should not be used in children less than 5 years of age. If a surgical airway is needed, an open tracheostomy can quickly give wide exposure to the upper airway.

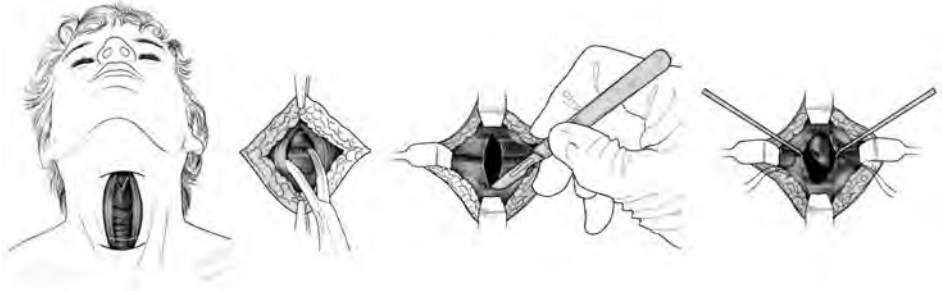


Figure 5.2 Procedure for emergency tracheostomy. Access to the trachea is best achieved through a vertical incision, which allows the strap muscles of the neck to be retracted laterally and avoids damage to other structures in the neck. Once exposed, stay sutures are placed in the second tracheal ring to help control the trachea. These are left in place to facilitate replacement of the tube should it become dislodged. A vertical incision is made through the first and second tracheal rings and a tracheostomy or endotracheal tube inserted and tied in place.

Emergency tracheostomy (Figure 5.2)

- ▶ Assemble the required equipment: scalpel blade and handle, artery forceps, assortment of cuffed and uncuffed endotracheal tubes, bag-valve-mask device and connector.
- ▶ Position the patient in the supine position. If cervical spine injury is suspected, do not extend the neck.
- ▶ Clean the anterior neck with alcohol or cleaning solution.
- ▶ Make a generous vertical incision halfway between the thyroid cartilage and the sternal notch.
- ▶ Bluntly spread the strap muscles with an artery forceps to expose the trachea.
- ▶ Place two sutures in the second or third tracheal rings to control the trachea. These sutures are left in place so that the tracheostomy tube can be replaced easily if it should become dislodged.
- ▶ Make a vertical incision through the second and third or third and fourth tracheal rings, without resecting any part of the tracheal wall.
- ▶ Introduce an endotracheal tube into the lumen of the trachea.
- ▶ Attach the bag-valve device and ventilate the patient.
- ▶ Suction the patient as needed.
- ▶ Auscultate the chest to assess correct position of tube while ventilating.
- ▶ Tie the tube securely in place.
- ▶ Obtain a chest radiograph to confirm proper placement.

Risks of an emergency tracheostomy include bleeding, aspiration of blood and injuries to other structures in the neck and subglottic stenosis.

Indications for referral

If you are unable to care for a child with an airway problem at your facility, transfer the patient as quickly as possible. If you anticipate an airway problem during transport, the child should be intubated before transfer.

▶▶ CHAPTER 6: Abdominal Problems

6.1 Abdominal pain

- 6.1.1 Diagnosis
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▶▶ 6.1 Abdominal pain

Key points ◀◀

- ◆ Abdominal pain in a child that lasts more than 6 hours should raise concern about a potential surgical problem.
- ◆ The most important part of the physical examination is to determine if the child has peritonitis (inflammation of the lining of the abdominal cavity). Most causes of peritonitis in children require surgery.
- ◆ Surgical problems of the abdomen have a better outcome when they are recognized early and treated promptly.

Abdominal pain is very common problem in children. While the majority of abdominal pain in children is self-limited, it can also herald the onset of a life-threatening problem.

6.1.1 Diagnosis

Most causes of abdominal pain can be diagnosed with a complete history and physical examination. The patient's age and sex, the location and duration of the pain and associated symptoms can provide important clues as to the cause of the problem.

- Some surgical conditions occur more commonly in different age groups (Figure 6.1). Intussusception is most common around 1 year of age. Appendicitis is more common in adolescents.
- Is the abdominal pain associated with other symptoms? The presence of nausea, vomiting, diarrhoea, constipation, fever, cough, headache, sore throat or dysuria

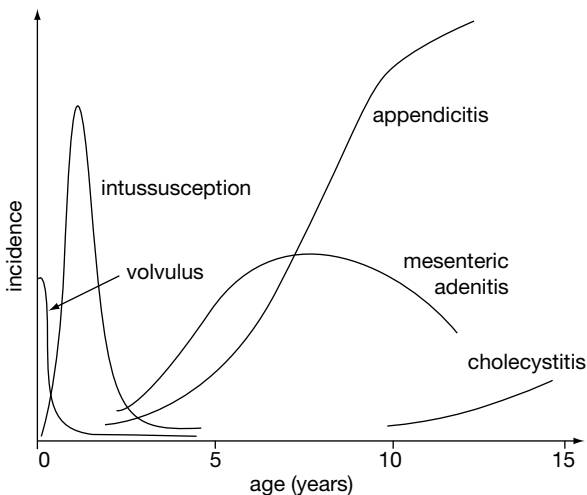


Figure 6.1 Common causes of abdominal disease by age.

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can provide information on the severity of the problem and help narrow the diagnosis.

- Where does it hurt? Ask the child to point to where it hurts the most. Peri-umbilical pain is a common complaint but is usually a non-specific finding.
- The abdominal exam is directed at answering the most important question: Does the child have peritonitis (inflammation of the lining of the abdominal cavity)?

Warning!

Most causes of peritonitis in children require surgery.

- Signs of peritonitis include tenderness with palpation, pain in the abdomen when the child jumps or has his/her pelvis shaken, and involuntary guarding (spasm of the abdominal musculature following palpation). A rigid abdomen that does not move with respiration is another sign of peritonitis.
- Making a diagnosis of peritonitis in young children can be difficult. Serial examination is by far the most important tool for making a difficult diagnosis.

Warning!

Gastroenteritis is the most common cause of abdominal pain in children, but not all abdominal pain is caused by gastroenteritis.

6.1.2 Investigations

Laboratory studies must be considered in the context of the history and physical exam findings, and should be used selectively. A full blood count, urinalysis and abdominal radiograph can add important information. If available, an abdominal ultrasound scan may be helpful in making a diagnosis.

6.1.3 Initial management

- ▶ Children with abdominal pain should not be fed.
- ▶ Pass a nasogastric tube if there is persistent vomiting or abdominal distension. A nasogastric tube is extremely effective in relieving nausea and vomiting.
- ▶ Most children presenting with abdominal pain are dehydrated and require IV fluids. Correct fluid deficits with normal saline or Ringer's lactate (20 mL/kg bolus, repeat as needed) followed by 150% of the required maintenance fluid (see Appendix 2).
- ▶ The use of analgesics in children with abdominal pain has been controversial. Pain medication should be given if the pain is severe. Pain medication will not mask a serious intra-abdominal problem, and may even facilitate a better exam.
- ▶ If the diagnosis is in question, repeat the exam after fluid resuscitation and placement of a nasogastric tube.

Warning!

Persistent or worsening abdominal pain is the single most important indication that a child may require surgery for an abdominal problem.

- ▶ Antibiotics should be administered if there are signs of peritonitis. To cover enteric flora (Gram-negative rods, Enterococci and anaerobes) use gentamicin, ampicillin and metronidazole.

6.1.4 Advice for parents

If you evaluate a child for abdominal pain but are not concerned that it is a surgical problem, tell the parents to bring the child back if the abdominal pain increases or the symptoms change.

▶▶ 6.2 Appendicitis**Key points**

- ◆ The most important clinical finding in children with appendicitis is persistent pain and tenderness in the right lower quadrant of the abdomen.
- ◆ The aim of surgery is to remove the appendix before it ruptures. Rupture of the appendix increases the risk of developing an intra-abdominal abscess or wound infection after operation.
- ◆ Most children who present with appendicitis will be dehydrated. Fluid deficits should be corrected before surgery.

Appendicitis is rare in many low-income countries, but is increasing in frequency as standards of living improve. Appendicitis is most commonly caused by obstruction of the lumen of the appendix. Faecalith, lymphoid hyperplasia and gastrointestinal parasites can cause the obstruction. The sequence of events that leads to a ruptured appendix is shown in Figure 6.2.

6.2.1 Diagnosis

- The most important clinical finding in children with appendicitis is persistent pain and tenderness in the right lower quadrant of the abdomen. Most children develop fever, anorexia and vomiting, although these symptoms may be variable. In early appendicitis, the pain may be in the peri-umbilical area, making it difficult to distinguish from a variety of other problems.
- Appendicitis is easy to confuse with gastroenteritis, mesenteric adenitis, urinary tract infections, kidney stones and ovarian problems. If the diagnosis is unclear, it is best to admit the patient to the hospital for close observation and repeat abdominal examination.

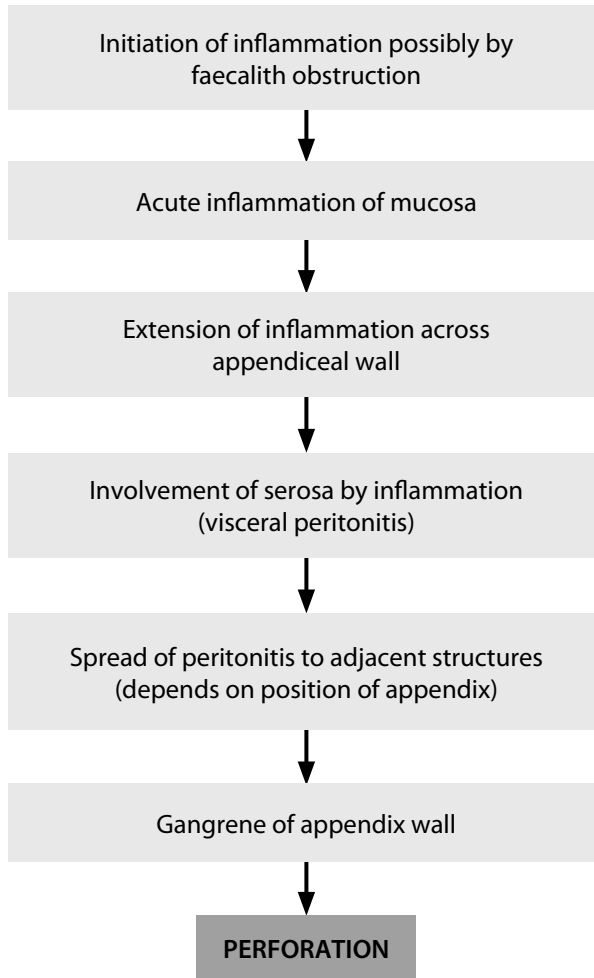


Figure 6.2 Pathophysiology of appendicitis.

- A patient with a ruptured appendix is usually much sicker. A child with perforated appendicitis will often present with diffuse tenderness and a ‘board-like’ abdomen due to severe diffuse peritonitis. Abdominal distension is often present because of ileus or actual mechanical obstruction from inflammatory adhesions around the appendix. Fever is more often present. In fact, perforated appendicitis should be considered in any child presenting with a febrile bowel obstruction. Although the white blood cell count does not reliably differentiate simple from perforated appendicitis, it is likely to be much higher (> 20 000) in patients with perforation.
- A subset of paediatric patients will present with contained perforated appendicitis (appendiceal mass). These patients typically present with more indolent symptoms that have developed over several days, and usually do not have diffuse peritonitis or severe ileus.

Warning!

Appendicitis is an easy diagnosis to miss.

6.2.2 Treatment

The general strategy for managing children with appendicitis is shown in Figure 6.3.

- ▶ An important principle is to correct fluid deficits before surgery using normal saline or Ringer's lactate (10–20 mL/kg bolus, repeat as needed) followed by 150% maintenance fluid (0.45% NaCl / 5% glucose + 20 mmol KCl per litre; see Appendix 2).
- ▶ Antibiotics (ampicillin, gentamicin and metronidazole; use clindamycin and gentamicin in patients who are allergic to penicillin) should also be started immediately for all patients with perforated appendicitis on presentation and for patients

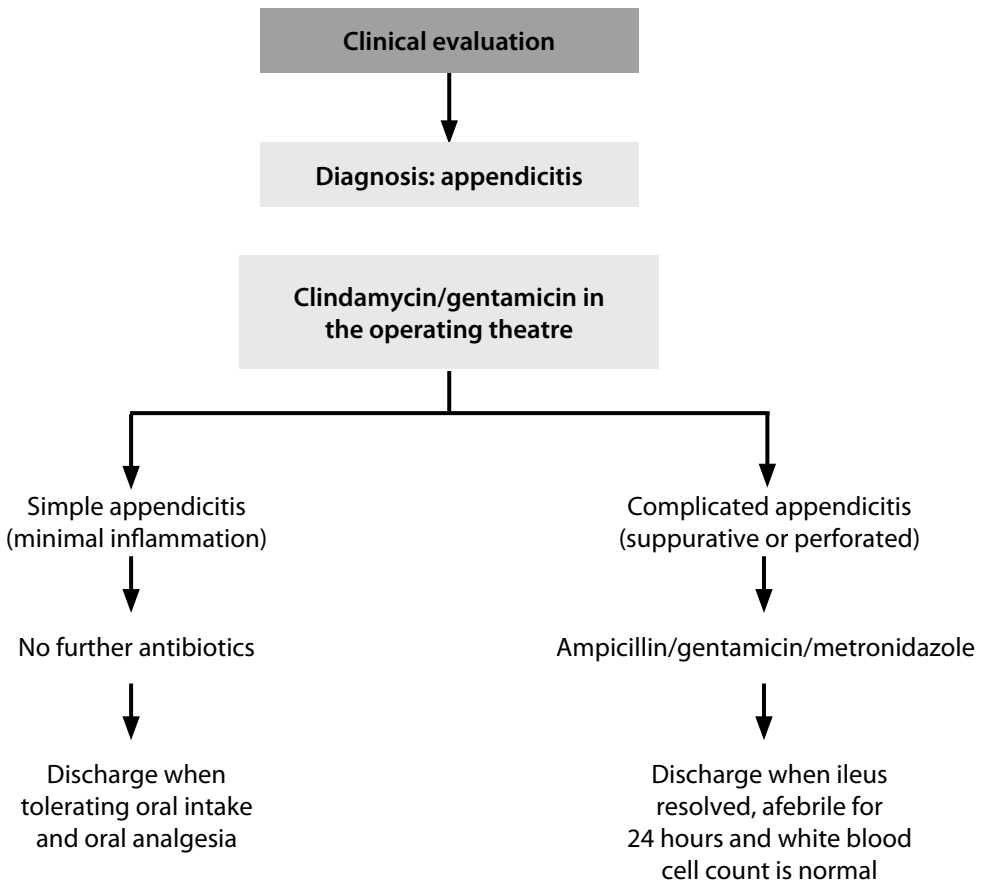


Figure 6.3 Treatment plan for paediatric appendicitis.

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with early appendicitis who cannot be operated on immediately. A preoperative antibiotic dose should always be given before incision, to provide prophylaxis against wound infection.

- ▶ Appendicitis, especially when perforated, is a painful condition and the patient must be given adequate analgesia throughout the hospital stay.
- ▶ The recovery period after appendicectomy depends on whether the appendix was ruptured. Children with perforated appendicitis may require hospitalization with IV antibiotics for a week or longer. In general, a patient can be discharged home when they are tolerating a regular diet, have been afebrile for 24 hours and have a normal white blood cell count. If a patient continues to be febrile for longer than 7 days, an intra-abdominal abscess should be suspected. Most wound infections occur by the fifth postoperative day.

6.2.3 Appendicectomy

The principles of performing an appendicectomy in a child are the same as for an adult. Figure 6.4 shows the important landmarks for performing an appendicectomy. McBurney's point is located one-third the distance along a line from the anterior superior iliac spine to the umbilicus. The appendix can extend inferiorly into the pelvis, medially toward the midline, superiorly or into the retrocaecal area. A transverse incision at McBurney's point, lateral to the rectus muscle, optimizes visualization of the caecum and localization of the appendix.

If the appendix is not easily identified, rocking the caecum in an oblique manner between the right shoulder and left hip will allow identification of the tenia coli, which leads the surgeon to the appendiceal base. If the operation is proving difficult, the surgeon should not hesitate to extend the incision medially to gain better access to the abdominal cavity.

If peritonitis is encountered, the peritoneal cavity should be irrigated with warm saline before closure. If the appendix has ruptured, always look for a faecalith. Children have

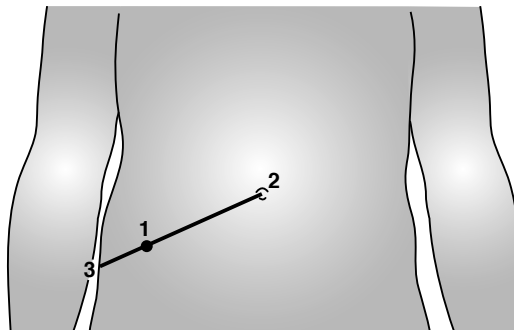


Figure 6.4 Landmarks for appendicectomy. 1 = McBurney's point (one-third the distance along a line from the anterior superior iliac spine (3) to the umbilicus (2)). A transverse incision at level 1 lateral to the rectus muscle provides optimal exposure.

low rates of wound infection, even with severe contamination, and it is safe to close the skin using an interrupted suture. Alternatively, the skin can be approximated loosely or the wound packed open.

6.2.4 Postoperative complications

Complications are common after perforated appendicitis, the most common being wound infections and intra-abdominal abscesses. Wound infections are diagnosed by simple examination of the wound and identification of redness, warmth and fluctuance.

The infected wound should be opened and packed with saline-soaked gauze. Intra-abdominal abscesses typically occur within 7–14 days after appendicectomy for perforated appendicitis, and present with fever, anorexia, ileus, abdominal pain, diarrhoea, or any combination of those symptoms. If such symptoms persist for longer than 7 days after appendicectomy or recur after initial improvement, a postoperative abscess should be suspected. Many abscesses have a pelvic component and can be detected by a rectal examination, revealing a tender, fluctuant mass in the pelvis. If radiology or ultrasound imaging is available, further details can be gained. Otherwise, re-exploration of the abdomen may be both diagnostic and therapeutic.

6.2.5 Advice for parents

On discharge, the child's parents should be educated about the possibility of adhesive bowel obstruction after appendicectomy and counselled to bring the child back immediately to the hospital should obstructive symptoms develop.

Indications for referral

Appendicectomy should be within the scope of surgery performed at a primary referral hospital. Transfer should be considered if the facilities are not available to perform the operation, provide the postoperative care or to deal with the potential complications.

▶▶ 6.3 Bowel obstruction beyond the neonatal period

Key points

- ◆ A bowel obstruction should be suspected in any child presenting with crampy abdominal pain, vomiting, abdominal distension and no flatus.
- ◆ Bilious (green) vomiting is a bowel obstruction until proven otherwise.
- ◆ Fluid resuscitation and placement of a nasogastric tube are the first two steps in treating a child with a suspected bowel obstruction. A nasogastric tube decompresses the stomach and can prevent bowel perforation.

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The most common causes of bowel obstructions in children beyond the neonatal period (> 1 month of age) are intussusception (Section 6.4 [page 150]), incarcerated hernia (Section 6.6.3 [page 157]), adhesions (scarring from previous surgery), worm infestations (Section 8.11.1 [page 224]), pyloric stenosis (Section 3.4.2, page 51) and malrotation (Section 3.4.2, page 50). In some areas, obstruction by the *Ascaris lumbricoides* worm is quite common.

6.3.1 Diagnosis

A detailed history and thorough physical examination is often sufficient to establish the diagnosis of bowel obstruction.

- The anatomical level of the bowel obstruction determines the clinical presentation. If the obstruction is above the level where the bile duct enters the bowel (duodenum), the vomit will be non-bilious. If the obstruction is below the level of the bile duct, the bile backs up into the stomach and the vomit will be bile coloured (green).
- Children with obstruction in the proximal small bowel (duodenum or jejunum) present mainly with vomiting and have minimal abdominal distension. Those with more distal obstruction (e.g. in the ileum or colon) typically present with abdominal distension, with vomiting occurring later (Figure 6.5).
- The most common findings in a child with a small bowel obstruction are crampy abdominal pain, vomiting, distension and no flatus. The infant is unable to complain of pain but will become irritable or fussy. The presence of bilious (green) vomiting by itself is indicative of bowel obstruction. Sometimes it is possible to see peristaltic waves through the abdominal wall.
- Children with unrelieved bowel obstruction may present late with signs of intestinal perforation and sepsis. This should be suspected when the child has fever, constant abdominal pain and generalized tenderness (peritoneal signs). In other cases, children with conditions such as appendicitis or typhoid perforation may initially present with signs of bowel obstruction.

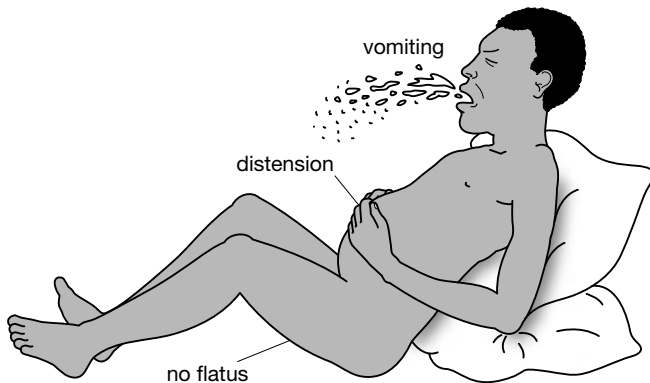


Figure 6.5 Clinical signs of a distal bowel obstruction. If there is no improvement within 24 hours the symptoms are more likely to be due to bowel obstruction than ileus.

- Abdominal pain, vomiting and distension can also be caused by gastroenteritis in children. The abdominal distension results from decreased bowel motility (ileus). It can be difficult to distinguish an ileus from a mechanical bowel obstruction in a child, as the radiograph and clinical exam can be similar. The best way to distinguish the two is by close clinical observation. Children with ileus will typically improve within 24 hours when treated with bowel rest.
- Pyloric stenosis should be suspected in any infant of 3–6 weeks of age who presents with non-bilious vomiting (see Section 3.4.2, page 51).

Warning!

Perforation is the most serious complication of a bowel obstruction. It can be prevented by keeping the stomach decompressed with a nasogastric tube.

6.3.2 Investigations

If available, plain abdominal radiographs are most helpful when taken in two views. The supine film shows distended loops of bowel, while the upright or lateral decubitus view shows air fluid levels. The upright film should be carefully inspected for free air under the diaphragm (or free air under the anterior abdominal wall in the decubitus view). Free air in the peritoneal cavity (pneumoperitoneum) indicates intestinal perforation, requiring prompt surgical intervention.

6.3.3 Initial management

- ▶ Children with bowel obstruction are usually dehydrated from vomiting and third-space fluid losses into the lumen of the bowel. In the infant, dehydration typically progresses quite rapidly, increasing the urgency of the situation.
- ▶ Correct fluid deficits with normal saline or Ringer's lactate (10–20 mL/kg bolus, repeat as needed) followed by 150% maintenance fluid (0.45% NaCl / 5% glucose + 20 mmol KCl per litre; see Appendix 2). The response to fluid resuscitation should be monitored by repeated assessment of clinical signs (moist tongue and buccal mucosa, reversal of sunken eyes or fontanel, lowering of heart rate, warm extremities). The most reliable index of optimal rehydration is adequate urine output, with a goal of 0.5–2 mL/kg per hour depending on age – see Appendix 1. This can be indicated by frequent change of wet nappies but, if available, a urinary catheter allows a more accurate record of urine output. Once the child is rehydrated, the fluid boluses can be replaced with maintenance fluid at the rate of 150% of normal requirements.
- ▶ The child should be nil by mouth.
- ▶ Pass a nasogastric tube and place the tube to gravity drainage or to suction if possible. A nasogastric tube is extremely effective in relieving nausea and vomiting, allows the bowel to decompress and prevents bowel perforation.

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- ▶ If there are signs of infection (fever, peritonitis) begin antibiotics: ampicillin, gentamicin and metronidazole.

6.3.4 Indications for surgery

The main indications for surgery on a child with a bowel obstruction are failure to show improvement or signs of peritonitis. Occasionally, a child will improve when treated with nasogastric decompression and fluid resuscitation. Signs of improvement include relief of pain and distension, with return of flatus or bowel movement. In children showing recovery with non-surgical treatment, the nasogastric tube may be removed under close monitoring. If the symptoms do not return, then oral intake is gradually introduced.

An operation (laparotomy) is mandatory for children who do not respond to the initial measures described above, or when there are signs of peritonitis or intestinal perforation. The operation is safer when fluid and electrolyte deficits have been corrected and the intestines have been decompressed with a nasogastric tube.

▶▶ 6.4 Intussusception

Key points

- ◆ Intussusception should be suspected in any child with colicky abdominal pain, vomiting and bloody mucoid diarrhoea, especially if they are between 3 and 12 months of age.
- ◆ If recognized early, intussusception can be reduced using an air or saline enema.
- ◆ If the child has had an intussusception for more than 48 hours, an air or saline enema is unlikely to work and surgery will be necessary.

This form of bowel obstruction, shown in Figure 6.6, occurs when one segment of the intestine telescopes into the next and in children most commonly occurs through the ileocaecal junction. Children with intussusception usually do not have an abnormality in the bowel where the process starts.

6.4.1 Diagnosis

- Intussusception occurs most commonly in children aged 3–12 months but can occur in older children.
- Early presentation is with colicky abdominal pain with vomiting and bloody mucoid diarrhoea ('redcurrant jelly stool'). The infant cries with pain, doubles up and pulls their legs up. On physical examination an abdominal mass may be palpated. The mass begins in the right lower quadrant of the abdomen and extends along the line of the colon. Early intussusception can be easily confused with gastroenteritis.

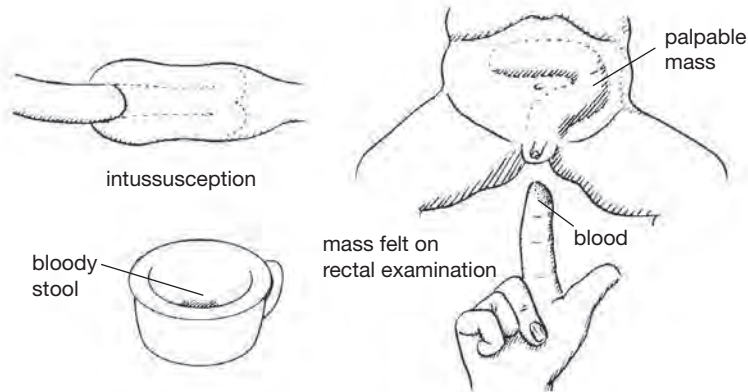


Figure 6.6 Intussusception.

- Late presentation is with abdominal distension, tenderness, bloody mucoid diarrhoea and dehydration or even hypovolaemic shock. If the intussusception is extensive, the small bowel may even protrude out of the rectum and be confused with a rectal prolapse. Figure 6.7 shows how to distinguish between an intussusception and a rectal prolapse.
- Ultrasound is the easiest way to confirm an intussusception. The intussuscepted bowel appears as concentric rings ('target sign') on ultrasound. If fluoroscopy is available the diagnosis can also be made, and sometimes treated with an air or warm saline enema.

Warning!

Intussusception is often misdiagnosed as dysentery and therefore requires a high index of suspicion.

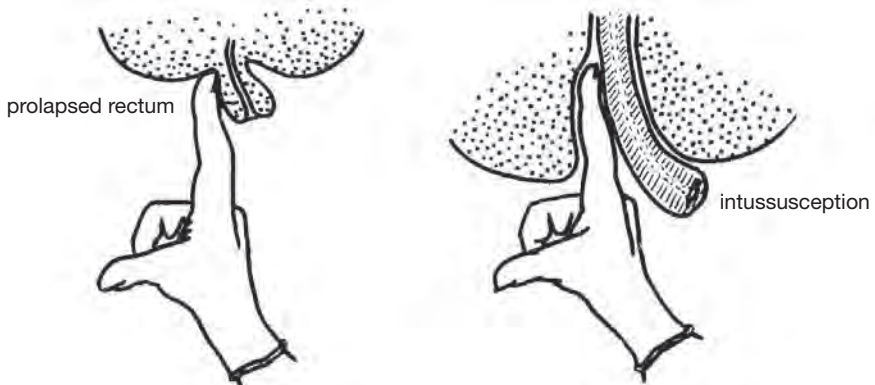


Figure 6.7 Distinguishing intussusception from a prolapsed rectum. If a finger cannot pass between the mass and the side wall of the rectum, the child has a rectal prolapse.

6.4.2 Initial management

- ▶ Children with intussusception are often dehydrated, so the initial priority is fluid resuscitation. Correct fluid deficits using normal saline or Ringer's lactate (10–20 mL/kg bolus, repeated as needed) followed by 150% maintenance fluid (0.45% NaCl / 5% glucose + 20 mmol KCl per litre; see Appendix 2).
- ▶ Pass a nasogastric tube.
- ▶ If there are signs of infection (fever, peritonitis) begin antibiotics: ampicillin, gentamicin and metronidazole.

6.4.3 Reducing the intussusception

- ▶ Early intussusception can often be reduced with an air or warm-saline enema. Air or warm saline is introduced into the rectum under ultrasound or fluoroscopic guidance and the intussusception is gradually reduced with pressure.

Warning!

A barium enema reduction is contraindicated for intussusception, as it can have devastating consequences if the bowel is perforated. Instead use air or saline.

- ▶ The longer the delay in presentation of intussusception, the less likely it is that enema reduction will be successful. The contraindications for enema reduction are peritonitis, significant bowel obstruction with delayed presentation, and prolapse of the intussusception out of the anus. The surgical technique for reducing an intussusception is shown in Figure 6.8. If there is dead bowel, the necrotic portion of bowel is removed and an end-to-end anastomosis is performed.

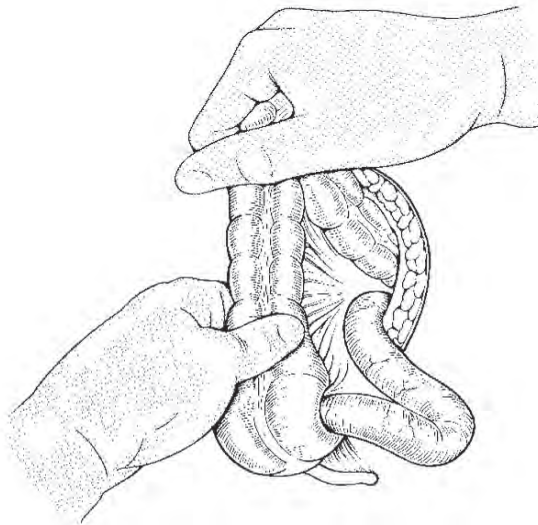


Figure 6.8 Technique for manual reduction of an intussusception. Note that the intussusception is being pushed rather than pulled. Bowel resection is required if the intussusception cannot be reduced.

- ▶ Successful enema reduction is suggested by complete resolution of symptoms. Persisting pain suggests incomplete reduction, recurrence of the intussusception or a bowel perforation.
- ▶ The duration of postoperative antibiotics depends on the severity of the disease. For uncomplicated intussusception reduced with an air or saline enema, 24 hours of antibiotics is usually sufficient. Complicated cases treated by bowel resection may require up to 5 days' antibiotic cover.
- ▶ The diet can be slowly resumed when the patient passes gas or has a stool.

6.4.4 Advice for parents

Inform the parents that even with successful reduction of the intussusception with air or saline solution, there is still a 5% chance that the problem could recur.

Indications for referral

If intussusception is suspected and ultrasound or fluoroscopy is not available, resuscitate the patient, place a nasogastric tube, start antibiotics and refer the patient to a centre that has these facilities.

▶▶ 6.5 Umbilical hernia

Key points

- ◆ Most umbilical hernias close spontaneously.
- ◆ Surgical repair is indicated for umbilical hernias that do not close by 6 years of age or if the hernia has ever been difficult to reduce.

Umbilical hernia (Figure 6.9A) is a common problem in children. The condition results from failure of the umbilical ring to close completely.

6.5.1 Diagnosis

- An umbilical hernia appears as a soft and reducible swelling at the umbilicus.
- Complications are rare, but a swelling that is not reducible suggests that the hernia may be incarcerated (trapped). An incarcerated umbilical hernia most commonly contains trapped omentum but may contain small bowel. In the latter case, the incarcerated small bowel results in bowel obstruction. Incarcerated umbilical hernias are more common in children with pica (eating sand or dirt to unconsciously treat their anaemia).
- Other known complications are rupture of the hernia from a full-thickness burn or severe ascites (e.g. from severe liver disease).

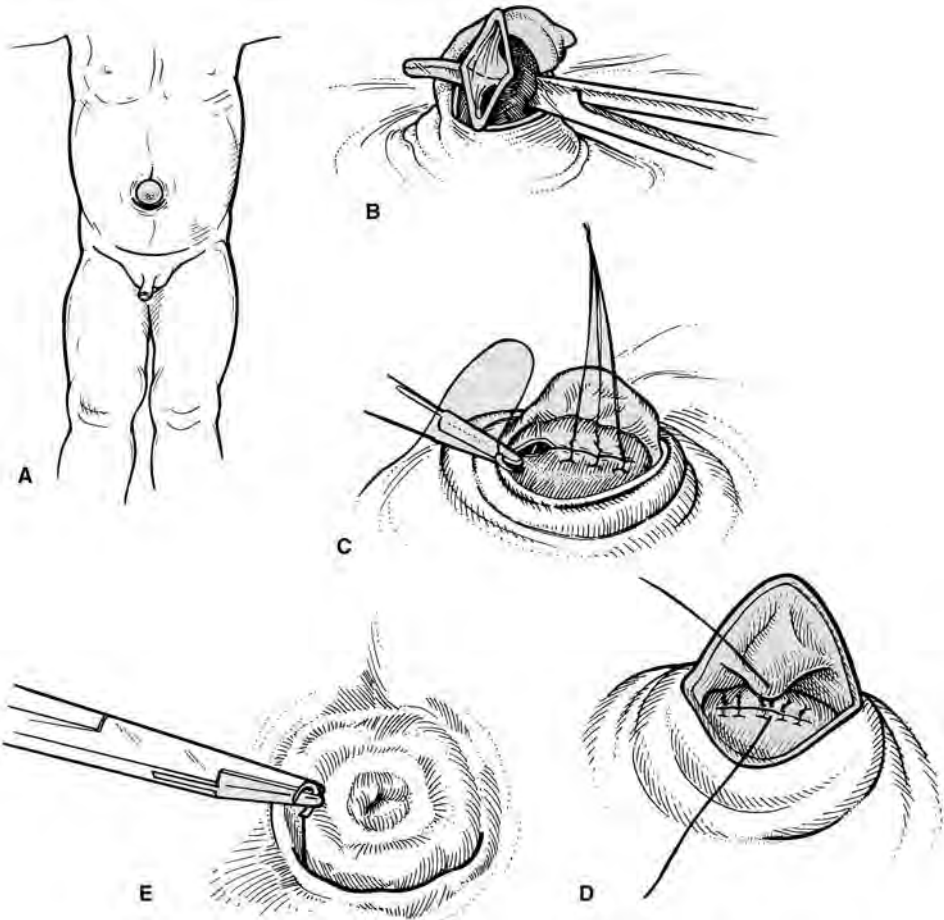


Figure 6.9 (A) Umbilical hernia – protrusion of peritoneum and fluid, omentum or abdominal organ(s) through the umbilical ring (the fibrous and muscle tissue around the navel). (B–E) Surgical repair of umbilical hernia. (B) A curved incision is made along a skin crease inferior to the umbilicus. (C) The neck of the hernia sac is isolated and opened. (D) The fascial defect is closed. (E) The skin is closed with a subcuticular suture.

6.5.2 Treatment

Remember that most umbilical hernias will close if left alone. Surgical repair should be done for umbilical hernias that do not close by 6 years of age, or if the hernia has ever been difficult to reduce. Umbilical hernia repair should be done under general anaesthesia.

Surgical repair (Figure 6.9)

- ▶ A curved incision is made in a skin crease below the umbilicus.
- ▶ The hernia sack is opened to expose the defect.
- ▶ The fascial margins are cleared and then closed transversely using a single interrupted or continuous layer of non-absorbable sutures.

- ▶ The protuberant skin should not be excised, as it will leave an unsightly scar. If left alone the redundant skin will shrink and create a near-normal umbilicus.
- ▶ A lightly applied pressure dressing can minimize the chance of a seroma forming under the skin.

Warning!

Taping or bandaging the umbilical hernia to keep it reduced is not recommended, as it will cause the skin to break down, and may even cause the hernia to rupture.

6.5.3 Advice for parents

Reassure the parents that most umbilical hernias will resolve on their own and that by waiting they can avoid the risks of an operation. Also explain that if the umbilical hernia becomes red or firm they should seek medical advice immediately, as it may mean that the hernia is incarcerated.

▶▶ **6.6 Hydrocele and inguinal hernia**

Key points

- ◆ The most common finding in a child with an inguinal hernia is a groin mass that reduces with gentle pressure.
- ◆ Incarceration (bowel or omentum trapped in the hernia sac) is the most serious complication of an inguinal hernia.
- ◆ If an incarcerated hernia cannot be pushed back in, emergency surgery is required.

Inguinal hernia and hydrocele are two of the most common surgical problems affecting children. They are more common in boys than girls, and tend to run in families. Most are congenital, even when they present in older children.

The best way to understand the diagnosis and treatment of inguinal hernia and hydrocele is to understand the anatomy. Hernia and hydrocele in children relate directly to the failure of the processus vaginalis – the embryological connection between the abdominal cavity and scrotum – to close. Figure 6.10 shows the spectrum of possibilities when the processus vaginalis does not close in a boy.

The size of the processus vaginalis determines the clinical presentation. If the processus vaginalis is small, only fluid passes and the result is a hydrocele. If it is larger, a piece of omentum or bowel can enter, thus creating a hernia.

6.6.1 Hydrocele

A hydrocele (so-called fluid hernia) is a collection of fluid around the testicle or spermatic cord and may or may not communicate with the abdominal cavity. Because

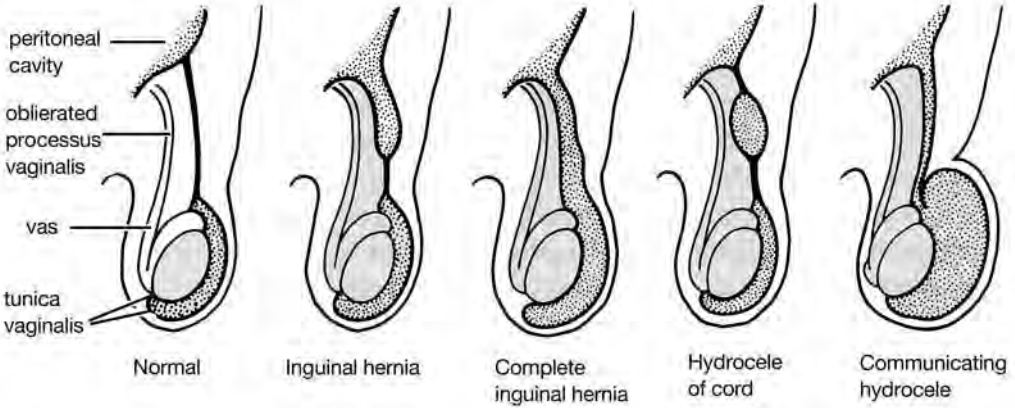


Figure 6.10 The most common variants of hernias and hydroceles arising from failure of the processus vaginalis to close. (Reproduced from KW Ashcraft & TM Holder, *Atlas of Pediatric Surgery*, WB Saunders, 1994.)

hydroceles are fluid-filled sacs, they transilluminate when a light is directed across the scrotum. Hydroceles rarely extend up into the inguinal canal, and an effort should always be made to ‘get above’ the hydrocele when examining the patient. If this is not possible an inguinal hernia should be suspected.

Hydroceles sometimes resolve during the first few years of life. Surgical repair should be considered if a hydrocele has not resolved by 5 years of age. There is no urgency and if the anaesthetist is not comfortable working with small children, the repair can be done later when the child is larger.

6.6.2 Inguinal hernia

The most important clinical finding is a groin mass that reduces with gentle pressure (Figure 6.11). The mass is usually more prominent when the child cries or strains. In girls, the hernia is usually felt a little higher and may contain an ovary. When a hernia

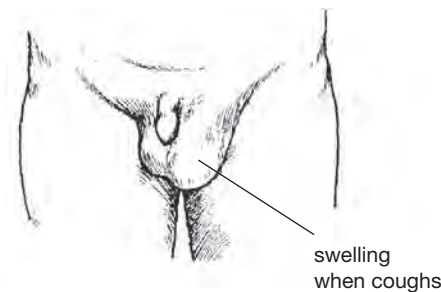


Figure 6.11 Inguinal hernia. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

is reduced (pushed back in), there is usually a squishy feeling as the bowel slides back into the abdominal cavity. A large hydrocele extending into the groin can easily be mistaken for an inguinal hernia but is not reducible. The repair of an uncomplicated inguinal hernia can be scheduled electively.

6.6.3 Incarcerated inguinal hernia

Incarceration – trapping of bowel or other intra-abdominal contents in the hernia – is the most serious complication of an inguinal hernia.

Warning!

If an incarcerated hernia is not treated promptly, the bowel trapped in the hernia sac will die and then rupture. It is impossible to tell if the bowel in an incarcerated hernia is dead without operating.

The most important finding in a patient with an incarcerated inguinal hernia is a non-reducible groin swelling. If intestine is trapped in the hernia sac, there may be signs of a bowel obstruction (vomiting and abdominal distension).

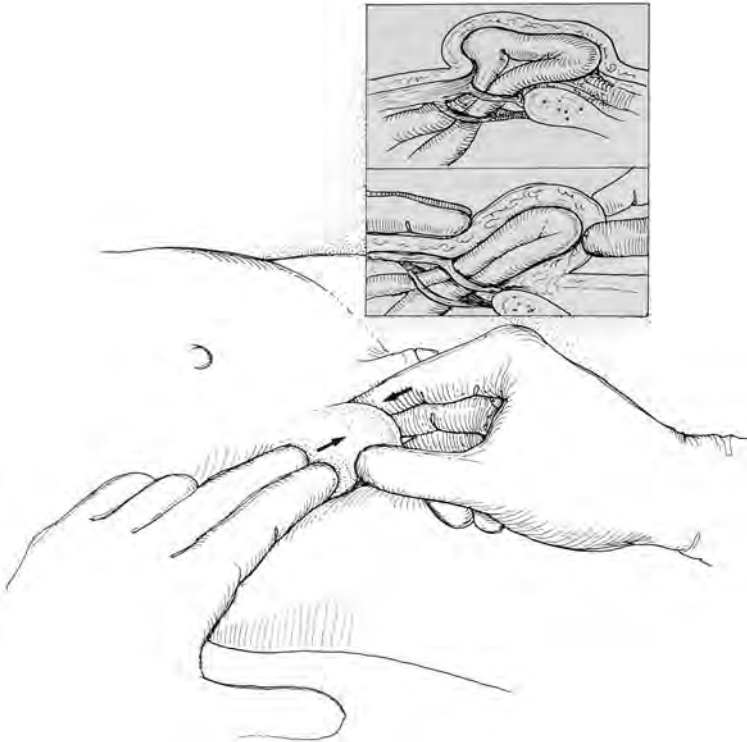


Figure 6.12 Technique for reducing an incarcerated inguinal hernia. (Adapted from KW Ashcraft & TM Holder, *Atlas of Pediatric Surgery*, WB Saunders, 1994.)

6 Abdominal problems

- ▶ An attempt should always be made to reduce an incarcerated hernia – the technique is shown in Figure 6.12. The key is to apply firm downwards pressure with the left hand to dislodge the hernia contents trapped beyond the external ring and then to apply counter pressure to slip the hernia contents back up through the inguinal canal. Administering analgesia or sedation can help.
- ▶ If an incarcerated hernia cannot be reduced, emergency surgery is required. If the hernia is successfully reduced, the child should still be admitted to the hospital and have the hernia repaired before discharge.

6.6.4 Surgical repair

Repair of inguinal hernia in infants and children differs from in adults. In contrast to adults, where the emphasis is on repairing the weakened inguinal floor, hernia and hydroceles in children are repaired using a technique called high ligation of the sac. Figure 6.13 shows the technique for repairing an inguinal hernia in a child.

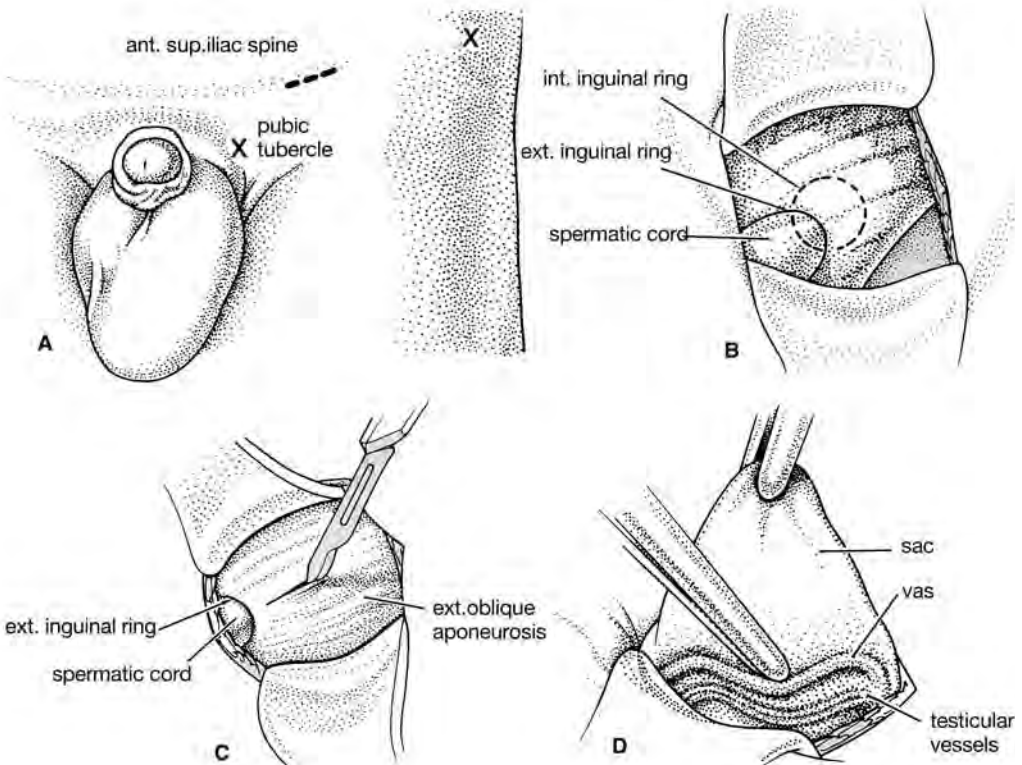


Figure 6.13 D, E and F continues ▶

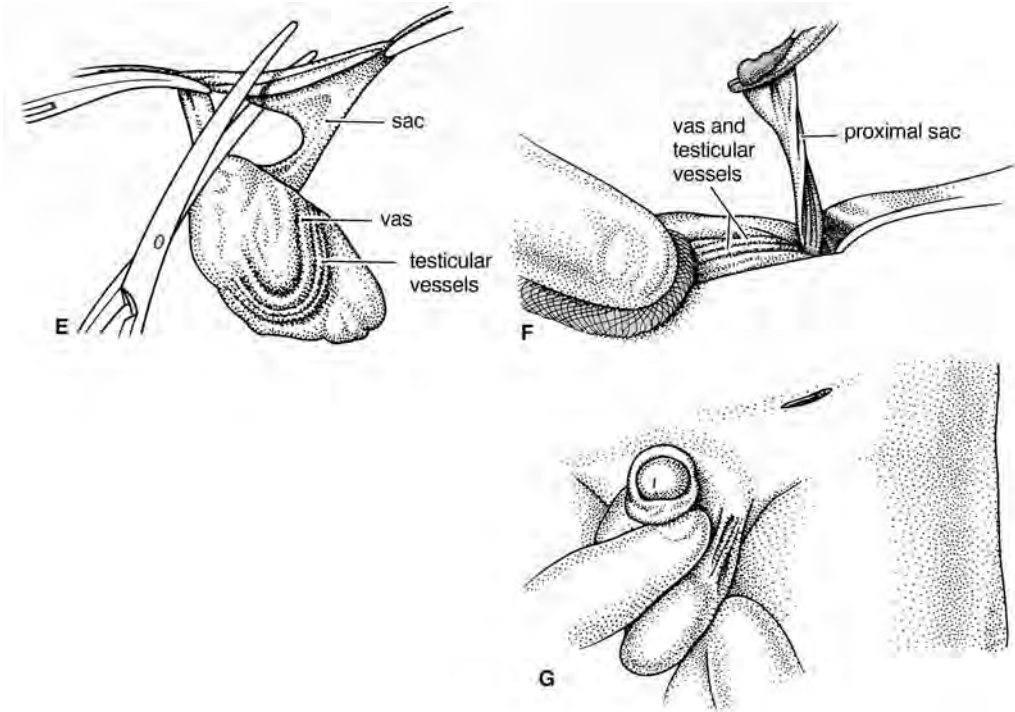


Figure 6.13 Repair of an inguinal hernia in a boy. (A) The pubic tubercle and anterior superior iliac spine are used as landmarks to place the inguinal incision over the internal ring (dashes); (B) In infants younger than one year, the internal and external rings overlap, and the inguinal canal is short. Often an incision in the external oblique fascia is not necessary to gain access to the internal ring; (C) In older children, the external oblique aponeurosis is incised lateral to the external ring and over the internal ring. The undersurface of the external oblique is cleared of cremasteric fibres. The cremaster muscle is spread to expose the spermatic cord, which is grasped and elevated; (D) The vas and spermatic vessels are then gently separated from the sac without touching them; (E) The hernia sac is inspected for contents. The empty sac is then sharply divided between clamps. The edges of the distal sac are cauterized and the distal sac dropped back into the wound. (F) The proximal sac is gently dissected to the level of the internal ring, where the preperitoneal fat will be seen. The sac is then twisted on itself taking care not to incorporate the vas deferens and vessels, and double-ligated. (G) The testis is pulled back into position in the scrotum, and the spermatic cord straightened. A standard layered closure is performed with absorbable suture.

6.6.5 Advice for parents

Inguinal hernias should be repaired for three reasons: 1) they don't go away, 2) they continue to get larger and 3) they may become trapped (incarcerate) and require an emergency operation, which has a much higher risk of complications than an elective operation for a non-incarcerated inguinal hernia.

Indications for referral

If an inguinal hernia cannot be reduced, and facilities for surgery are not available, resuscitate the patient with IV fluid, place a nasogastric tube, start antibiotics and transfer the patient to a centre that can perform the needed surgery.

▶▶ 6.7 Rectal prolapse

Key points

- ◆ Rectal prolapse refers to the condition where the rectum is pushed out past the anal sphincter.
- ◆ It is most commonly caused by straining with bowel movements, from either chronic constipation or diarrhoea.
- ◆ Most rectal prolapses can be treated by pushing the rectum back in, strapping the buttocks with tape and then treating the underlying cause.

Rectal prolapse occurs when a poorly fixed rectum is pushed out past the anal sphincter. It is most commonly caused by straining with bowel movements, from either chronic constipation or diarrhoea. Causative factors include gastrointestinal parasites (*Trichuria*) and cystic fibrosis. When caused by chronic diarrhoea, the children is usually poorly nourished.

6.7.1 Diagnosis

- The prolapse may be just the mucosal layer or include all the layers of the rectum. In the most extreme cases a large sausage-shaped mass is seen poking out of the anus (Figure 6.14). Initially the prolapse may occur only after defecation. As it progresses, the rectal prolapse becomes more and more difficult, and eventually impossible, to reduce.
- Rectal prolapse can be confused with severe cases of intussusception when the small bowel prolapses out of the anus. Children with this degree of intussusception are typically very ill and have abdominal distension. A simple method for distinguishing the two conditions is to see if a finger can pass between the mass and the side wall of the rectum. If a finger cannot be passed, the child has a rectal prolapse (see Figure 6.7, page 151).
- Rectal prolapse can also be seen in children with spina bifida or a history of a repaired imperforate anus. In such cases, the prolapse is usually related to a weak anal sphincter. Chronic excessive straining may cause submucosal fibrosis and thickening that further contributes to the tenesmus.

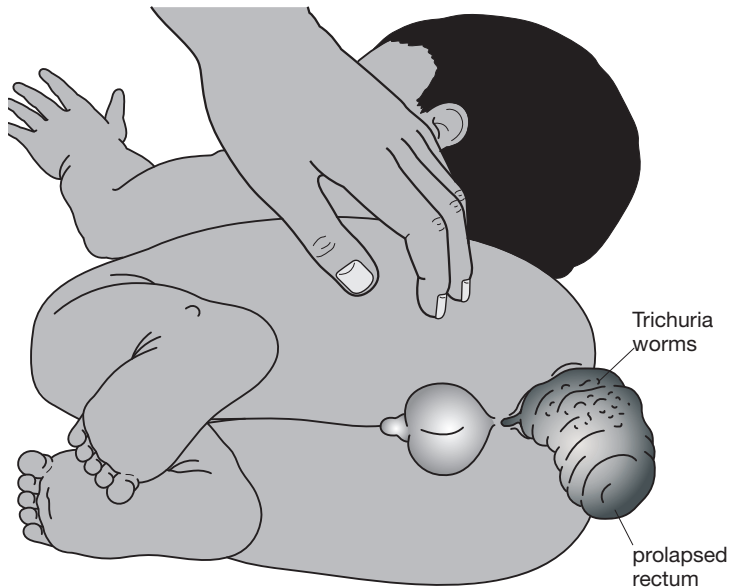


Figure 6.14 Prolapsed rectum.

6.7.2 Treatment

Provided that the prolapsed rectum is not dead (i.e. it is pink or red and bleeds), reduce with gentle constant pressure. Most rectal prolapses can be pushed back in if constant pressure is applied. It may take 20–30 minutes of pressure to reduce a large rectal prolapse.

Warning!

If the prolapsed rectum is dead (black and does not bleed), do not attempt to push it back. A gangrenous irreducible prolapsed rectum will require surgery.

- ▶ Following reduction, strap the buttocks firmly with tape for 24 hours (Figure 6.15).
- ▶ Treat for helminth infections (mebendazole), determine whether there are other causes of chronic constipation and diarrhoea, and improve the child's nutrition.
- ▶ If the condition recurs, repeat the treatment.
- ▶ The majority of rectal prolapses resolve if the underlying problem is corrected. For the rare child who develops chronic rectal prolapse there are several surgical options. An absorbable suture (Thiersch stitch) can be placed around the anus to slightly narrow the diameter. Care must be taken to avoid placing the suture too tightly. Alternatively, rectal prolapse can be repaired through a posterior sagittal incision to suspend the rectum. We do not recommend sclerotherapy to treat rectal prolapse.



Figure 6.15 Buttock strapping for treatment of a rectal prolapse.

- ▶ For the mucosal prolapse associated with repairs of anorectal malformations, excision of the excessive mucosa under general anaesthesia is usually satisfactory.

Indications for referral

A children with a rectal prolapse that does not respond to simple measures (buttock strapping, treatment of helminth infections and improvement in nutrition) should be referred to someone with paediatric surgical experience.

▶▶ 6.8 Hirschsprung's disease

Key points

- ◆ Hirschsprung's disease is caused by lack of nerve development in the lower bowel, which results in a functional bowel obstruction.
- ◆ The most important complication of Hirschsprung's disease is enterocolitis (inflammation of the bowel), which can lead to bowel perforation.
- ◆ Hirschsprung's disease can be treated with surgery.

Although uncommon, Hirschsprung's disease is common enough and the complications potentially so great that everyone caring for children should have some knowledge of the disease. The disease is caused by lack of nerve development (absence of ganglion cells) within the lower bowel. The affected segment of bowel does not relax, resulting in a functional obstruction.

6.8.1 Diagnosis

- A careful history usually reveals symptoms dating back to birth. Common symptoms include delayed passage of meconium at birth and constipation. If the

diagnosis is delayed, abdominal distension can be very significant. Vomiting usually occurs during the neonatal period. Explosive passage of stools following rectal examination is highly suggestive of Hirschsprung's disease.

- Abdominal radiographs show distended loops of intestine. Absence of rectal air or collapsed rectum may be seen on a prone abdominal radiograph. A transition zone (where the dilated proximal bowel and narrow affected bowel come together) can sometimes be identified.
- Contrast enema is the best method for demonstrating the transition zone, but is not always accurate. Retained contrast in the colon 24 hours after the study is also suggestive of Hirschsprung's disease. Certain technical aspects improve the diagnostic accuracy of contrast enema. Rectal washouts should be avoided for 24–48 hours before the study. A short catheter without a balloon should be inserted into the anus to avoid missing short-segment disease.
- Rectal biopsy is the gold standard for demonstrating the absence of ganglion cells histologically. If a specially designed suction biopsy forceps is available, this can be done as a bedside procedure without anaesthesia. If it is not available, a full-thickness rectal biopsy should be done under general anaesthesia. The biopsy specimen must be read by a pathologist familiar with the diagnostic criteria.
- In neonates, free gas in the peritoneal cavity and the finding of a caecal perforation at operation is highly suggestive of Hirschsprung's disease.

6.8.2 Enterocolitis

Enterocolitis – mucosal inflammation – is the most important complication of undiagnosed Hirschsprung's disease, and will sometimes be the initial presentation. It occurs proximal to the aganglionic segment of bowel. The typical presentation is fever and abdominal pain in a child with a history of constipation. Physical exam usually shows a distended and tender abdomen with explosive diarrhoea on rectal examination. If unrecognized, enterocolitis can progress to bowel perforation and sepsis, and may prove fatal. Enterocolitis can be easily confused with gastroenteritis or other causes of colitis.

Children with enterocolitis associated with Hirschsprung's diseases can be very ill. Medical management is the preferred treatment:

- ▶ fluid resuscitation (see Section 1.4.3 [page 7])
- ▶ nil by mouth
- ▶ broad-spectrum antibiotics (ampicillin, gentamicin and metronidazole)
- ▶ an important aspect of treating enterocolitis is to decompress the obstructed colon, which is done twice daily by rectal washouts using warm saline.

If the response to antibiotics and rectal washout is not satisfactory, an early defunctioning colostomy can be life-saving.

6.8.3 Surgical treatment

Decompression of the bowel is the aim until the patient can undergo surgical decompression with either a colostomy or a definitive procedure. Daily saline washouts or anal dilatations are effective methods for keeping the bowel decompressed. Remember that as long as the bowel is decompressed there is no risk of enterocolitis. Daily rectal washouts / anal dilatations are a useful method for temporarily managing children with Hirschsprung's disease when surgical expertise is not readily available.

The goal of surgery is remove the aganglionic segment of bowel, thus removing the functional bowel obstruction. The surgical treatment depends on the age at diagnosis.

Infants

- The traditional approach for treating a newborn with Hirschsprung's disease is to perform a 'levelling colostomy' shortly after diagnosis, and then to do a definitive pull-through procedure after 3–6 months. The colostomy must be done in normal bowel. In 75% of cases the transition zone is in the sigmoid colon.
- It is often possible to see the transition zone at the time of surgery. The bowel will be dilated just proximal to the transition zone. Colostomies created at this level do not always function well, and it is better to perform the stoma at a level where the bowel diameter is close to normal. If you are uncertain about the transition zone, a safe approach is to do a transverse colostomy. If available, frozen sections taken during the operation can be extremely helpful. Always take a specimen of bowel from the stoma site to prove that colostomy was done at the correct level.
- There are several different types of pull-through procedures. The most commonly used are the Soave endorectal pull-through and the Duhamel procedure. The Soave pull-through is commonly used for rectosigmoid disease. It involves a laparotomy, extramucosal dissection of the diseased rectosigmoid and ano–colonic anastomosis. The Duhamel procedure (retrorectal pull-through) is used for both rectosigmoid and total colonic Hirschsprung's disease; a stapler is usually used to perform the operation.
- More recently, endo–anal pull-through, with or without the use of laparoscopy, has become an established surgical technique. This approach is used if the condition is diagnosed early and its advantage is that the operation is done as a single-stage operation without performing a colostomy.

Older children

Treatment of older children can be technically challenging because delay in diagnosis can result in massive dilation of the bowel. These children usually require an end colostomy and a mucous fistula to allow the distal bowel to be cleaned out before the definitive surgery. In situations where the bowel is so dilated as to prevent an end colostomy, a 'blowhole' stoma can be created (see Section 6.10.3, page 173). The definitive pull-through operation is usually delayed for 6 months until the proximal bowel has returned to its normal diameter.

6.8.4 Postoperative complications

Children who undergo pull-through operations for Hirschsprung's disease continue to be at risk for enterocolitis. The management includes rectal washouts and antibiotics. Surgically correctable causes of post-operative enterocolitis include retained segment of aganglionic bowel, anastomotic stricture and cuff stricture. These can be excluded by physical examination and contrast enema. With proper surgical care, 90% of patients with Hirschsprung's disease will live a normal life.

6.8.5 Advice for parents

Reassure the parents that Hirschsprung's disease is a correctable condition. Explain that children with treated Hirschsprung's disease can still develop enterocolitis and describe the signs and symptoms (fever, abdominal pain and abdominal distension).

Indications for referral

Pull-through operations for Hirschsprung's disease should be done by someone with specialized training in paediatric surgery.

▶▶ 6.9 Abdominal masses

Key points

- ◆ The diagnosis of most abdominal masses can be narrowed by a detailed history and physical exam.
- ◆ Ultrasound is a valuable tool for determining the site and origin of the mass.
- ◆ Most children with an abdominal mass will require an operation at some stage during their care.

The care of a child with an abdominal mass may require resources that are not available at the primary referral hospital. It is therefore important to recognize your limitations and not to start on a path that will be to the detriment of the child. A poorly planned procedure may lead to complications, such as rupture of a tumour, that reduce the chances of survival even in expert hands. Therefore, think well before you start.

6.9.1 Diagnosis

Rather than listing all possible causes, it is better to think of groups of causes. You should be able to determine the major cause of an abdominal masses in most children from a detailed history and physical exam. The most common malignant and benign masses, categorized by the organ of origin, are given in Tables 6.1 and 6.2, respectively.

History

- Was the mass present at birth (congenital, e.g. ovarian or mesenteric cyst) or did it appear later (acquired)? If so, when was it detected?

Table 6.1 Most frequent malignant tumours seen in children, categorized by organ of origin

Location	Tumour
Liver	Hepatoblastoma Hepatocellular carcinoma (related to hepatitis B) Rhabdomyosarcoma
Kidney	Nephroblastoma Congenital mesoblastic nephroma (< 6 months of age)
Retroperitoneal	Burkitt's lymphoma Neuroblastoma (adrenal, sympathetic chain)
Ovary	Burkitt's lymphoma Germ cell tumour (malignant teratoma)
Vagina	Rhabdomyosarcoma (sarcoma botryoides)
Bladder/prostate	Rhabdomyosarcoma

Table 6.2 Most frequent benign masses in children, categorized by organ of origin

Location	Most likely cause
Liver	Hydatid cyst Congenital cyst
Biliary tract	Choledochal cyst (congenital)
Spleen*	Congenital cyst Abscess Torsion of wandering spleen
Pancreas	Traumatic pseudocyst Congenital cyst
Mesentery	Mesenteric cyst
Kidney	Cystic dysplastic kidney
Ovary	Cyst Teratoma
Appendix	Abscess

*Infectious diseases (e.g. malaria or typhoid) are the most common causes of an enlarged spleen in children living in the tropics but produce diffuse enlargement.

- Is the mass growing rapidly? (This suggests a malignant tumour.)
- Has there been an injury (traumatic pancreatic pseudocyst)?
- Has the child had fever and signs of an acute abdomen, as in perforated appendicitis with abscess formation?
- Consider the geographic location where you are working and the most common conditions in your area. Hydatid (echinococcal) cysts of the liver and other organs are seen in Northern Kenya and Sudan. Burkitt's lymphoma is common in tropical Africa. A rapidly growing retroperitoneal mass in an African child is much more likely to be Burkitt's lymphoma or a nephroblastoma (Wilms' tumour) than a neuroblastoma.

Physical examination

- Does the mass move with respiration? Lack of movement with respiration suggests that the mass is fixed to retroperitoneal structures.
- Are there large veins on the abdominal wall suggestive of collateral porto-systemic blood flow (caput medusae)?
- Is there venous congestion of the lower limbs, indicating long-term compression of the vena cava?
- Is the mass soft (cystic) or firm? A cyst under tension can also feel firm.
- Is the mass tender (as in abscess)?
- Can the mass be outlined clearly? Is it fixed or mobile?
- In which area of the abdomen is the mass located? This can provide valuable clues as to the organ of origin. However, some masses are very mobile, such as a wandering spleen or an ovarian cyst.

6.9.2 Investigations

Ultrasonography is helpful in most patients. Try to perform a systematic abdominal examination to see the liver, spleen, pancreas, kidney, uterus and ovaries, which may help you to find the organ of origin. Ultrasound can show whether the mass is cystic (low echodensity; 'black') or solid (echogenic; use the liver as standard). A plain radiograph of the abdomen may show calcifications, as occurs in a teratoma or neuroblastoma.

A complete blood count is helpful to detect signs of bacterial infection (a high white blood cell count would be expected). If you are able to estimate tumour markers, elevated levels of alpha-fetoprotein points to malignant teratoma (germ cell tumour) or hepatoblastoma.

6.9.3 Initial management

By putting all the information together, you should be able to make a working diagnosis: malignant tumour, probably of retroperitoneal origin; benign cyst, probably of the ovary; or inflammatory mass, probably of the appendix.

6 Abdominal problems

The next step is to decide whether you are able to treat the child in your setting, or whether it is better to refer the patient to a larger centre. Many factors will need to be considered, the most important being that a child with an abdominal mass will require an operation at some stage during their care, for which special skills and facilities are required.

Treatment of malignant tumours is based on tissue diagnosis. If you decide to treat the child in your hospital, you will need to make a tissue diagnosis. In countries where the main differential diagnosis is between a Burkitt's lymphoma and a nephroblastoma, this is best done using a needle biopsy. The best approach is a dorsal extraperitoneal route, ideally using ultrasound for guidance. This may give you sufficient material for cytology ('starry sky' appearance in Burkitt's lymphoma) or even histology. Alternatively, an open surgical biopsy can be performed, but this will contaminate the field with tumour cells and upstage the tumour in the case of nephroblastoma.

6.9.4 Management of malignant tumours

If all the findings are consistent with a malignant tumour (e.g. nephroblastoma), you will have to decide whether it is possible to remove it completely. Although nephroblastoma is usually chemosensitive, it can only be cured by complete removal of the tumour. There is no place for debulking. If there is any doubt, consider chemotherapy to shrink the tumour and improve the chances for a radical resection.

The primary treatment for Burkitt's lymphoma is chemotherapy. For details on chemotherapy regimens, refer to the standard textbooks or websites of the Children's Oncology Group (www.childrensoncologygroup.org) or the International Society of Paediatric Oncology (www.siop.nl).

Rhabdomyosarcoma is another highly malignant tumour that may arise in any organ but is more frequently seen in some sites in the body than others. Urogenital (bladder, prostate, vagina or uterus) rhabdomyosarcoma presents as a mass in the lower abdomen with haematuria or vaginal bleeding. Rhabdomyosarcoma is also sensitive to chemotherapy, up to a degree of almost complete remission (disappearance of the tumour) after several courses. This may lead to the false impression that the patient is cured but the tumour is likely to recur if the treatment is incomplete.

The aim of surgery for nephroblastoma and other malignant tumours is complete removal of the tumour, if possible with a margin of normal tissue. Sacrifice of other organs or structure is usually not necessary but is sometimes unavoidable. Tumour growth into the mesentery may necessitate bowel resection. Occasionally, part of the diaphragm or liver has to be resected in order to achieve complete removal. A tumour that is growing into the inferior vena cava via the renal vein (termed 'tumour thrombus') can be extracted via an opening in the inferior vena cava; secure control of the vein below and above the venotomy will reduce the blood loss. A more detailed discussion of nephroblastoma is provided in Section 7.7 (page 192).

6.9.5 Management of benign masses

The decision to operate on a benign intra-abdominal mass depends on the patient's symptoms, the type and origin of the mass, and on your skills and available facilities. A pancreatic pseudocyst can be treated with internal or external drainage, but only if its physical presence is causing problems and it has not resolved on its own after several months. A hydatid cyst of the liver should never be drained but needs excision, which can be a difficult operation.

The size of the mass does not always predict the technical difficulties. A huge ovarian cyst can be removed by division of two pedicles without much dissection, whereas a small mesenteric cyst may interfere with the blood supply of the intestine and therefore be impossible to remove completely. Ovarian cysts can twist, resulting in necrosis of the ovary; this is the reason for removal of an ovarian cyst larger than 5 cm diameter, preferably by excisional biopsy, in order to save ovarian tissue.

6.9.6 Advice for parents

Before starting chemotherapy to treat a malignant tumour, it is important to emphasize to the parents that the mass will probably become smaller but that an operation will still be necessary. Otherwise, they may get the impression that treatment with drugs will be sufficient and leave with the tumour in place and not come back for the operation. Some paediatric surgeons therefore keep the children in hospital until the operation.

Indications for referral

Transfer the child if the diagnostic and therapeutic skills and facilities are not available at your hospital.

▶▶ 6.10 Bowel management

Key points

- ◆ Most causes of constipation in infants and children can be diagnosed by a thorough history and physical examination.
- ◆ Constipation associated with fever, abdominal distension, anorexia, nausea, vomiting, weight loss or poor weight gain should suggest a possible organic cause.

6.10.1 Constipation

Constipation is defined as a delay or difficulty in defecation lasting longer than 2 weeks and sufficient to cause significant distress to the patient.

- Functional constipation is the most common cause of constipation in children and has been called idiopathic constipation, functional faecal retention and faecal withholding.

6 Abdominal problems

- Functional constipation is constipation without objective evidence of a pathological condition. The most common cause is voluntary withholding of faeces by a child who wants to avoid unpleasant defecation having experienced painful bowel movements. Many events can lead to painful defecation, such as toilet training, changes in routine or diet, stressful events and intercurrent illness. Postponing defecation can lead to prolonged faecal stasis in the colon, with reabsorption of fluids and an increase in the size and hardness of the stools.
- Constipation associated with fever, abdominal distension, anorexia, nausea, vomiting, weight loss or poor weight gain should suggest a possible organic cause. Only a minority of children have an organic cause for constipation.

Warning!

Bloody diarrhoea in an infant or child with a history of constipation could be an indication of enterocolitis complicating Hirschsprung's disease (see Section 6.8 [page 162]).

Most causes of constipation in infants and children can be diagnosed by a thorough history and physical examination.

- All children with constipation should have a rectal examination, to ensure that the anus is properly positioned, the anal sphincter tone is normal and the anal canal is not narrowed.
- A stool test for occult blood is recommended in all constipated infants and in children who also have abdominal pain, failure to thrive, diarrhoea or a family history of colon cancer or polyps.
- In selected patients, an abdominal radiograph can be useful to diagnose faecal impaction.
- Rectal biopsy with histopathological examination is the only test that can reliably exclude Hirschsprung's disease.
- ▶ The treatment of constipation is directed at the underlying cause. The general approach to managing a child with functional constipation involves determining whether faecal impaction is present, treatment of any impaction, starting treatment with oral laxatives, provision of parental education and close follow-up, with adjustment of medications as necessary.

6.10.2 Faecal incontinence after repair of an anorectal malformation

Faecal incontinence and other defecation disorders can occur after repair of anorectal malformations. Despite surgeons' best efforts, approximately 30% of children will experience faecal incontinence, and another 30% will have functional defecation disorders such as constipation, occasional soiling and faecal incontinence during periods of diarrhoea. Faecal incontinence is a devastating social problem that can lead to social isolation and psychological turmoil.

Fortunately, the causes of faecal incontinence following repair of an anorectal malformation can be diagnosed using simple tests and managed using relatively simple methods.

Children with faecal incontinence and other defecation disorders can be classified into three categories by history, physical examination, spinal and sacral radiographs and contrast enema. Magnetic resonance imaging of the pelvis can add additional information but is rarely available. Electrical stimulation of the anal sphincter under general anaesthesia using a nerve stimulator can also provide information on the location and function of the anal sphincter.

Candidates for re-operation

These children have a completely mislocated rectum and a well-preserved sphincter and therefore have the potential for bowel control provided the anus can be placed in the correct position. These patients should have their reconstructive surgery redone.

Candidates for bowel management

In these patients the rectum may be well located (within the limits of the sphincter mechanism) or mislocated, but they are not considered candidates for a reoperation because they have no potential for voluntary bowel control on the basis of their history and anatomy. Children in this category have a poorly developed sacrum, poor sphincters, and evidence of being born with a defect that has a poor functional prognosis (e.g. rectobladder neck fistula).

This group includes patients with two distinct types of faecal incontinence: those with a tendency to constipation and those with a tendency to diarrhoea. Each subgroup requires a different type of bowel management.

Pseudo-incontinent patients

These patients have a well-located rectum and favourable anatomy. However, they have constipation that may evolve into a megasigmoid (massively dilated colon). The treatment of this group is primarily with laxatives.

Management

Figure 6.16 shows an algorithm for managing anorectal malformation in patients who have postoperative faecal incontinence.

- ▶ Rectal washouts are an effective method for managing faecal incontinence. These consist of a large enema or colonic irrigation, every 24 hours, to keep the bowel empty. Patients do not receive a special diet or medication. A well-lubricated rectal rubber tube (20–24F) is passed as high as possible to deliver the enema fluid into the left colon. If this method is unsuccessful, a large Foley catheter can be introduced into the rectum (approximately 8 cm) and the balloon inflated with 10 mL water; sometimes 20 or 30 mL is needed to ensure that the balloon is large enough to remain inside the rectum during the irrigation. The enema is given while traction is applied on the catheter with the balloon inflated. The balloon thus serves as a plug to

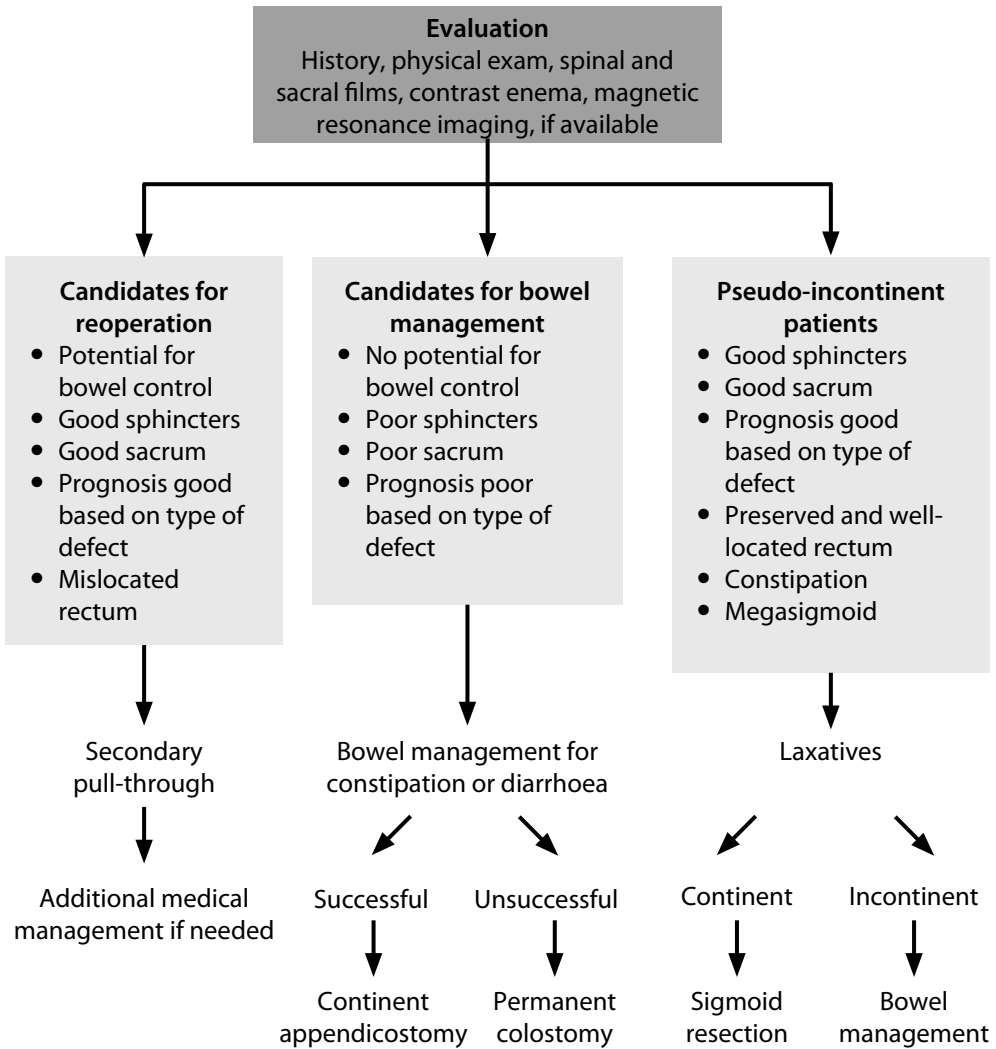


Figure 6.16 Strategy for managing children who have faecal incontinence following repair of an anorectal malformation.

avoid leakage, creating a more efficient enema. The enema should be administered 1 hour after eating to take advantage of the gastric–colic reflex.

- ▶ Saline enema should be used. The recipe for normal saline is 1.5 teaspoons of table salt (9.4 grams) dissolved in 1000 mL tap water. Do not change this recipe; doing so could be harmful.
- ▶ Correct administration of an enema on a daily basis should result in a bowel movement followed by a period of 24 hours of complete cleanliness. The volume of the enema is determined by trial and error. If the child soils at any point during the following 24 hours, the bowel washout was incomplete.

6.10.3 Colostomy and ileostomy care

Having a stoma is a major challenge for the child, family and surgeon, and the quality of life is directly related to the quality of the stoma. Therefore when the need for a stoma arises, the best results will be achieved when there is thoughtful planning based on the indications for the stoma and the strategies for reconstruction and reversal in the future.

There are several types of intestinal stoma. The clinical situation determines the type of stoma created and its location in the bowel. In children, the most common stoma types are the loop and end ostomies.

- For an **end stoma**, the bowel is divided and the proximal end is brought through the abdominal wall. The distal non-functioning limb can be brought out through the same abdominal wall opening as the end stoma (double-barrel stoma), through a separate incision (mucous fistula), or it can be closed and left in the peritoneal cavity (Hartmann procedure).
- A **loop stoma** is created by pulling a segment of bowel up through the abdominal wall without completely dividing the bowel. The bowel is kept from slipping back into the abdominal cavity by a tube or rod placed underneath the bowel. Loop stomas provide excellent decompression, but are not completely diverting because proximal contents can spill over into the distal limb. They should therefore be used with caution in patients in whom stool in the distal bowel may be problematic (e.g. infants with imperforate anus).
- A **'blowhole' stoma** can be created where emergency decompression is required in a critically ill patient, by opening the antimesenteric border of the bowel without mobilizing the entire loop of bowel. The edge of the opened bowel is sutured to the skin margin. Blowhole stomas are typically used to decompress a massively dilated colon resulting from chronic obstruction.

Warning!

The more proximal the stoma in the bowel, the greater the risk for developing fluid, electrolyte and nutritional problems.

- ▶ In small infants, it is unnecessary to create another wound for the stoma site as the stoma can be located in the laparotomy incision.
- ▶ When creating a colostomy for a child with imperforate anus or Hirschsprung's disease, it is important to evacuate the meconium in the distal pouch to avoid difficulties when the reconstruction is performed at a later stage.
- ▶ If possible, children with stomas should be followed up by a stoma therapist. Stoma therapists have important roles in teaching families and trouble shooting when problems arise. Minor issues such as poor bag adhesion, skin excoriation, minor bleeding, fungal infections and granulation tissue can be addressed quickly.

6 Abdominal problems

- ▶ Stoma complications such as prolapse, stenosis and retraction should be reviewed by a surgeon.
- ▶ Most stomas are temporary; the aim must be early closure with early correction of the primary diagnosis. Stomal closure should not be undertaken lightly; good planning will ensure a good outcome.

Indications for referral

Children with faecal incontinence or constipation following repair of an anorectal malformation should be evaluated by someone with specialized training in paediatric surgery.

▶▶ CHAPTER 7: Urological and Gynaecological Problems

7.1 Common urological problems

- 7.1.1 Urinary tract infection
- 7.1.2 Urinary tract obstruction
- 7.1.3 Posterior urethral valves

7.2 Foreskin problems

- 7.2.1 Normal anatomy
- 7.2.2 Phimosis
- 7.2.3 Paraphimosis

7.3 Circumcision

- 7.3.1 Neonatal circumcision
- 7.3.2 Circumcision in older children
- 7.3.3 Complications

7.4 Scrotal pain

- 7.4.1 Torsion of the testicle
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7.6 Hypospadias

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- 7.6.3 Advice for parents

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- 7.7.1 Diagnosis
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- 7.8.4 Spontaneous rectovaginal fistula
- 7.8.5 Sexual abuse
- 7.8.6 Advice for parents

▶▶ 7.1 Common urological problems

Key points

- ◆ Urinary tract infection is the most common urological problem in children.
- ◆ Recurrent urinary tract infections in children are often caused by a structural problem in the urinary tract.
- ◆ Urinary tract infections can damage the kidneys and can lead to renal failure if left untreated.

7.1.1 Urinary tract infection

Infection is the most frequently encountered problem of the urinary tract. It is commonly associated with voiding problems and vesicoureteral reflux.

- The clinical presentation of a urinary tract infection is different in children from adults. It can range from an acutely ill child with symptoms of acute pyelonephritis to the asymptomatic child with significant bacteraemia.
- Pyuria (white blood cells in the urine) is the most common finding on microscopic examination that leads to a diagnosis of urinary tract infection. The presence of white blood cell casts (clumps of white blood cells) in the urine implies pyelonephritis. If culture facilities are available, urinary tract infection is defined as greater than 1×10^5 colony-forming units per mL urine. Fewer organisms than this may suggest a urinary tract infection if the urine specimen has been properly collected (catheterized specimen, suprapubic aspirate or a clean-catch specimen in a male).
- Neonates can present with irritability, lethargy, anorexia, vomiting and even jaundice.
- Toddlers may present with failure to thrive. Irritability is common, as is vomiting. Children may also have urinary retention, daytime or night-time wetting or foul-smelling urine.
- Older children tend to have more specific symptoms, as found in adults (frequency, urgency and dysuria).

Warning!

Chronic and recurrent infection in the urinary tract damages the kidneys and can result in renal failure if left untreated.

Every child diagnosed with recurrent urinary tract infection should have their urinary tract evaluated for structural anomalies. Ultrasound is the ideal way to screen the upper urinary tract (kidneys and ureters). A voiding cystourethrogram is the study of choice for determining the functional characteristics of the bladder. In the male, the urethra should be examined during voiding to exclude the possibility of posterior urethral valves (see Section 7.1.3).

7.1.2 Urinary tract obstruction

Obstruction of the urinary tract can occur anywhere from the kidney to the urethra. The most common sites are the ureteropelvic junction (junction of kidney and ureter), the vesicoureteral junction (junction of bladder and ureter), the bladder and the urethra.

Warning!

Urinary tract obstruction predisposes to urinary tract infection and if prolonged can result in damage to the kidneys.

- Failure to void in the early neonatal period is not uncommon. Most neonates void by 12 hours of life, 90% by 24 hours, and 99% by 48 hours. Suspicion for an underlying urological abnormality should begin at 12 hours, with the evaluation beginning at 24 hours.
- The most common causes of lower urinary tract obstruction are posterior urethral valves in a boy (see Section 7.1.3) and meatal stenosis in a girl. Other causes include anomalies of the spine and sometimes anomalies of the nerve supply to the bladder.
- When possible, any child with suspected urinary tract obstruction should undergo ultrasound imaging of the whole urinary tract to outline the site of obstruction and the anatomical changes that have occurred to the system.
- ▶ The fundamental principle of treating urinary tract obstruction is to relieve the obstruction and treat the infection.
- ▶ Treatment depends on the site and nature of the obstruction.

7.1.3 Posterior urethral valves

Urethral valves are small web-like structures that obstruct urine flow through the urethra in boys. They are most commonly located in the posterior urethra. Unrecognized posterior urethral valves can result in serious urinary tract problems, including renal failure.

- Ultrasonography of the urinary tract will demonstrate a distended bladder and bilateral hydronephrosis.
- The most important investigation is a micturating cystourethrogram. The bladder is filled with contrast material using a Foley catheter under sterile conditions. The catheter is removed and radiographs are taken when the child passes urine.
- Cystoscopy is the definitive diagnostic test and also allows for valve ablation. Endoscopic ablation is typically done with a 7.5F endoscope with an operating channel.
- ▶ Placement of a Foley catheter will allow decompression of the urinary tract until a more definitive valve ablation can take place. Occasionally, the catheter can ablate or erode the urethral valves and relieve the obstruction. Be aware that because of the thick-walled bladder, drainage of the bladder can cause obstruction at the vesicoureteral junction and lead to renal failure.
- ▶ Vesicostomy may be needed in children with severe disease or where endoscopic ablation is not possible.

Indications for referral

Children with urinary tract obstruction or recurrent urinary tract infection should be evaluated by someone with experience in paediatric urology.

▶▶ 7.2 Foreskin problems

Key points ◀◀

- ◆ Phimosis (inability to retract the foreskin) and paraphimosis (inability to pull the foreskin over the glans) are the two most common problems affecting the foreskin.
- ◆ Both conditions are treated by circumcision.

7.2.1 Normal anatomy

In infancy the foreskin (prepuce) naturally adheres to the glans and can be retracted in only 20% of boys by 6 months of age. Ten percent of normal boys will still have an unretractable foreskin at 3 years of age.

7.2.2 Phimosis

Phimosis refers to inability to retract the foreskin from over the glans penis. The advantage of a retractable foreskin is that it allows for easy cleaning of the penis.

- The child's mother may report ballooning of the foreskin when the child urinates. There may also be continued drops of urine after the child has finished urinating. Phimosis can also cause painful urination and foreskin irritation. Phimosis is associated with increased risk of urinary tract infections.
- On examination the orifice of the foreskin is narrowed (Figure 7.1) and may appear scarred or closed.

Treatment

- ▶ Topical corticosteroid cream (0.05% betamethasone) applied twice a day for 1 month can soften the foreskin and make retraction easier; begin retracting the foreskin on the fifth day. This method has a 70% response rate when used to treat an unscarred foreskin.
- ▶ Circumcision is the treatment of choice when the above approaches have failed or when there is significant scarring.
- ▶ Forceful retraction can be very traumatic to the child and should be avoided.

7.2.2 Paraphimosis

Paraphimosis is the inability to pull the foreskin back down over the glans penis (Figure 7.2).

- This condition occurs when the foreskin has been pulled up over the glans penis and has not been pulled downwards for some time. The foreskin becomes tight and swollen. The tightness blocks fluid from draining from the glans and the tissue becomes more and more swollen.

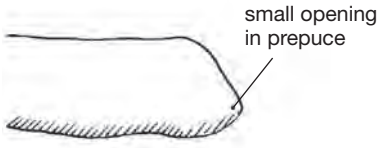


Figure 7.1 Phimosis.

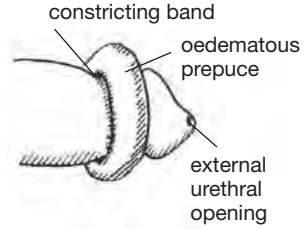


Figure 7.2 Paraphimosis.

Treatment

- ▶ If the paraphimosis has been present for only 1 or 2 days, attempt a manual reduction by pulling the foreskin into place while applying firm constant compression to evacuate the tissue swelling (Figure 7.3). Pushing the glans inwards can also help.
- ▶ If reduction is not successful, make a small slit incision in the long axis of the dorsal surface of the penis (on the opposite side from where the urethra is located), at the junction where there is a tight band (Figure 7.4). When the band is divided the foreskin should easily return to its place.

Figure 7.3 Reduction of paraphimosis. The affected penis (A); injecting local anaesthetic in a ring around the base (B); squeezing the oedematous part of the penis (C, D); the foreskin (E) is pulled over the glans (F).

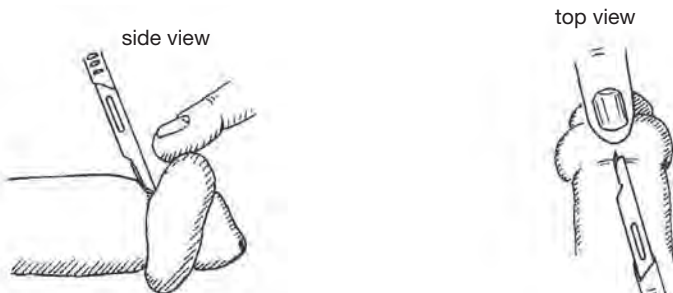
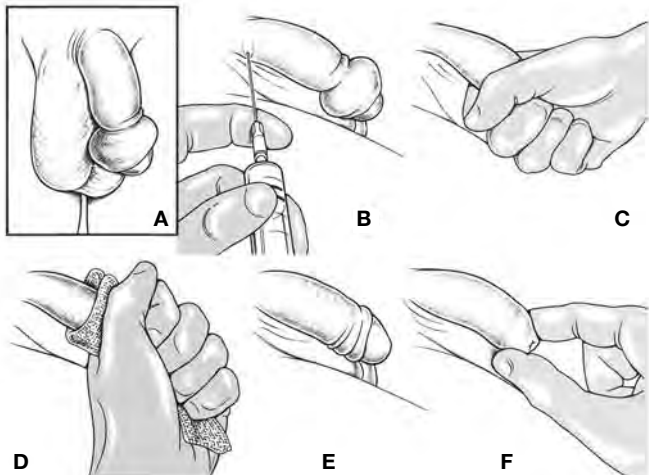


Figure 7.4 Dorsal split operation for paraphimosis.

- ▶ At a later date an assessment is made to determine whether circumcision is required. Circumcision should not be done until the swelling has resolved.

▶▶ 7.3 Circumcision

Key points

- ◆ The potential of circumcision to cause serious complications is often underestimated.
- ◆ Boys with hypospadias should not be circumcised, as the foreskin is often used for the repair.
- ◆ For boys who are not circumcised at birth, defer the operation until the child is at least 1 year old to minimize the risks associated with anaesthesia.

Circumcision is the most common paediatric surgical procedure, and is probably the most common procedure performed by non-surgeons. There are both medical and non-medical reasons for performing circumcision. Non-medical reasons include cultural and religious reasons, and parental preference. Medical conditions include:

- inability to retract the foreskin (phimosis)
- inability to pull the foreskin over the glans (paraphimosis)
- foreskin infection (posthitis)
- infections of the glans penis (balanitis)
- prophylaxis against a variety of conditions:
 - urinary tract infection – any uncircumcised male who has had a urinary tract infection should undergo circumcision
 - sexually transmitted infection
 - penile cancer and the risk of cervical cancer in female partners
 - HIV/AIDS infection – circumcision is now recognized as one of the most effective methods for preventing this infection.

7.3.1 Neonatal circumcision

Warning!

A circumcision should not be done in a baby with a hypospadias because the foreskin is often used in the repair (see Section 7.6). If hypospadias is encountered during neonatal circumcision, the procedure should be halted.

Circumcision is easiest when performed in newborns. The most commonly used methods are the Plastibel and the Gomco clamp. Both procedures begin with complete separation of the glandular adhesions. A dorsal split is sometimes needed

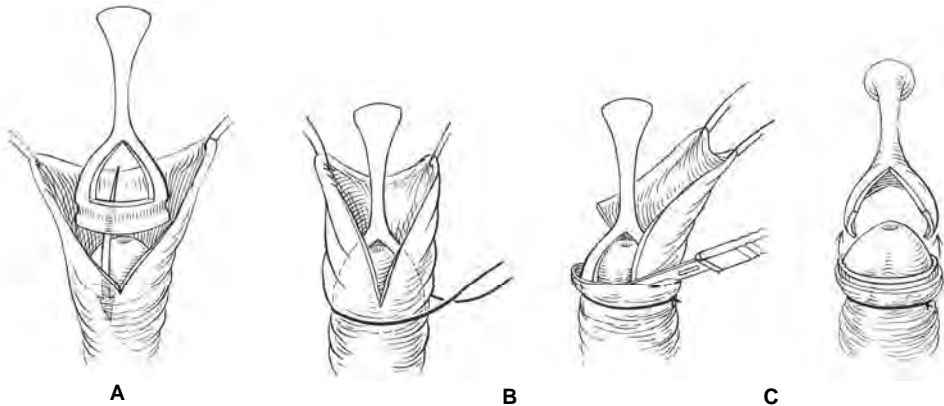


Figure 7.5 Plastibell circumcision: (A) After a dorsal slit is done, an appropriately sized Plastibell is placed over the glans of the penis, and the prepuce is drawn over the plastic ring: (B) With gentle outward traction on the redundant prepuce, a heavy suture is tied over the prepuce in the groove of the plastic ring. Inspection of the glans assures the proper placement of the suture prior to securing the knot. The knot should be tied tightly to keep the plastic ring in place, and render the distal prepuce ischemic. (C) The redundant prepuce is excised to expose the underlying glans. The breakaway holder is removed.

to allow complete retraction of the foreskin. If a Plastibel is used, a cotton tie is used to tie the foreskin around a plastic ring (Figure 7.5). The foreskin is trimmed to the appropriate length and the plastic ring left in place to fall off approximately a week later. A Gomco clamp crushes and then seals the foreskin (Figure 7.6).

Regardless of the method and the age of the patient, circumcision is a painful procedure. As such, every effort should be made to minimize the pain.

- ▶ The preferred method of analgesia for circumcision in a neonate is a dorsal penile block (Figure 7.7). Lidocaine 1% or bupivacaine 0.25%, without epinephrine, is injected at the base of the penis dorsally to block the dorsal penile nerve (see Section 1.8.6, page 29).

Warning!

Epinephrine should never be used for local anaesthesia in an end organ (digits, ear, penis).

- ▶ Rectal paracetamol (15 mg/kg) can be given half an hour before surgery.
- ▶ A sucrose pacifier (2 mL 24% sucrose) can also provide additional pain relief.

7.3.2 Circumcision in older children

The hand-sewn technique (Figure 7.8) is the preferred method of circumcision once a child is several months old. If a child is not circumcised as a newborn, and there is not a medical indication for the procedure, defer the operation until the child is over 1 year of age, to avoid the risks associated with anaesthesia.

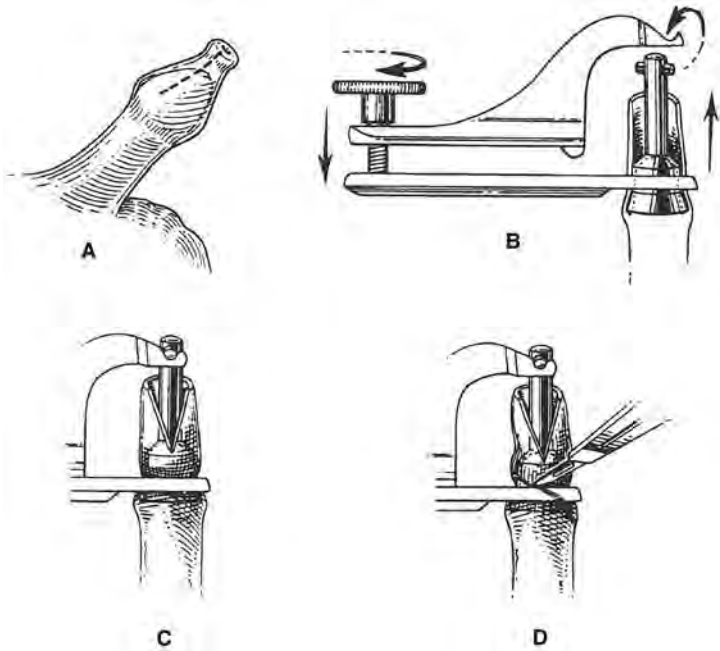


Figure 7.6 Gomco clamp circumcision: (A) A dorsal split is made following application of a straight crushing haemostat, and the prepuce retracted. (B) An appropriately sized Gomco bell is placed over the glans and the prepuce drawn over the bell. (C) The clamp is placed over the bell and the prepuce is tightly screwed shut. (D) The excess prepuce is sharply excised and the clamp removed. (Source: *Operative Pediatric Surgery* (Zigler, Azizkhan & Weber).

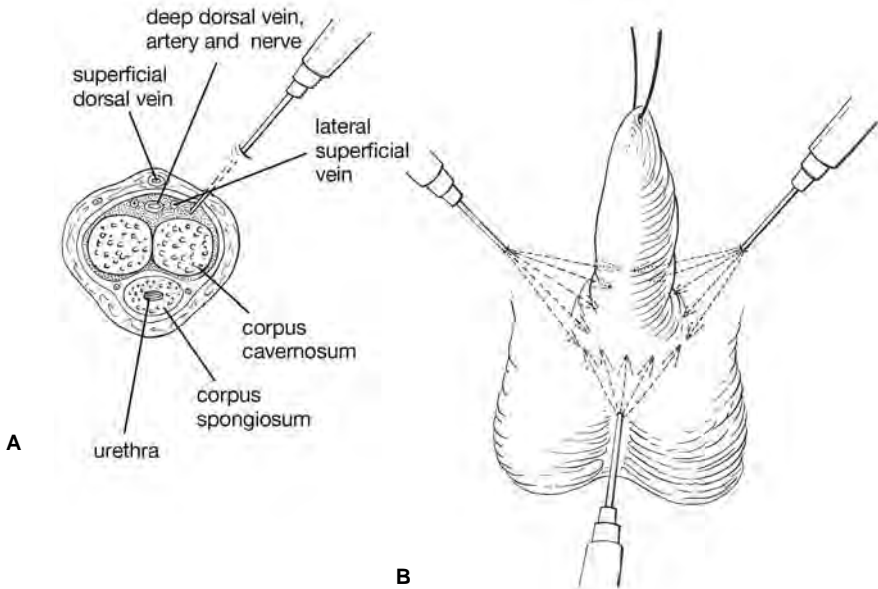


Figure 7.7 Technique for a sensory blockade of the penis. After a dorsal penile injection, the anaesthetic agent is infiltrated with a lateral and ventral fan-like distribution. (Source: *Operative Pediatric Surgery* (Zigler, Azizkhan & Weber).

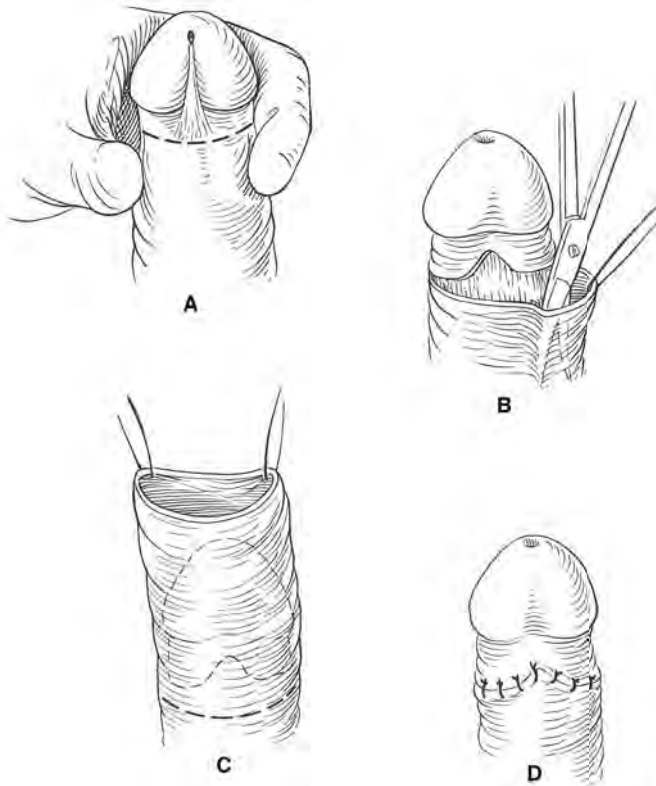


Figure 7.8 Hand-sewn circumcision: (A) After separation of preputial adhesions, a circular incision is made around the penile shaft 1 cm proximal to the corona; (B) The shaft skin is then bluntly and sharply elevated off the surface of the body of the entire circumference of the penile shaft. (C) The undermined shaft skin and redundant prepuce are then pulled over the gland and a second circumferential is made around the penis, excising the redundant prepuce. Haemostasis must be secured with forcep and electrocautery, with bleeding vessels raised off the surface of the penis before coagulation. (D) Interrupted absorbable sutures are then placed in a circumferential fashion between the proximal and distal shaft skin.

The hand-sewn circumcision

- ▶ Perform the procedure in an operating room under general anaesthesia using sterile conditions.
- ▶ Administer a dorsal penile block or local anaesthesia before surgery.
- ▶ Retract the foreskin and clean the smegma.
- ▶ Cut the skin 5 mm below the subcoronal sulcus, stopping bleeding vessels as you proceed. If available, use a diathermy machine to control bleeding, otherwise use plain catgut to tie off bleeding vessels. Haemostasis is very important.
- ▶ Excise the excess skin.
- ▶ Suture the skin margins using absorbable suture.

7 Urological and gynaecological problems

- ▶ Apply a petroleum gauze dressing reinforced by sterile gauze.
- ▶ Postoperative care: the wound can be left open from the second day. It should be cleaned using a 10 minute salt bath three times a day for 1 week.

7.3.3 Complications

Circumcision is not a benign procedure and can be associated with significant complications and even death. The most common complications include:

- bleeding
- infection
- wound disruption
- injury to the glans penis
- urethrocutaneous fistula
- skin loss
- incomplete circumcision
- toxicity from local anaesthesia.

▶▶ 7.4 Scrotal pain

Key points

- ◆ Sudden onset of severe pain in the scrotum is torsion of the testicle until proven otherwise.
- ◆ It may be impossible to determine if a child has torsion of the testicle based solely on physical examination. It is better to operate and find a normal testicle than to not operate and lose a testicle.

Sudden onset of pain in the scrotum can be caused by a number of problems, some surgical and some non-surgical (Table 7.1). The most important problem to exclude is torsion (or twisting) of the testicle.

Table 7.1 Causes of scrotal pain in children

- Torsion of the appendix epididymis testis
- Torsion of the testis
- Epididymitis
- Trauma
- Other local conditions:
 - incarcerated inguinal hernia
 - acute hydrocele
 - infections such as tuberculosis and pyogenic abscess

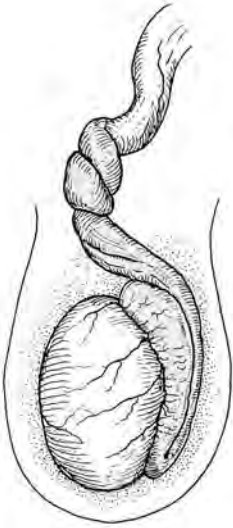


Figure 7.9 Torsion of the testicle. (Reproduced from KW Ashcraft & TM Holder, *Atlas of Pediatric Surgery*, WB Saunders, 1994.)

7.4.1 Torsion of the testicle

In this condition, the spermatic cord twists, cutting off the blood supply to the testicle (Figure 7.9). It results from inadequate fixation of the testicle in the scrotum.

Warning!

If torsion of a testicle is not recognized and treated within 6 hours, the testicle will die from lack of blood flow.

Although rare, torsion can also occur in the neonatal period. Torsion of the testis in the newborn is seen as a large and firm scrotal mass. In most cases the testis is dead by the time the condition is diagnosed.

Diagnosis

- Testicular torsion should be suspected in any boy with sudden onset of severe unilateral scrotal pain. The condition is most common in adolescents. It can be associated with nausea and vomiting. The affected side is swollen and tender.
- If available, a Doppler ultrasound study can show reduced blood flow to the affected testicle.

Treatment

Because it may be impossible to distinguish a testicular torsion from non-surgical causes, all suspected cases of testicular torsion should be explored surgically. This may seem excessive, but it is better to do a negative exploration than to miss a problem that could result in loss of the testicle. The technique for exploring a scrotum for a suspected torsion is shown in Figure 7.10. A vertical incision is made through the median raphe. Should a testicular torsion be found, it is untwisted by rotating in a clockwise position.

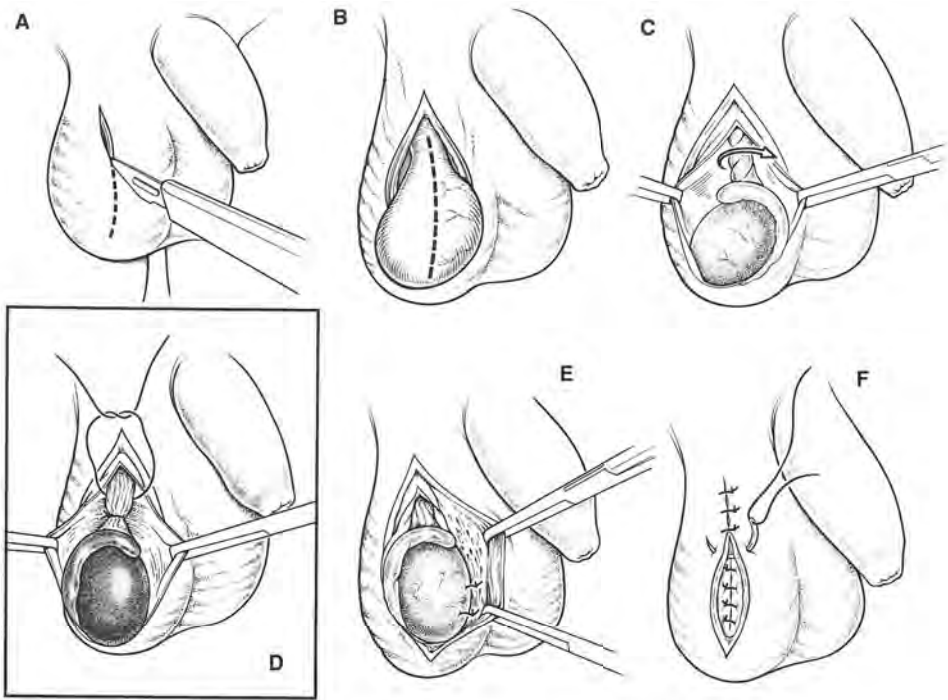


Figure 7.10 Treatment of torsion of the testicle. Incisions are made in (A) the scrotum and (B) the tunica vaginalis. (C) The torsion is untwisted in the direction of the arrow. (D) Excision of a gangrenous (black) testis and double ligation of the cord. (E) Fixing the tunica albuginea of a non-gangrenous testis to the scrotal septum. (F) Closure of the wound in two layers. (Reproduced with permission from JA O'Neill et al. *Principles of Pediatric Surgery*, Mosby, 2003.)

If the testicle is dead (black), it is removed. If the colour of the testicle improves after untwisting, the testicle should be fixed so that it will not twist again. An important principle is to also fix the other testicle in position to prevent it from twisting.

7.4.2 Other causes of scrotal pain

Torsion of the appendix epididymis testis

This condition results when a small appendage of the testicle twists (Figure 7.11). The scrotal pain and swelling is less severe than with testicular torsion. This condition is self-limiting and can be treated with analgesics. If there is any question that the pain might represent torsion of the testicle, the scrotum should be explored.

Epididymitis

Epididymitis in adolescents and young adults is often related to sexual activity and may not be caused by a urinary tract infection. If a urine culture is negative, the symptoms are most likely to be due to abacterial epididymitis caused by urine reflux. Bed rest and scrotal elevation are often helpful. NSAIDs and analgesics can be used to alleviate symptoms.

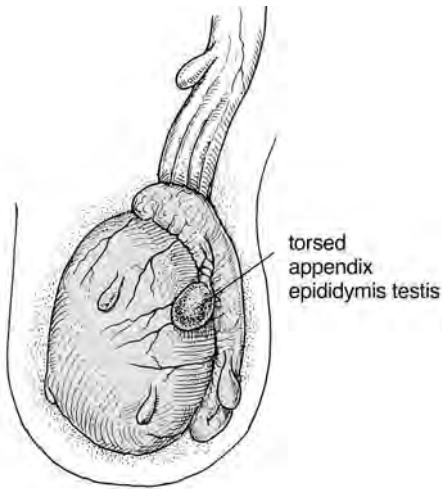


Figure 7.11 Torsion of appendix epididymis testis. (Reproduced from KW Ashcraft & TM Holder, *Atlas of Pediatric Surgery*, WB Saunders, 1994.)

In prepubertal boys, however, epididymitis is almost always due to a urinary tract infection related to a urinary tract anomaly. Boys with epididymitis should be evaluated with a renal/bladder sonogram and a voiding cystourethrogram to rule out structural problems. Treatment is with antibiotics.

Orchitis

Acute orchitis is rare as an isolated entity. More often, the testis is involved in the advanced stages of acute epididymitis. However, orchitis can be caused by viral (e.g. mumps) or bacterial infections. The patient who has acute orchitis will have an acutely tender and swollen testis without any involvement of the epididymis (unless associated with epididymitis). Orchitis is easily confused with torsion of the testicle.

▶▶ 7.5 Undescended testicles

Key points ◀◀

- ◆ An undescended testicle is one that is not located in the scrotum.
- ◆ Always try to distinguish between a retractile testicle and true undescended testicle. A retractile testicle can be brought down into the scrotum by gentle manipulation, and does not require surgery.
- ◆ An undescended testicle is more likely to develop cancer, less likely to produce sperm, resulting in reduced fertility, and is more likely to be injured from blunt trauma if located in the inguinal canal.
- ◆ If a testicle has not descended into the scrotum by 2 years of age, consider bringing the testicle down surgically (orchidopexy).

Testicles usually descend from the abdomen into the scrotum during the 28th week of gestation and should be in the scrotum at birth.

7.5.1 Diagnosis

- An empty scrotum may be the result of retractile testes or true undescended testicle; 20–30% of premature infants and approximately 4% of term infants will have an empty scrotum.
- A true undescended testicle has never been in the scrotum.
- Retractable testes move in and out of the scrotum. It is best to examine a child when they are relaxed. Retractable testes can usually be placed into the scrotum by gentle manipulation. No surgical treatment is needed.

7.5.2 Treatment

The testes may descend into the scrotum spontaneously up until 1–2 years of age. Boys younger than this should be observed to see if the testes descend. If a testicle has not descended by about 2 years of age, consider bringing it down surgically (orchidopexy). However, there are no long-term data to strongly support orchidopexy by 2 years of age, so consider leaving the operation until 5 years of age if there is concern about the safety of general anaesthesia.

Figure 7.12 shows the technique for performing an orchidopexy.

- ▶ An inguinal incision is made, as for inguinal hernia repair (see Figure 6.13, page 158).
- ▶ Locate the testicle and free it from the surrounding tissue to provide sufficient length to get it to the base of the scrotum. The testicular artery usually limits how far the testicle can be brought down, and getting adequate length is sometimes challenging. Ideally, the testicle should be placed at the bottom of the scrotum, although the upper part of the scrotum is acceptable.
- ▶ Undescended testes are usually associated with a hernia sac or patent processus vaginalis, which is ligated as part of the surgery for the undescended testicle. Extreme care must be taken to avoid injuring the vessels and the vas deferens when the testicle dissected off the hernia sac.
- ▶ Ligate the hernia sac, as in inguinal hernia repair.
- ▶ Create a scrotal pocket for the testicle by blunt dissection.
- ▶ Place a suture through the bottom of the testicle and then pass it down through the inguinal canal and out through the scrotal skin.
- ▶ Anchor the testicle to the pocket created in the scrotum.
- ▶ Close the groin incision.

7.5.3 Advice for parents

The mother will have noticed that a testicle is not in the scrotum at the time of birth. Reassure the parents that testes sometime descend during the first or second year of life. If a dead testicle is found, reassure the parents that one testicle provides sufficient fertility to have children.

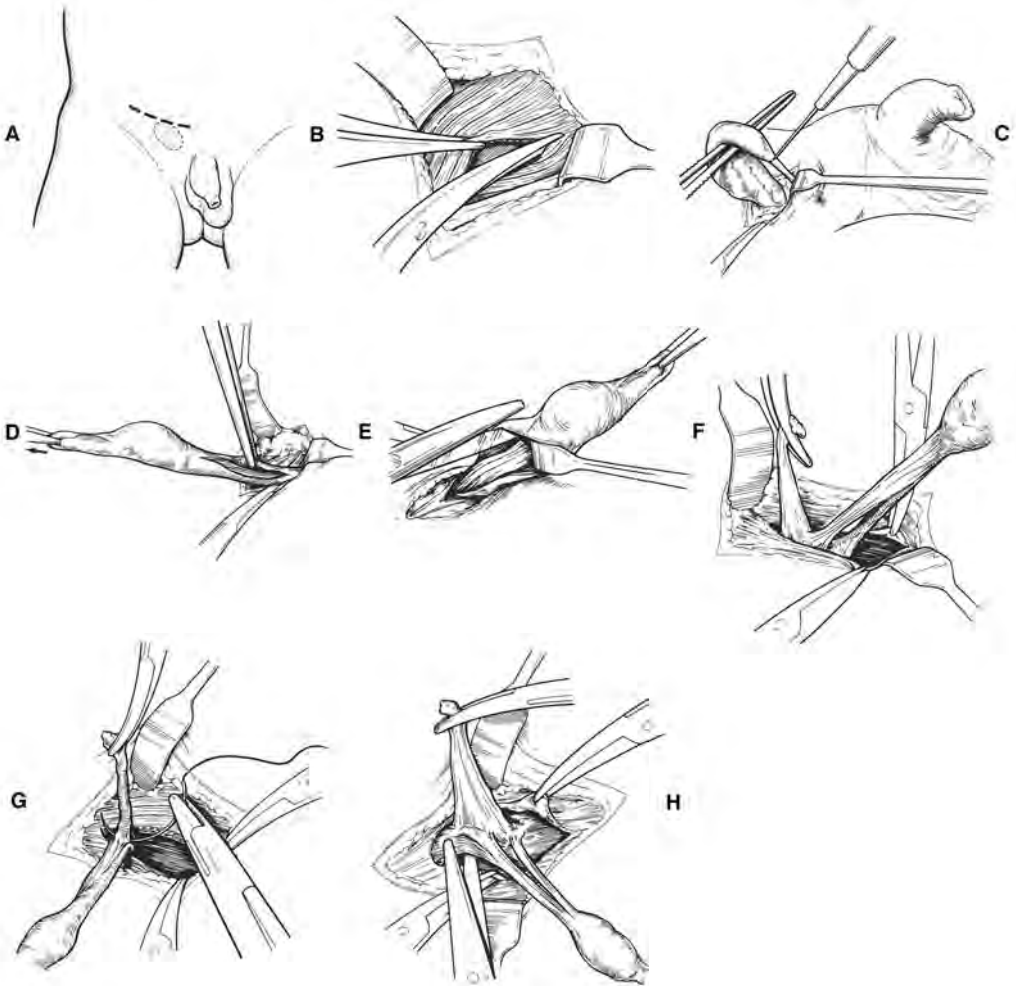


Figure 7.12A Orchidopexy. (A) Skin crease incision over external ring and extending laterally. (B) After dividing Scarpa's fascia, the external oblique aponeurosis is exposed and opened with a scalpel and extended medially toward the external inguinal ring with scissors. Application of mosquito forceps to the edges may facilitate subsequent identification and closure. (C) A testis in the superficial inguinal pouch or public region is easily seen at this point, and it can be picked up so traction on the spermatic cord can permit the distal attachment of the gubernaculum to be identified and divided. In most instances, the gubernaculum is attached just lateral or above the neck of the scrotum. (D) With traction on the tunica vaginalis, the cremaster muscle fibres are stripped off, and any residual processus vaginalis is dissected off the vas and vessels, beginning posteriorly where the free edges of the sac are found. (E) The vas and vessels are identified separate from the hernial sac and are protected by a small retractor while the sac is clamped and divided. (F) The anteromedial processus vaginalis is dissected from the posterolateral gonadal vessels up to the internal inguinal ring, where the vas deferens diverges medially. (G) Transfixion and ligation of the processus vaginalis at the internal ring. Twisting the sac first ensures that the needle does not catch any intraperitoneal structures inadvertently. (H) Extra length may be achieved by freeing up the lateral side of the gonadal vessels in the retroperitoneal space. (*Pediatric Surgery*, 6th edition. JLG Grosfield, JA O'Neill, AG Coran, EW Fonkalsrud. Mosby, 2006.

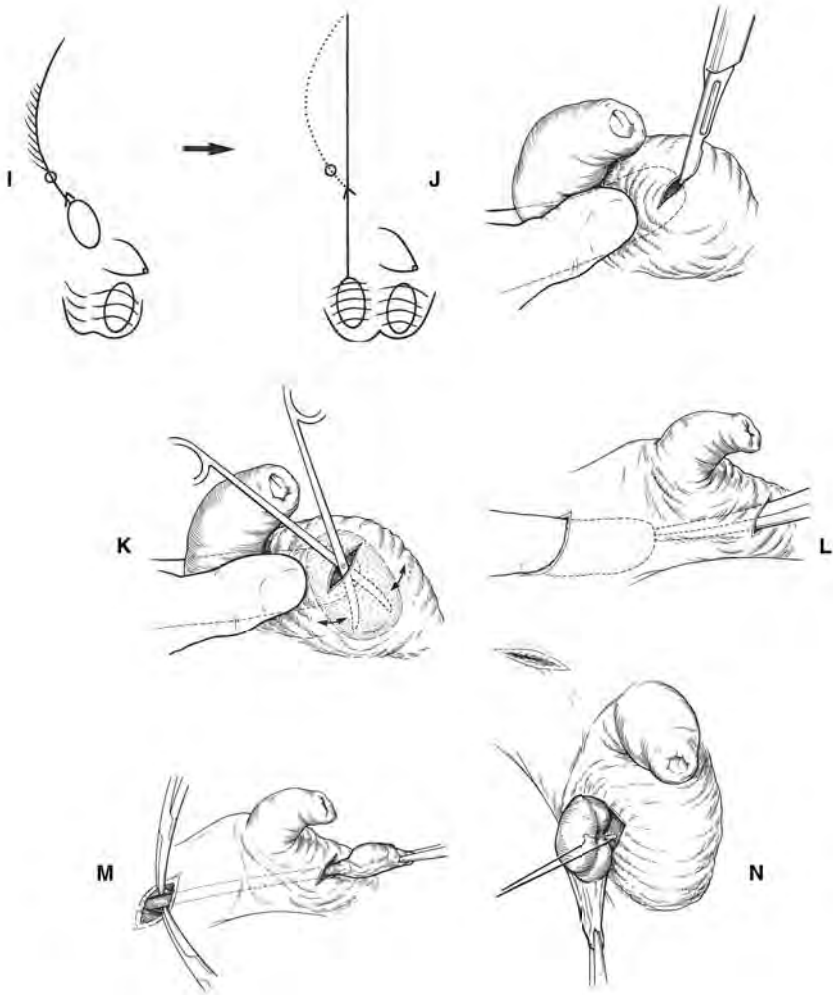


Figure 7.12B (I) Straightening of the path taken by the gonadal vessels may allow the testis to reach the scrotum. (J) Incising the scrotal skin after blunt finger dissection has created a path to the scrotum from the inguinal incision. Either midline or transverse incisions may be used to gain entrance to the subdartos space; I prefer the latter because there is less bleeding. (K) A subcutaneous pouch is made in the scrotum by undermining the incision with scissors or artery forceps. Careful attention must be given to haemostasis to avoid a post-operative hematoma. (L) A fine artery forceps is pushed through the inguinoscrotal fascia, guided by the retreating finger, to connect the two incisions by a small buttonhole. (M) The forceps grasps the testis, being careful not to twist the cord structures, and pulls the testis down to the scrotal incision through the fascial buttonhole into the subdartos pouch. (N) There may not be tension on the testis, and anchoring is optional. The testis may be sutured to the scrotal septum by a fine suture through the tunica albuginea, or alternatively the opening in the fascial buttonhole can be narrowed with one or two sutures, particularly if there is any tension on the cord structures, so the testis does not retract upward. The scrotal and inguinal incisions are closed in routine fashion. (From Spitz L, Coran Ag: *Pediatric Surgery*. In *Rob and Smith's operative surgery*, ed. 5, London, 1995, Chapman & Hall.)

Indications for referral

Orchidopexy is a difficult procedure and should only be done by someone with experience in this type of surgery.

▶▶ 7.6 Hypospadias**Key points**

- ◆ Hypospadias should be suspected when there is incomplete formation of the foreskin, chordee (downward bowing or curvature of the penis) and more proximal opening of the urethral opening.
- ◆ Because the foreskin is often used to repair the hypospadias, infants with a hypospadias should not be circumcised.
- ◆ Hypospadias is a correctable problem.

Hypospadias is an abnormality of anterior urethral development in which the urethral opening is ectopically located on the ventrum of the penis proximal to the tip of the glans. In severe cases, the opening may be as proximal as the scrotum or perineum. It is commonly associated with a downward bowing or curvature of the penis (chordee). The more proximal the urethral opening, the more likely the urinary stream is deflected downward, which may require urinating in a sitting position. Any curvature of the penis can exacerbate this problem. Fertility may be affected because of the curvature and more proximal meatus.

Other associated abnormalities include undescended testes and inguinal hernia. Upper urinary tract anomalies are rarely associated with hypospadias and routine imaging in these patients is not justified unless other organ system anomalies are present.

7.6.1 Diagnosis

- Most forms of hypospadias are immediately recognized during physical examination of the newborn. Hypospadias should be suspected when there is incomplete formation of the foreskin. In the normal newborn the foreskin should completely cover the glans. It is adhered to the glans and should not be retracted.
- Hypospadias is classified by the position of the urethral opening (Figure 7.13). The opening may be anterior (glanular and subcoronal), middle (distal penile, midshaft or proximal penile) or posterior (penoscrotal, scrotal or perineal). The subcoronal position is the most common overall.

7.6.2 Treatment

The aim of surgery is to straighten the penis and to place the opening of urethra at the tip of the penis and is done for functional and cosmetic reasons. Repair done at 12–18 months of age is associated with a better emotional and psychological outcome.

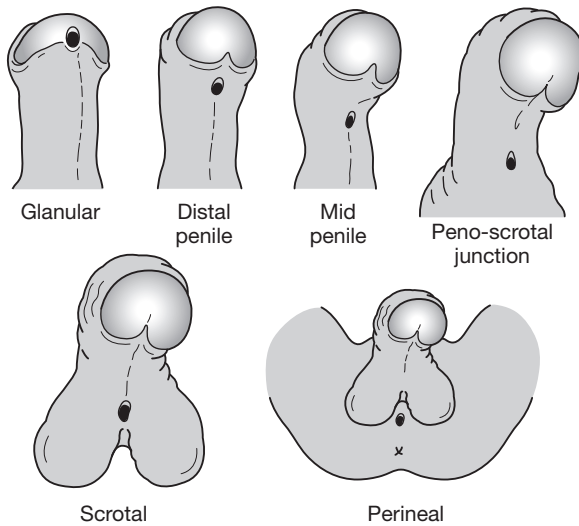


Figure 7.13 Types of hypospadias.

Warning!

Infants with hypospadias should not be circumcised, as the foreskin is often used for the repair. If hypospadias is encountered during neonatal circumcision, the procedure should be halted.

7.6.3 Advice for parents

Reassure the parents that the condition is treatable and that repair is not urgent.

Indications for referral

Hypospadias repair is a technically difficult procedure and should be done by someone with experience in this type of surgery.

7.7 Wilms' tumour (nephroblastoma)

Key points

- ◆ Wilms' tumour is common throughout sub-Saharan Africa, where it is second in frequency only to Burkitt's lymphoma as a cause of death due to malignant solid tumours in children.
- ◆ Wilm's tumours grow rapidly and spread early.
- ◆ It is often curable, even when presenting as advanced disease.

Wilms' tumour is a rapidly growing cancer of embryonal origin that metastasizes early. Treatment protocols in settings of limited resources must accommodate the often advanced disease and comorbidities such as malnutrition, HIV infection, tuberculosis and hypertension. Irregular supply of chemotherapy agents and lack of supportive facilities such as radiotherapy further complicate care. In addition, parents are often unaware of malignancy and require intensive counselling to minimize protocol violations. Despite these challenges, management of these children can be rewarding.

7.7.1 Diagnosis

- The tumour often presents as a painless abdominal mass. Typically, the child is between 3 and 5 years of age, although any age can be affected. Children have often already been treated unsuccessfully by a traditional healer. Occasionally haematuria is the presenting feature, and rarely the tumour is damaged in a fall or other accident.
- Unfortunately, the differential diagnosis of a flank mass or haematuria is widespread and this contributes to delays in diagnosis. Delays in diagnosis are particularly common in areas of endemic bilharzia or where malaria with resultant splenomegaly is common. All abdominal masses should be examined by ultrasound or an IV pyelogram if available.
- About 50% of patients with Wilms' tumours will be hypertensive and may demonstrate the complications of chronic elevation of blood pressure: cardiomegaly or encephalopathy. Diseases endemic in the population, such as malnutrition, HIV/AIDS and intestinal parasites, may overshadow the primary symptoms. Nevertheless, the clinical finding of an abdominal mass always warrants further investigation.

7.7.2 Investigations

- The diagnostic work up invariably depends on the resources available. As a minimum, a chest radiography looking for pulmonary metastases and an ultrasound of the primary lesion and the liver should be done. Fine-needle aspiration biopsy is useful if cytology is available, or a Tru-cut needle biopsy can be done. Where pathology skills are lacking, the diagnosis can be made on clinical and radiological evidence alone; time should not be wasted seeking confirmation of the clinical diagnosis.
- Baseline laboratory studies such as a complete blood count are necessary to assess the patient's ability to tolerate chemotherapy, but there are no specific diagnostic blood tests. The patient must be evaluated to the full extent of the facilities available, with special attention to any comorbid conditions.

7.7.3 Treatment

Wilms' tumour is highly responsive to chemotherapy – a trait it shares with most other rapidly growing childhood tumours. It therefore makes sense to provide

an initial course of simple inexpensive chemotherapy whilst using the window of opportunity that this provides to reduce the patient's operative risk by managing comorbidities, particularly malnutrition. Such 'neoadjuvant' chemotherapy will also reduce the size of the tumour, making eventual surgery easier and safer; the response of lung metastases is often dramatic.

Many centres use a combination of vincristine and actinomycin, which has a low toxicity and is generally effective. Vincristine can be used alone but it is more effective when used in combination with actinomycin. Wilms' tumour can be safely treated by surgeons and, although desirable, a paediatric oncologist is not essential. Surgeons and general paediatricians throughout Africa have been achieving remarkable results in the absence of oncology units and oncologists, although treatment is certainly easier as part of a regional or national protocol.

Surgery

- ▶ The surgeon operating on a child with Wilms' tumour has three responsibilities:
 - ▷ to remove the entire tumour without allowing any tumour cells to spill into the peritoneal cavity
 - ▷ to stage the tumour accurately and safely, which involves inspection and palpation of the contralateral kidney, liver and inferior vena cava as well as biopsy of the para-aortic nodes
 - ▷ to ensure care in the perioperative period.
- ▶ Surgery is certainly easier – and safer – after a single 4-week course of chemotherapy. Even so, complications do occur, including postoperative ileus, intussusception and intraoperative blood loss. It may occasionally be necessary to remove organs beyond Gerota's fascia, such as the tail of the pancreas, liver or spleen. Involvement of the marginal artery of Drummond, which is usually draped over the tumour, may threaten the viability of the colon.
- ▶ Poor nutrition and an immune system stressed by malnutrition, viral infection and the suppressive effect of chemotherapy increase the risk of wound complications such as infection and incisional hernia.

7.7.4 Supportive care

- ▶ It is essential to provide patients with Wilms' tumour with adequate nutrition. Preoperatively this must be achieved in the face of chemotherapy drugs that cause nausea and vomiting and in the presence of a large abdominal tumour that will cause a feeling of fullness and early satiety, and that is growing rapidly, deriving its energy from the patient's food. Under these circumstances, it is prudent to pass a nasogastric tube and to provide continuous feeds during the night, allowing the patient a full ward diet during the day. If a ward diet is not tolerated, or spurned, 24 hour continuous feeds can be given. See Section 1.7 (page 19) for additional information on nutritional support.

- ▶ Blood transfusion may be required to correct pre-existing anaemia or anaemia caused by the effect of chemotherapeutic agents on the bone marrow. For this reason, facilities for the frequent assessment of blood count and transfusion should be available.
- ▶ The chemotherapy regimens used in the primary management of Wilms' tumour are relatively non-toxic and their management should be well within the scope of the primary referral hospital.

7.7.5 Prognosis

Approximately 25–30% of children with Wilms' tumour are cured by surgery alone, and many centres in the developed world have achieved cure rates as high as 85–90% using a judicious blend of chemotherapy and radiotherapy. Results have lagged behind in developing countries, for fairly obvious reasons; however, the situation is far from hopeless and all children deserve an initial trial of chemotherapy. Many African centres have reported long-term survival rates of 40–50%, which is laudable given the circumstances of practice. Nevertheless, there is room for improvement. An important aspect is to make clinicians aware of the potential for cure even when the patient may present with metastases and locally advanced disease. Clinicians should not be intimidated by the prospect of administering chemotherapy, and administrators need to understand that investment in such treatment is cost-effective.

Children with early-stage disease (Stages I and Stage II; see Table 7.2) can be expected to do well with a relatively short course of chemotherapy. Advanced disease (Stages III and IV) usually requires intensification of chemotherapy and the introduction of radiotherapy, although studies from Central America suggest that this may not be as necessary as first thought.

Table 7.2 Staging of Wilms' tumours

Stage	Characteristics
I	Tumour confined to the kidney and can be completely removed
II	Tumour spread beyond the renal capsule but can be completely removed
III	Residual non-haematogenous disease within the abdomen. Includes operative spillage, positive para-aortic nodes, peritoneal deposits or any unresected tumour
IV	Haematogenous metastases (tumour that spreads to distal sites via the blood)
V	Synchronous or metachronous bilateral disease

7.7.6 Advice for parents

Advise the parents that Wilms' tumour is a curable condition and that both chemotherapy and surgery will be required.

Indications for referral

Transfer should be considered if facilities are not available to diagnose (ultrasound, needle biopsy and pathology services) and treat (chemotherapy and surgery) a child with a Wilms' tumour.

▶▶ 7.8 Common gynaecological problems

Key points

- ◆ Gynaecological problems are often missed or the diagnosis delayed, resulting in a great deal of anxiety for the patient and their parents.
- ◆ Most gynaecological problems can be diagnosed with a careful history and physical examination.

Gynaecological problems can develop in childhood. However, the diagnosis is often delayed or missed, and frequently unnecessary investigations are done because of lack of suspicion or understanding.

7.8.1 Labial adhesion

This is the fusion of the labia minora to each other and usually presents in infants below 1 year of age, but may occur in older girls. The condition usually causes parental anxiety.

Careful examination of the perineum (after parting the labia) will show a thin semi-transparent membrane (Figure 7.14); occasionally it may be a well-formed skin bridge. The urethral opening may appear as only a small hole (the lower part may be occluded by the adhesion). Some patients may have dermatitis due to dribbling of urine.



Figure 7.14 Labial adhesion.

Treatment

- ▶ After application of local anaesthetic cream (leave for 5 minutes to act), the fused labia minora can be completely separated by the smooth curve of a paper clip or gentle digital pressure. Then apply oestrogen cream to the raw surfaces of the labia minora; 1% silver sulfadiazine or petroleum jelly may be used if oestrogen cream is not available. Show the mother how to apply the cream, which should be done twice daily for 10–14 days to prevent recurrence.
- ▶ If there is a skin bridge, the separation should be done under general anaesthesia.

7.8.2 Hydrocolpos and hydrometrocolpos

This refers to distension of the vagina (hydrocolpos) and uterus (hydrometrocolpos) by fluid other than blood. It is usually due to an imperforate hymen, and less commonly to a congenital vaginal septum or vaginal atresia, which obstructs the outflow of vaginal secretions. The result is accumulation of the secretions.

- The typical patient is less than 6 months of age and presents with lower abdominal swelling. Sometimes there may be difficulty with urination and/or constipation due to compression on the bladder or bowel.
- In girls with an imperforate hymen, examination reveals a bulging pale-pink hymen. Girls with a vaginal septum may have no findings on perineal examination unless it is quite low in the vagina. A few babies have a persistent cloaca (only one opening in the perineum and no anal opening).
- Pubertal girls with a vaginal septum or atresia can present with cryptomenorrhoea and haematocolpos/haematometocolpos (no menses and lower abdominal swelling) which increases in size cyclically. Pelvic ultrasound can confirm the origin of the swelling.
- Sometimes, the collection becomes secondarily infected and the child may then have a fever.
- An abdominal ultrasound can confirm the diagnosis.

Treatment

- ▶ Antibiotics should be started in patients with evidence of infection.
- ▶ Treatment of an imperforate hymen involves drainage under general anaesthesia.
 - ▷ First do a needle aspiration of the bulging hymen to confirm that you are in the right place.
 - ▷ Then make a cruciate (cross-like) incision on the hymen. There will be a gush of fluid which should be aspirated completely using a suction tube.
 - ▷ Excise the edges of the cruciate incision.
 - ▷ Leave an appropriate-sized Foley catheter within the vaginal cavity. The catheter is left to drain into a urine bag for 3–4 weeks to avoid recurrence.

Indications for referral

Girls with a suspected vaginal septum or vaginal atresia should be referred to a paediatric surgical centre.

7.8.3 Vaginal bleeding and discharge

Vaginal bleeding in prepubertal girls may be due to trauma, sexual abuse or a tumour; careful history and examination will help determine the cause. The perineum should be examined under good lighting for bruises and lacerations. A prolapsing mass (usually grape-like) from the introitus suggests a butyroid tumour (rhabdomyosarcoma). Any injuries should be treated; sexual abuse should be handled accordingly (see below).

Vaginal discharge in prepubertal girls is usually due to an infection, although sexual abuse and presence of a foreign body should be excluded. Specimens of the discharge should be sent for microbiological culture, and appropriate antibiotics given.

7.8.4 Spontaneous rectovaginal fistula

This is a connection between the rectum and vagina in a girl with a normal anal opening. It is heralded by the passage of faeces or feculent material from the vagina, usually when the child is passing stool. It is now a frequent presentation of HIV infection, but a few patients are HIV-negative.

Examination of the vulva and vagina under good lighting will reveal the fistula on the lower posterior vagina wall. A HIV test should be done, and tuberculosis should be excluded. The management of rectovaginal fistulas associated with HIV infection is described in Section 8.10.4 (page 222).

7.8.5 Sexual abuse

The following in a prepubertal girl should raise suspicion of sexual abuse:

- vaginal bleeding
 - vaginal discharge
 - vaginal bruises and lacerations.
- A complete history and careful examination of the perineum should be done. In particular, look for evidence of disruption of the hymenal ring. Specimens of any secretions or discharges should be taken for microbiology. If possible, document the injury with photographs.
 - If there is evidence of vaginal penetration, test the patient for HIV infection (this must be repeated after 6 weeks and 6 months if initially negative).
 - Appropriate antibiotics should be given for infection and any lacerations should be repaired. Psychological support and counselling will be required, and the child will need to be removed from further risk. Social welfare workers will need to be involved.

7.8.6 Advice for parents

Gynaecological problems usually cause a great deal of anxiety for the parents and older girls. Reassure the parents and the patient that you will do your best to get the problem treated properly.

Indications for referral

If the patient has a complex gynaecological problem (e.g. suspected vaginal septum or atresia, mass or fistula) they should be evaluated by someone with specialized training in paediatric surgery.

▶▶ CHAPTER 8: Surgical Infections

8.1 Abscess

- 8.1.1 Diagnosis
- 8.1.2 Treatment

8.2 Pyomyositis

- 8.2.1 Diagnosis
- 8.2.2 Treatment

8.3 Osteomyelitis

- 8.3.1 Pathophysiology
- 8.3.2 Acute osteomyelitis
- 8.3.3 Chronic osteomyelitis

8.4 Septic arthritis

- 8.4.1 Diagnosis
- 8.4.2 Treatment
- 8.4.3 Joint exploration

8.5 Empyema

- 8.5.1 Diagnosis
- 8.5.2 Treatment

8.6 Buruli ulcer

- 8.6.1 Diagnosis
- 8.6.2 Treatment

8.7 Noma (cancrum oris)

- 8.7.1 Diagnosis
- 8.7.2 Treatment

8.8 Surgical complications of typhoid fever

- 8.8.1 Small-bowel perforation
- 8.8.2 Other surgical complications

8.9 Surgical complications of tuberculosis

- 8.9.1 Tuberculous lymphadenitis
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8.10 Surgical complications of HIV/AIDS

- 8.10.1 Infections requiring drainage or debridement
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8.11 Surgical complications of common parasitic infections

- 8.11.1 Ascariasis
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- 8.11.4 Hydatid cyst
- 8.11.5 Bilharzia (schistosomiasis)
- 8.11.6 Amoebiasis

▶▶ 8.1 Abscess

Key points

- ◆ Pus should be drained.
- ◆ Always consider the underlying cause of an abscess (e.g. foreign body, underlying bone infection).

An abscess refers to a collection of pus and can occur in any part of the body.

8.1.1 Diagnosis

- An abscess should be suspected when there is localized pain, swelling, tenderness and fluctuance.
- Fever is typically present, although lack of fever does not exclude the presence of an abscess.
- When an abscess is suspected, consider the underlying cause (e.g. injection, foreign body or underlying bone infection). Injection abscesses usually develop 2–3 weeks after the injection and are most common on the buttocks.

8.1.2 Treatment

- ▶ Pus should be drained by incision or aspiration (Figure 8.1). Remember that there is no blood flow into an abscess cavity, so antibiotics cannot kill the bacteria.
- ▶ Most abscesses can be drained under local anaesthesia but general anaesthesia may be required for drainage of large abscesses.
- ▶ Packing is placed in an abscess cavity to control bleeding and to ensure that the incision site does not close. It can be gradually pulled out, starting 48 hours after incision and drainage.
- ▶ Antibiotics are required to treat the cellulitis surrounding an abscess. Cloxacillin should be given for 5 days or until the surrounding cellulitis resolves. If bowel

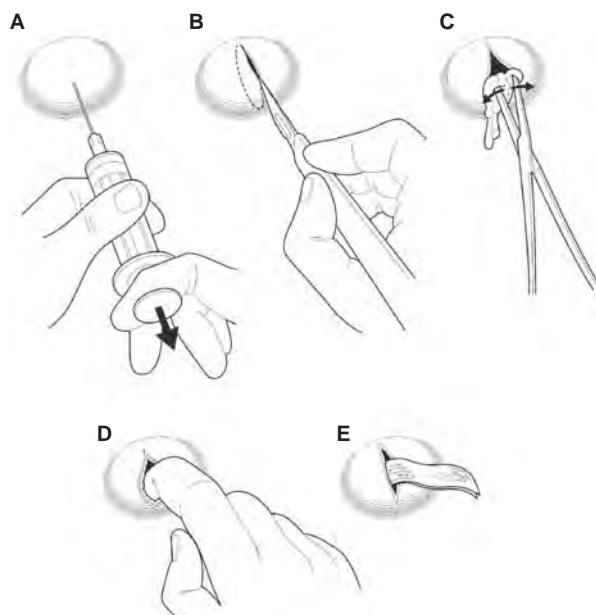


Figure 8.1 Incision and drainage of an abscess: (A) infiltration with local anaesthesia and aspiration to identify the site of pus; (B) elliptical incision; (C, D) breaking up loculations; (E) loose packing in place. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

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flora are suspected (e.g. a perirectal abscess), give ampicillin, gentamicin and metronidazole.

▶▶ 8.2 Pyomyositis

Key points ◀◀

- ◆ Pyomyositis should be suspected when a child presents with fever and tenderness of a muscle or muscle group.
- ◆ Because the pus is typically deep within the muscle, incision and drainage should be done under general anaesthesia.

Pyomyositis is so common in many tropical countries that it is also called pyomyositis tropicans. The condition is characterized by the development of primary abscesses within skeletal muscle and is associated with varying degrees of systemic illness, although in 75% of cases there is only one abscess.

Predisposing factors include trauma (muscle sprain or contusion), chronic skin infection (pyoderma), malnutrition and coexisting diseases that impair host immunity. *Staphylococcus aureus* is isolated in more than 90% of cases, although other organisms have been cultured from the pus.

8.2.1 Diagnosis

Pyomyositis should be suspected when a child presents with fever and tenderness of a muscle or muscle group. Most patients are healthy before the onset of infection and are young males. The differential diagnosis includes other infections (septic arthritis, osteomyelitis), cellulitis, thrombophlebitis, viral or parasitic myositis, and neoplasia. The muscles around the hip and thigh are most commonly affected, but any muscle group can be involved.

The clinical signs and symptoms depend on the stage of disease. Pyomyositis typically progresses in three stages.

- **Invasive stage:** characterized by generalized illness with fever, chills and malaise. A few days later the patient develops cramp-like pain in the affected muscle, which is swollen and tender on examination. The disease may resolve or progress to the next stage (suppuration).
- **Suppurative stage:** in this stage the involved muscle contains pus. Fluctuance may not be apparent, as the inflammation is deep within the muscle. In dark-skinned children the swelling appears shiny rather than red.
- **Late stage:** at this stage the signs of inflammation have subsided and there is a large collection of pus within the muscle. The patient is often bedridden and severely malnourished.

8.2.2 Treatment

- ▶ If the diagnosis is made at an early stage, antibiotics may successfully eradicate the infection.
- ▶ Once pus is formed in the muscle, the treatment is incision and drainage, which, because the pus is typically deep within the muscle, should be done under general anaesthesia. Needle aspiration, once the patient is anaesthetized, can help determine the best site for the incision. A sudden release of pressure during incision and drainage of the abscess can cause considerable bleeding. This can be controlled by packing the cavity with gauze, which is left in place for 48 hours. Before packing the wound, explore the abscess cavity with your finger. Break up any loculations and feel the surface of the bone. A rough area in the bone surface suggests osteomyelitis. Leave a drain in place for 2–3 days to prevent the abscess from reforming.

Warning!

Persistent drainage from the incision site suggests an underlying bone infection.

- ▶ Give cloxacillin (50 mg/kg IM or IV four times a day) for 5–10 days, as the most common organism is *S. aureus*.
- ▶ Take radiographs of the affected area to exclude underlying osteomyelitis.

▶▶ 8.3 Osteomyelitis

Key points

- ◆ Acute osteomyelitis is characterized by pain and tenderness of the involved bone.
- ◆ Early osteomyelitis can be cured by antibiotics.
- ◆ Chronic osteomyelitis is characterized by chronic draining sinuses (cloacae), bone loss and new bone formation (involucrum).
- ◆ The treatment of chronic osteomyelitis is to surgically remove the infected dead bone whilst preserving the structural integrity of the bone.

Osteomyelitis is a bone infection which occurs most frequently in children. Predisposing factors include anaemia, malnutrition, poor hygiene and coexisting infectious diseases (e.g. parasites and HIV infection). The infection usually results from bacterial seeding through the blood but may also occur following an operation on the bone (e.g. open reduction and internal fixation of a fracture).

Pyogenic bacteria such as *S. aureus* are identified most commonly (*Salmonella* in sickle cell disease). Organisms seen with less frequency include *Mycobacterium tuberculosis*

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and *Brucella*. Although any bone can be involved, 50% of cases involve the femur or tibia. Considerable morbidity can be averted by early diagnosis and treatment. Complications of acute osteomyelitis include chronic osteomyelitis, secondary septic arthritis, pathological fracture, bone loss (focal or segmental) and injury to the physis (leg-length discrepancy, angular limb deformity).

8.3.1 Pathophysiology

The infection usually starts at the distal aspect of the bone in the metaphysis. Organisms lodge in small veins, and an abscess forms on the inside of the bone, which increases the pressure and damages the internal blood supply. As the abscess enlarges it strips the periosteum off the bone (Figure 8.2). With damage to the blood supply, sections of the bone die. These dead sections of bone (sequestrae) may harbour microorganisms and give rise to recurrent episodes of infection (chronic osteomyelitis).

8.3.2 Acute osteomyelitis

- Acute osteomyelitis is characterized by pain and tenderness over the involved bone, with or without fever, and the child may refuse to bear weight or use the affected limb (Table 8.1). In early osteomyelitis the radiograph may be normal and it usually takes 12–14 days for radiographic changes to appear. A high index of suspicion is required to diagnose osteomyelitis at an early stage.
- If microbiology services are available, obtain blood cultures from febrile patients and aspirate any sites of suspected osteomyelitis.
- Aspiration should be done at the site of maximal tenderness. If subperiosteal aspiration reveals no fluid, the metaphysis may be aspirated.

Treatment

- ▶ Early osteomyelitis can be cured by antibiotics alone, preferably by the IV route for 2–4 weeks. Conversion to the oral route may be possible depending on the clinical response. Improvement is suggested by resolving fever, lessening of pain and

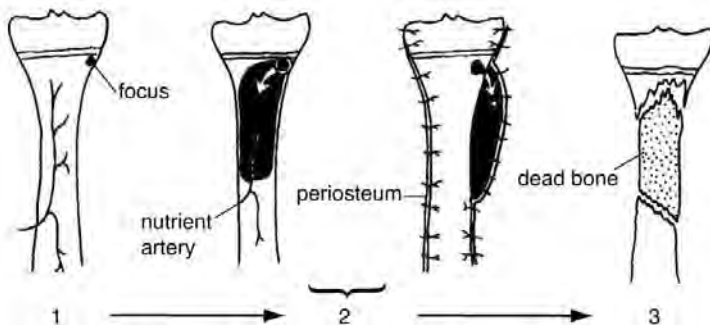


Figure 8.2 Pathogenesis of osteomyelitis. Infection beneath the periosteum strips the nutrient arteries off the bone.

Table 8.1 Clinical characteristics of acute and chronic osteomyelitis

	Acute osteomyelitis	Chronic osteomyelitis
Symptoms	Fever Pain over involved bone	Recurrent episodes of infection (drainage, pain)
Physical findings	Soft tissue swelling +/- erythema Bone tenderness Deformity if pathological fracture	Sinus +/- drainage Exposed bone Limb shortening or deformity
Diagnosis	Clinical +/- plain radiographs Bone aspiration over area of tenderness Joint aspiration if signs of septic arthritis	Plain radiograph
Radiography findings	Soft-tissue swelling Bony abnormality can be seen 12–14 days after the infection begins (periosteal reaction or lucency)	Sequestrum (collection of dead bone) Involucrum (new bone formation) Cloacae (sinus tracts) Pathological fracture Bone loss
Treatment	Antibiotics Irrigation and debridement	Sequestrectomy/debridement to eradicate foci of infection Bone grafting
Complications	Chronic osteomyelitis Septic arthritis	Pathological fracture Bone loss Growth disturbance Leg length discrepancy Angular deformity Cancer in sinus tract (> 20 years)

improvement in laboratory studies (erythrocyte sedimentation rate and C-reactive protein). The duration of therapy is typically 6 weeks.

- Indications for surgery include abscess formation, bony changes and failure to respond to antibiotics. If antibiotics are unavailable, open drainage through a small window should be considered even in the absence of abscess or bone destruction.

8.3.3 Chronic osteomyelitis

- Chronic osteomyelitis is characterized by chronic draining sinuses (cloacae), bone loss and new bone formation (involucrum) (Table 8.1; Figure 8.3).
- ▶ The treatment of chronic osteomyelitis is to surgically remove the infected dead bone whilst preserving the structural integrity of the bone. It is sometimes prudent to delay surgery, even with draining sinuses, in order for adequate new bone to form.

Warning!

The timing of surgery is critical, as operating before the new bone forms risks a fracture. Plain radiographs are useful in planning the timing of surgery.

- ▶ The first stage is to remove all devitalized bone and soft tissue. Bleeding can be a significant problem because of increased blood flow to the tissues from chronic infection; blood for transfusion should therefore be available. The skin incision should be long enough to provide access to all devitalized bone. All sinus tracts and devitalized soft tissue must be removed. An oval window in the bone (created by connecting a series of drill holes) allows access to the intramedullary space. This should be created over the thinnest area of the involucrum to preserve stability while allowing removal of all sequestrae and debridement of the inside of the bone.
- ▶ The degree of bone resection is defined by finding healthy bone (punctate bleeding is present). The cavity is then irrigated and packed open or, if possible, the skin can be loosely approximated over drains. Boiled or distilled water is an effective irrigant if sterile saline is not available. If the margins are uncertain a second debridement can be performed. The bone edges can often be sculpted to improve soft-tissue coverage. Once all devitalized tissue is removed and the bed is sterile, reconstructive procedures may be required.
- ▶ A cast or an external fixator may be required if the bone is unstable or at risk for fracture following debridement. Bone grafting may be required in the presence of focal bone loss. When the infection involves subcutaneous bones such as the tibia or ulna, an open cancellous grafting technique may be helpful. Either conventional bone grafting or bone transport is required to reconstruct segmental defects. In the

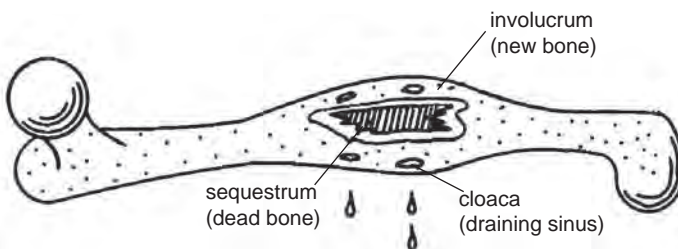


Figure 8.3 Late osteomyelitis of the femur. Shown is a collection of dead bone with draining sinuses.

forearm and the lower leg, bypass procedures (tibialization of the fibula or creation of a single bone forearm) can successfully reconstruct the extremity without the need for bone grafting or transport.

- ▶ Antibiotics should be used during the perioperative period. If possible, the antibiotic should be chosen on the basis of deep cultures (bone or pus) obtained at the time of the initial debridement. Sinus-tract cultures are not reliable and should not be performed. If available, we recommend a 6-week course of antibiotics for chronic osteomyelitis. Remember that chronic osteomyelitis is a surgical disease, and antibiotics complement the appropriate surgical management.

▶▶ 8.4 Septic arthritis

Key points

- ◆ Septic arthritis should be suspected when a child presents with a swollen, painful joint and fever.
- ◆ When septic arthritis is suspected, the joint should be aspirated to confirm the diagnosis.
- ◆ Damage to the joint can occur within 24–48 hours of the onset of infection, so it is important to recognize and treat the problem promptly.

Septic arthritis is infection of a joint and may result in serious disability if treatment is delayed. Organisms gain access to the joint by haematogenous seeding of the synovium, direct inoculation (trauma or surgery) or by spread from an adjacent bone infection. Infection in a joint can result in joint stiffness or ankylosis (fusion), instability and painful degeneration of the articular cartilage (arthritis). Damage to the joint can occur within 24–48 hours of the onset of infection.

8.4.1 Diagnosis

- Septic arthritis should be suspected when there is joint pain (at rest, worsened with motion), fever and soft-tissue swelling. Range of motion is restricted because of discomfort, and the joint will be held in a position of maximum comfort. Physical examination will reveal pain with motion, tenderness over the involved joint, often soft-tissue swelling and redness. Patients with lower extremity involvement may be unable to bear weight.

Warning!

If the infection is in the hip, the leg will be held in a position of flexion, abduction and external rotation. In septic arthritis of the hip there is always pain on rotation.

- The differential diagnosis depends on the joint involved, and includes infections (osteomyelitis, pyomyositis), inflammatory diseases (juvenile rheumatoid

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arthritis), neoplasms (leukaemia) and synovitis with other causes (reactive, viral, Lyme disease, haemophilia). Other diagnoses that may be confused with hip sepsis include psoas abscess, sacroiliac joint sepsis, pelvic osteomyelitis and appendicitis or other intra-abdominal processes.

- Plain radiographs may reveal soft-tissue swelling and effusion, and widening of the joint space (hip). Laboratory findings may include an increase in the white blood cell count with a shift to the left on the differential, an elevation in the erythrocyte sedimentation rate and C-reactive protein. Blood for culture should be drawn if the patient is febrile, and is positive in 40–50% of the cases.
- While normal joint fluid is typically viscous and clear, in cases of septic arthritis it is often thin and cloudy (whitish, yellowish), and the ‘string sign’ may be positive: when normal joint fluid is held between two gloved fingers and the fingers are separated, the viscous material will form a ‘string’ or bridge between the fingers; in cases of joint sepsis the fluid will not form a string.
- ▶ When septic arthritis is suspected, the joint should be aspirated to confirm the diagnosis. The aspirated fluid should be sent for cell count/differential, Gram stain (positive in 50% of cases) and culture/sensitivity, if available. Cultures are positive in 50–80% of patients. Findings consistent with a diagnosis of septic arthritis include a white blood cell count above 50 000 cells/mL and more than 90% polymorphonuclear lymphocytes, and bacteria on the Gram stain.

Joint aspiration

Several techniques have been described for aspirating each of the major joints (Figure 8.4). The following summarizes our preferred methods.

Hip

- Three techniques have been described for aspirating the hip.
- The anterior approach involves first palpating the femoral artery at the level of the inguinal ligament; the insertion point for the needle is 2.5 centimetres (1½ fingerbreadths) distal and 2.5 centimetres lateral. The needle is inserted at a 45-degree angle, aiming slightly medial.
- The medial approach involves inserting the needle under the adductor longus tendon (hip is flexed and abducted), aiming for the ipsilateral shoulder, and orienting the needle 20–30 degrees downwards from the horizontal axis.
- In the lateral approach, the needle is inserted at a 45-degree angle, starting inferior and proximal to the greater trochanter and advancing proximal and medial.

Knee

- The knee is commonly aspirated from a superolateral location, entering the joint at the superior pole of the patella. Alternatively, the knee may be flexed 30–40 degrees and the needle inserted at the level of the joint, in the soft spot just medial or lateral to the patellar ligament, aiming for the middle of the joint.

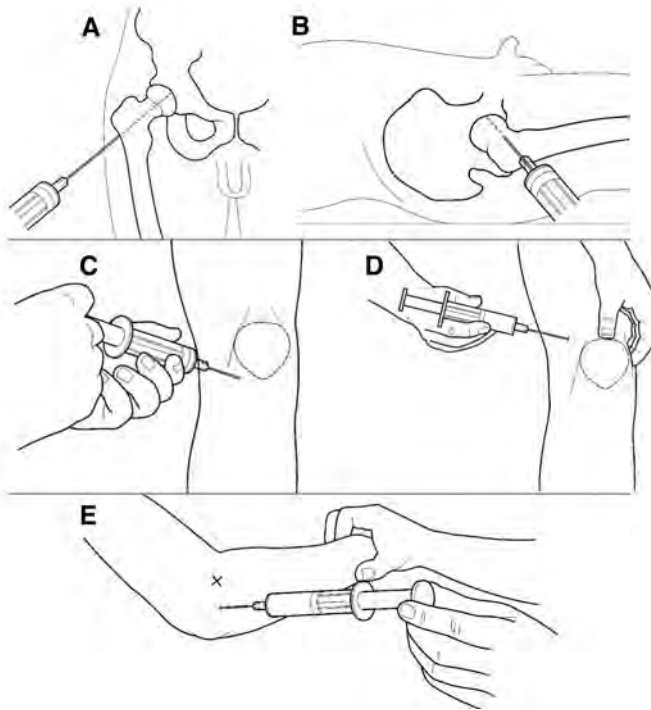


Figure 8.4 Techniques for aspirating major joints. (A, B) Aspiration of pus from the hip joint using a needle introduced laterally and pointed medially and upwards. (C, D) Aspiration of pus from the knee joint using a needle inserted at the lower pole of the patella or at the upper pole of the patella (for effusion mainly in the suprapatellar bursa). (E) Aspiration of pus from the elbow joint; the needle is introduced posteriorly just above the head of the radius; the bony landmark is marked. (Reproduced with permission from the *Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources*. WHO, 2005.)

Shoulder

- The shoulder may be aspirated anteriorly by inserting the needle midway between the coracoid and the anterior edge of the acromion.

Elbow

- The elbow can be aspirated using two techniques.
 - In the posterior approach, the needle is inserted (elbow flexed 90 degrees) in the soft spot just above the tip of the olecranon (proximal ulna) into the olecranon fossa.
 - In the lateral approach, the needle is placed in the soft spot between the lateral epicondyle, the proximal ulna and the radial head.

Ankle

- The ankle is aspirated through an anterolateral approach. The needle is inserted about 2.5 centimetres proximal and 1.5 centimetres anterior to the tip of the fibula.

8.4.2 Treatment

- ▶ When the diagnosis is suggested by clinical findings, prompt drainage of the involved joint is required. While repeated aspirations may suffice for small joints, larger joints (hip, knee, elbow, shoulder, ankle) are usually treated by open surgical drainage. Septic arthritis of the hip is viewed as a surgical emergency and thus deserves special mention; urgent surgical drainage is performed through an anterior approach to avoid damage to the blood supply of the femoral head.
- ▶ Empiric antibiotics are administered once material has been obtained for culture, and the initial agent should be effective against staphylococci. While recognizing that regional differences may be observed, common organisms are as follows:
 - ▷ **Neonates:** *S. aureus*, Group B Streptococcus, Gram-negative organisms
 - ▷ **3 months to 6 years:** *S. aureus*, *Streptococcus pneumoniae* and *pyogenes*, *Kingella kingae* and *Haemophilus influenzae* B. Infection with *H. influenzae* is common in regions where the vaccination is unavailable; up to 20% of these patients may have coexisting meningitis, and a lumbar puncture may be required for diagnosis.
 - ▷ **6 years to adolescence:** *S. aureus*, *Neisseria gonorrhoeae*.
- ▶ When cultures are negative (up to 50%) or microbiology facilities are unavailable, antibiotic therapy is selected on the basis of the likely organism. The erythrocyte sedimentation rate and/or C-reactive protein level are useful for evaluating the response to treatment and guide the duration of therapy.

8.4.3 Joint exploration

Several surgical approaches have been defined for each of the major joints.

Hip

A transverse incision is made 1–2 fingerbreadths below the anterior superior iliac spine, centred over the interval between the sartorius and the tensor fascia lata. The fascia is opened longitudinally, and the interval between the sartorius and tensor is developed bluntly, exposing the rectus femoris. The rectus femoris is retracted laterally, exposing the hip capsule. A square window of the joint capsule is removed to allow free drainage, and a small rubber catheter may be inserted into the joint to facilitate irrigation. The wound is loosely re-approximated, and a soft rubber drain is left in for 24–48 hours.

Knee

Using a lateral approach, a small longitudinal incision is centred at the level of the superior pole of the patella. The subcutaneous tissues are spread, and a haemostat can be used to enter the joint.

Ankle

The anterolateral approach provides access to the ankle joint. A longitudinal incision is placed anterior to the fibula at the level of the ankle joint, and the extensor tendons

may be retracted medially, exposing the ankle joint. Care must be taken to avoid branches of the superficial peroneal nerve.

Elbow

The elbow joint is drained via a posterolateral approach.

Shoulder

The shoulder can be drained through an anterior or posterior approach.

▶▶ 8.5 Empyema

Key points

- ◆ Empyema (pus in the pleural cavity) should be suspected in a child with a chest infection that does not improve despite appropriate treatment.
- ◆ Small amounts of fluid in the pleural cavity can resolve on antibiotics alone, without drainage.
- ◆ Large collections of pus require drainage with an intercostal drain (chest tube).
- ◆ Collections of pus in the chest do not always connect with one another, making it sometimes impossible to drain the pus with a single intercostal drain.
- ◆ Ultrasound is a valuable tool for demonstrating loculations (undrained areas) and for determining when open drainage is required.

Empyema refers to a collection of pus in the pleural cavity. It occurs as a complication of a bacterial infection such as pneumonia or lung abscess. It can also be from an infection of the pleura, as occurs in tuberculosis. Initially the fluid is thin and serum-like but it rapidly thickens and may contain lumps of fibrin. As the collection of pus enlarges, it compresses the lung.

8.5.1 Diagnosis

- An empyema should be suspected in a child with a chest infection that does not improve despite appropriate treatment.
- Physical exam reveals diminished breath sounds on the involved side and there is dullness on percussion. If the empyema is large, the child may be short of breath.
- A chest radiograph is diagnostic and shows opacification of the affected side. When the diagnosis is in doubt, an ultrasound scan may be helpful. An ultrasound can also provide information on the extent of loculations and the presence of a lung abscess.
- If ultrasound is not available, a cross-table lateral decubitus film is helpful for demonstrating empyema.

8.5.2 Treatment

- ▶ Small pus collections in the pleural space can resolve on antibiotics alone, without drainage.
- ▶ Large fluid collections require placement of an intercostal drain (see Section 4.8.8, page 112). The intercostal drain is connected to an underwater seal bottle (2–3 cm sterile fluid is enough) and left in place for as long as it continues to drain and fluctuates with respiration. If the fluid level in the bottle does not fluctuate with respiration, the intercostal drain is blocked.
- ▶ A chest radiograph that does not improve following placement of an intercostal drain implies either an underlying pneumonia or an undrained collection of pus in the chest. Ultrasound is a valuable tool for demonstrating loculations (undrained areas), and to determine whether it is possible to drain the fluid collection with another intercostal drain or whether open drainage (thoracotomy) is required.
- ▶ In our experience it is unusual for an empyema in a child to require thoracotomy; drainage and antibiotics will resolve most cases. Small residual fluid collections in the chest usually resolve with antibiotics alone. If drainage of an empyema reveals an underlying lung abscess (suggested by an air–fluid level on chest radiograph), these should also be treated with antibiotics, as most resolve without surgery.

▶▶ 8.6 Buruli ulcer

Key points

- ◆ Buruli ulcer can cause extensive destruction of skin and soft tissue, with the formation of large ulcers, usually on the legs or arms.
- ◆ First-line treatment for all forms of active disease is a combination of rifampicin and streptomycin/amikacin for 8 weeks.
- ◆ Surgery may be required to remove dead tissue, cover skin defects and correct deformities.

Buruli ulcer is caused by infection with *Mycobacterium ulcerans* and can lead to extensive destruction of skin and soft tissue, with the formation of large ulcers, usually on the legs or arms. Patients who are not treated early often suffer long-term functional disability such as restriction of joint movement, as well as obvious cosmetic problems. Early diagnosis and treatment are vital in preventing such disabilities.

8.6.1 Diagnosis

- All ages and sexes are affected, but most patients are children under 15 years of age. The disease can affect any part of the body. In about 90% of cases the lesions are on the limbs, with nearly 60% of all lesions on the legs.

- Buruli ulcer often starts as a painless mobile nodule in the skin. It can also present as a large area of induration or a diffuse swelling of the legs or arms. Typically there is no pain or fever, which may partly explain why those affected often do not seek treatment promptly. However, without treatment, massive ulcers with the classic undermined borders result.
- Buruli ulcer causes permanent disabilities in 25% of affected patients. The infection can involve the bones of the arms, hands, legs and feet, resulting in deformities. Moreover, as the infection heals there may be scarring around joints, restricting movement of the limbs.
- Conditions that mimic Buruli ulcer include tropical ulcer, leishmaniasis (particularly in South America), onchocerciasis nodules and fungal skin infections.
- The diagnosis can be confirmed by direct smear, culture, polymerase chain reaction or histopathology. In endemic areas Buruli ulcer is often diagnosed and treated by experienced health workers solely on clinical findings.

8.6.2 Treatment

- ▶ First-line treatment for all forms of active disease is a combination of rifampicin and streptomycin/amikacin for 8 weeks. Nodules and uncomplicated cases can be treated without hospitalization.
- ▶ Surgery may be needed to remove necrotic tissue, cover skin defects and correct deformities.
- ▶ Splinting may be needed to prevent joint contractures.
- ▶ Early detection of cases at the community level requires education and communication.

▶▶ 8.7 Noma (cancrum oris)

Key points

- ◆ Noma is a necrotizing infection of the mouth that can result in severe deformities of the face.
- ◆ It occurs primarily in debilitated children and has a high associated mortality.
- ◆ Risk factors include severe protein malnutrition (kwashiorkor) and other infections.

Noma is a progressive necrotizing infection of the face that begins in the cheek and can invade the gums and jaw bone. The infection can lead to severe deformities of the face. The exact aetiology of noma is not known, but it is probably caused by bacterial infection, specifically fusospirochetal organisms.

8.7.1 Diagnosis

- Noma is characterized by rapidly developing necrotic ulceration of the face. The ulceration is usually unilateral, and large defects can develop quickly.
- It occurs predominantly in malnourished children, most commonly between 2 and 6 years of age.
- Many of the children also have malaria, measles or other systemic illnesses.
- The infection can lead to severe deformities of the face.

8.7.2 Treatment

- ▶ Active infections should be treated with systemic penicillin.
- ▶ Clean the wound.
- ▶ Use salt-water rinses to keep the mouth clean.
- ▶ Improve nutrition and treat other infections.
- ▶ Supplement with Vitamin A (see Section 1.7.4, page 21).
- ▶ Reconstructive surgery may be required for extensive defects.
- ▶ Early detection of cases at the community level requires educational programmes.

▶▶ 8.8 Surgical complications of typhoid fever

Key points

- ◆ Small-bowel perforation is the most common surgical complication of typhoid fever.
- ◆ Other complications include cholecystitis, which rarely requires surgical treatment, septic arthritis, which typically involves the larger joints such as the knee or hip, and, very rarely, osteomyelitis.

8.8.1 Small-bowel perforation

Determining whether a child with typhoid fever has a bowel perforation can be difficult. The diagnostic challenge lays in the fact that most patients with typhoid fever, even in the absence of bowel perforation, will have fever and abdominal pain. For this reason, the clinician must base their suspicion of perforation on abdominal pain that is either more severe than expected or getting worse.

- The clinical signs of bowel perforation in typhoid fever can mimic acute appendicitis, although the history of the abdominal pain spans a period of weeks rather than days.
- The abdominal pain in perforated typhoid fever also tends to be more generalized and does not usually localize except to be more intense in the lower abdomen.

- There is usually prolonged fever with associated malaise and generalized body pain.
- An upright chest radiograph or cross-table lateral film looking for free air can be helpful.
- Occasionally, the ultrasound finding of free peritoneal fluid can help make the diagnosis.
- The white blood cell count is notoriously unreliable for diagnosing a typhoid perforation. Check the haemoglobin to ensure that the patient is not anaemic and to determine anaesthetic risk.

Section 6.1 (page 141) gives more detailed guidance on the evaluation of abdominal pain in children.

Preparation for surgery

Operative repair is the treatment of choice for small-bowel perforation associated with typhoid fever. However, it is important to prepare the patient properly for the operating theatre – this may take up to 24 or even 48 hours depending on how ill the patient is on presentation. Preparation for operations should include:

- ▶ fluid resuscitation and correction of abnormal electrolytes (see Section 1.4 [page 6] and Appendix 2)
- ▶ passing of a nasogastric tube to empty the stomach and minimize the chance of aspiration
- ▶ insertion of a urinary catheter to monitor urine output; adequate fluid resuscitation is indicated by a urine output of 1–2 mL/kg per hour (see Appendix 1)
- ▶ IV antibiotics (see below)
- ▶ blood cultures if possible to confirm the diagnosis.

The patient is ready for surgery when the blood pressure has returned to the normal range, electrolytes are corrected and urine output is satisfactory.

Antibiotics

Antibiotics should be directed against *Salmonella typhi*, enteric Gram-negative bacilli and anaerobes. For *S. typhi*, give chloramphenicol, 25 mg/kg every 8 hours (maximum 1 g per dose) for 14 days. When drug resistance to chloramphenicol and ampicillin among *S. typhi* isolates is known to be significant, follow the national guidelines for typhoid treatment. Other appropriate antibiotics for *S. typhi* are ceftriaxone and ciprofloxacin. Give gentamicin for enteric Gram-negative bacilli, and metronidazole for anaerobes.

Surgery

The goal of surgery is to identify the perforations, oversee the perforations and other areas where perforation might be imminent, and to irrigate the peritoneal cavity. The

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ileum should be examined along its entire length once the peritoneal fluid has been aspirated. Any perforations along its antimesenteric border are noted in relation to their distance from the ileocaecal junction. These are then covered with gauze held with a Babcock forceps while the rest of the bowel is inspected.

Perforations and other areas in question are oversewn in a transverse fashion so that the lumen of the bowel is not narrowed. If the perforations are multiple, with extensive areas of necrosis or close to the ileocaecal valve, it may be more prudent to do a segmental small-bowel resection or a right hemicolectomy with a careful one- or two-layered anastomosis, depending on the expertise of the surgeon.

Wound infection and intra-abdominal abscess are the most common postoperative complications. The risk of wound dehiscence is increased if the patient is malnourished.

Warning!

After repair of a typhoid perforation, the patient may perforate in new areas. Close postoperative monitoring is necessary to identify this development. Repeat laparotomy is required with washout and closure of the new perforations.

8.8.2 Other surgical complications

- **Cholecystitis** should be suspected when the abdominal pain has localized in the right upper quadrant. Cholecystitis usually responds to treatment with antibiotics. Occasionally, the infected gallbladder will perforate and a cholecystectomy will be necessary.
- **Gastrointestinal bleeding** associated with typhoid fever rarely requires surgery unless there is uncontrollable haemorrhage.
- **Osteomyelitis** (see Section 8.3, page 203)
- **Septic arthritis** (see Section 8.4, page 207).

▶▶ 8.9 Surgical complications of tuberculosis

Key points ◀◀

- ◆ Tuberculosis can involve any organ system. It most often involves the lungs, kidneys and meninges. Less common sites include the cervical lymph nodes, bones, joints, abdomen and skin.
- ◆ Tuberculosis can be difficult to diagnose in children. Many children present only with failure to grow, weight loss or prolonged fever. A chronic cough (persisting for longer than 3 weeks) is another common presentation.

The clinical course of children exposed to *Mycobacterium tuberculosis* is variable and depends on the competence of the immune system. Factors such as young age, malnutrition and other infections (particularly HIV/AIDS) can impair the immune system and render a child more susceptible to tuberculosis.

Surgery has several important roles in the management of children with tuberculosis. Surgeons are sometimes called on to biopsy a lymph node or other tissue to help make the diagnosis, or they may be consulted to deal with complications of the disease.

The following are some of the more common presentations of tuberculosis that the surgeon might encounter.

8.9.1 Tuberculous lymphadenitis

Enlarged cervical lymph nodes are a common presentation of tuberculosis. Initially there is inflammatory enlargement of the glands, which are firm to palpation and discrete. Later the nodes become matted together, and ultimately form sinuses to the skin. Children will often have other signs of tuberculosis (failure to grow, weight loss, chronic cough). In difficult-to-diagnose cases, biopsy of an involved lymph node may be required.

- ▶ Because tuberculosis is a systemic illness, the treatment of choice is medical therapy with anti-tuberculosis medications according to the National Tuberculosis Programme. Resolution is the rule unless there is pus formation or a resistant strain.

8.9.2 Abdominal tuberculosis

The key to diagnosis is maintaining a high index of suspicion, as the symptoms are often insidious and non-specific. Most patients look ill and are malnourished but some look fit at the time of presentation.

The symptoms include abdominal pain and abdominal swelling due to enlarged, matted mesenteric lymph nodes or loops of bowel wrapped by a tubercle-laden greater omentum.

Since most cases are secondary to pulmonary tuberculosis, the chest radiograph may show old or active disease in the lungs. The abdominal radiograph may show calcified lymph nodes or dilated loops of bowel with air–fluid levels suggesting intestinal obstruction. The triad of ascites, absence of bowel gas in the right iliac fossa and segmental dilatation of the terminal ileum is highly suggestive of abdominal tuberculosis. Abdominal tuberculosis can present in three different ways.

Intestinal tuberculosis

The terminal ileum and caecum are most commonly affected. Tuberculosis of the small intestine may present as an acute illness mimicking appendicitis, or in a more chronic form with an inflammatory mass in the right lower quadrant of the abdomen. Usually

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there have been episodes of abdominal pain, nausea and vomiting and diarrhoea, with weight loss in the preceding months. The disease usually progresses to a fibrous stricture of the bowel, leading to a partial intestinal obstruction.

Tuberculous peritonitis

Two-thirds of patients with tuberculous peritonitis present with ascites. The peritonitis may be purulent, loculated/encysted or fibrous. Patients with tuberculous peritonitis will commonly have peripheral oedema, malnutrition and chest signs.

Glandular tuberculosis

This is characterized by massive enlargement of the abdominal lymph nodes. Usually there is progressive ill health, followed by swelling of the abdomen and legs. Abdominal pain is often absent, and if present is mild and transient. If the lymph nodes are large, an abdominal mass may be palpated. Other presentations include a fever of unknown origin or a bowel obstruction due to adhesions. In some patients enlarged lymph nodes can also be felt in the neck, axillae or groins.

8.9.3 Tuberculosis of the spine (Pott's disease)

Tuberculosis can involve the skeleton, and the vertebrae are one of the most common sites. When tuberculosis involves the bones it is usually secondary to an infection in the lungs or lymph nodes.

- The classic finding is a localized swelling over the spine, called a gibbus. The swelling represents a localized kyphosis of the spine. The thoracic spine is most commonly affected.
- Pain is a common complaint. It usually has a gradual onset, is continuous and is associated with spasm of the paraspinal muscles.
- There may be fever, malaise, weight loss and loss of appetite.
- Plain radiograph of the vertebrae shows narrowing of the intervertebral space, destruction/collapse of the vertebrae, with or without paravertebral shadows indicative of cold abscesses.

Warning!

If the deformity is severe, spinal cord compression can result, suggested by hypertonia and hyperreflexia, sustained ankle clonus and hypotonia.

Treatment

- ▶ Anti-tuberculosis chemotherapy, bed rest and, later, protective bracing during mobilization are the mainstays of treatment for vertebral tuberculosis.
- ▶ The majority of patients with Pott's disease in the lumbar or thoracic region, without neurological deficits or kyphosis, can be treated non-operatively.

- ▶ Surgical intervention may be required to decompress the spinal cord when there is:
 - ▷ a progressive neurological deficit
 - ▷ no response to medical management
 - ▷ persistent neurological deficit.

Indications for referral

Children with tuberculosis should be treated in an organized National Tuberculosis Programme.

8.9.4 Atypical mycobacterial infections

Atypical mycobacterial infections are infections other than tuberculosis and leprosy that are caused by mycobacteria. The most common presentation in a child is swollen, non-tender and non-inflamed lymph nodes in the neck. The skin test is usually positive.

- ▶ Because atypical mycobacteria infections do not respond to anti-tuberculosis drugs, the treatment of choice is surgical excision.

▶▶ 8.10 Surgical complications of HIV/AIDS

Key points

- ◆ HIV/AIDS should be suspected in any child who presents with an infection at either an unusual site or with atypical organisms.
- ◆ Complications of HIV/AIDS that may require surgical care include oesophageal strictures, bowel obstruction or perforation, rectal fistulas (especially into the vagina) and cancer.
- ◆ The indications for doing an emergency operation (e.g. bowel obstruction or perforation) in a child with HIV/AIDS are the same as for an HIV-negative patient.
- ◆ HIV-positive children without AIDS who undergo surgery have a similar outcome to HIV-negative patients.

Whilst most children with HIV/AIDS will not require a surgical procedure as a direct result of their illness, a growing number will require a procedure either to assist in the diagnosis of a HIV/AIDS complication or to address a life-threatening complication of the disease. Moreover, as the prevalence of HIV infection increases, more HIV-positive children will require routine surgical procedures.

Surgical complications of HIV/AIDS in children fall into five major categories (Table 8.2):

- infections requiring drainage or debridement
- oesophageal disease (oesophagitis, oesophageal strictures)

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- intra-abdominal problems (bleeding, obstruction, perforation and pain)
- perineal disease (rectal fistula)
- associated malignancies.

Table 8.2 Surgical complications of HIV/AIDS in children

	Clinical presentation	Differential diagnosis	Surgical principles
Surgical infections	Abscess Necrotizing fasciitis Septicaemia	Opportunistic infections: <i>Candida</i> , herpes simplex, CMV, tuberculosis, Salmonella	Drain pus Debride dead tissue
Oesophageal diseases	Oesophagitis Oesophageal stricture	<i>Candida</i> oesophagitis CMV oesophagitis Herpes oesophagitis Idiopathic ulcers (HIV) Malignancy (e.g. Kaposi's sarcoma) Non-HIV-related conditions Gastroesophageal reflux	Barium swallow to identify strictures Endoscopy with biopsy
Intra-abdominal problems	Gastrointestinal bleeding, perforation and/or obstruction	CMV Kaposi's sarcoma Mycobacterial infection Non-Hodgkin's lymphoma	Same approach used for HIV-negative patient to diagnose gastrointestinal bleeding, perforation and obstruction
Perineal disease	Anocutaneous fistula (typically anterior) Warts (condyloma) Rectovaginal or rectourethral fistula	CMV	No treatment for minor problems Fulguration using diathermy for condyloma Colostomy for sepsis with rectovaginal and rectourethral fistula
Malignancy		Non-Hodgkin's lymphoma Kaposi's sarcoma Leiomyosarcoma B cell lymphoma MALT lymphoma	Biopsy of mass

CMV, cytomegalovirus; HIV, human immunodeficiency virus; MALT, mucosa-associated lymphoid tissue

8.10.1 Infections requiring drainage or debridement

HIV-positive children are prone to recurrent infection, and infections tend to occur either at unusual sites or with atypical organisms.

- The most common infecting organisms are *Streptococcus pneumoniae*, *H. influenzae* B and *Salmonella* species. Gram-negative infection can spread rapidly in HIV-positive patients, and a high index of suspicion must be maintained for necrotizing fasciitis. When possible, cultures should be obtained.
- **Ecthyma gangrenosum** is a cutaneous infection caused by *Pseudomonas* that is seldom seen in HIV-negative individuals. It begins as a papular rash that progresses to areas of necrosis. It is commonly seen in the perineal area, where it may form large, extremely painful ulcers.
- **Molluscum contagiosum**: lesions are identical in appearance to those in HIV-negative patients but the lesions tend to be larger, occur in greater number and recur more often. The most severe cases should be treated by superficial surgical curetting under general anaesthesia.
- Ulcerating lymphadenopathy associated with *M. bovis* infection has been observed in severely immunocompromised children receiving the BCG vaccination. Despite the appearance, we favour non-surgical treatment.

8.10.2 Oesophageal disease

- Young children with oesophagitis present with poor feeding, and weight loss. Older children complain of pain with swallowing.
- Opportunistic infections are the leading cause of oesophageal complaints. *Candida* oesophagitis is the most common cause, followed by cytomegalovirus (CMV), herpes simplex virus and lastly idiopathic infective ulcers. Because of the overlap of symptoms, it is difficult to make a specific diagnosis without endoscopy. If endoscopy is unavailable, empiric fungal therapy is indicated.
- Oesophagitis can scar the oesophagus, resulting in narrowing (strictures), which may require dilation to keep the oesophagus open.

8.10.3 Intra-abdominal disease

The diagnosis and management of children with intra-abdominal surgical pathology can be challenging. Localized signs and symptoms are frequently misleading because of underlying immunosuppression, debilitation and prior or current antibiotic use. Gastrointestinal bleeding, distension, obstruction, perforation and pain are the most common clinical problems associated with intra-abdominal diseases in HIV-positive children.

Gastrointestinal bleeding

- **Upper gastrointestinal bleeding** is much more common than lower gastrointestinal bleeding. Bleeding may represent opportunistic infections such as CMV or

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Candida infection, but also result from HIV-associated malignancies. Conditions unrelated to HIV infection (e.g. peptic ulcer disease or portal hypertension) must also be excluded.

- **Lower gastrointestinal bleeding** is caused predominantly by HIV-associated problems. CMV colitis is the most common cause, followed by tuberculosis, malignancy and idiopathic colonic ulcer. In contrast to HIV-negative individuals, haemorrhoids and anal fissures can result in significant bleeding in patients with AIDS because of associated thrombocytopenia. In circumstances where endoscopy is not available, empiric therapy should be instituted.

Abdominal distension

Diagnosing the cause of abdominal distension in an HIV-positive child can be difficult, as many of the causes (chronic diarrhoea, ileus and mechanical obstruction) appear similar on radiograph. Repeated physical examinations and prone radiographs to demonstrate air in the rectum can aid this assessment. Considerations in the HIV-positive child should include inflammatory and infective processes, with tuberculosis, histoplasmosis and *Candida* being the most common. Neoplastic obstruction related to lymphoma or Kaposi's sarcoma can also occur.

Gastrointestinal perforation

Children with HIV/AIDS are at increased risk for bowel perforation. The most common causes are CMV and, to a lesser extent, tuberculosis, histoplasmosis and lymphoma. One of the more common presentations is an infant outside the neonatal period who presents with chronic diarrhoea and abdominal distension which is followed by intestinal perforation. Laparotomy usually reveals multiple areas of patchy necrosis on the antimesenteric border similar to that seen in necrotizing enterocolitis. The surgical approach to these patients should be stoma formation.

Abdominal pain

Many of the gastrointestinal pathologies already described are associated with abdominal pain. Management of pain in these patients can be extremely difficult.

8.10.4 Perineal disease

Perineal disease, although not usually life-threatening, can be extremely painful.

HIV-positive patients are more likely to have anal fistulas. These may be incomplete, leading to a blind pouch, or form a fistula to the vagina or urethra. The term 'watering-can perineum' has been used to indicate multiple fistulas. Management includes drainage of pus, debridement of dead tissue, and antibiotics to control infection. Our current practice is to institute antiretroviral treatment and to use stoma diversion only to control sepsis. Definitive repair is reported to have poor results.

8.10.5 Associated malignancies

HIV infection increases the risk of malignancy (e.g. lymphoma and sarcomas). Biopsy of the tumour is often needed to confirm the diagnosis.

8.10.6 Management of the HIV-positive child with a surgical problem

Children with HIV/AIDS come to the attention of a surgeon in three clinical scenarios:

- emergency procedures to deal with a life-threatening complications of the disease
- non-emergency procedures where surgical assistance is required to assistance in the diagnosis of an HIV-related complication
- elective procedures for the treatment of routine childhood surgical problems.

Figure 8.5 shows a decision-making tree for surgery in a HIV-positive child.

Emergency procedures

For children presenting with life-threatening complication of HIV/AIDS infection (e.g. bowel obstruction or perforation), we use the same indications for surgery as for a HIV-negative patient. Most of the children presenting in this category have not been diagnosed with HIV and consequently are not receiving antiretroviral medications. Because their HIV disease is untreated, most children present in a debilitated state with poor nutrition.

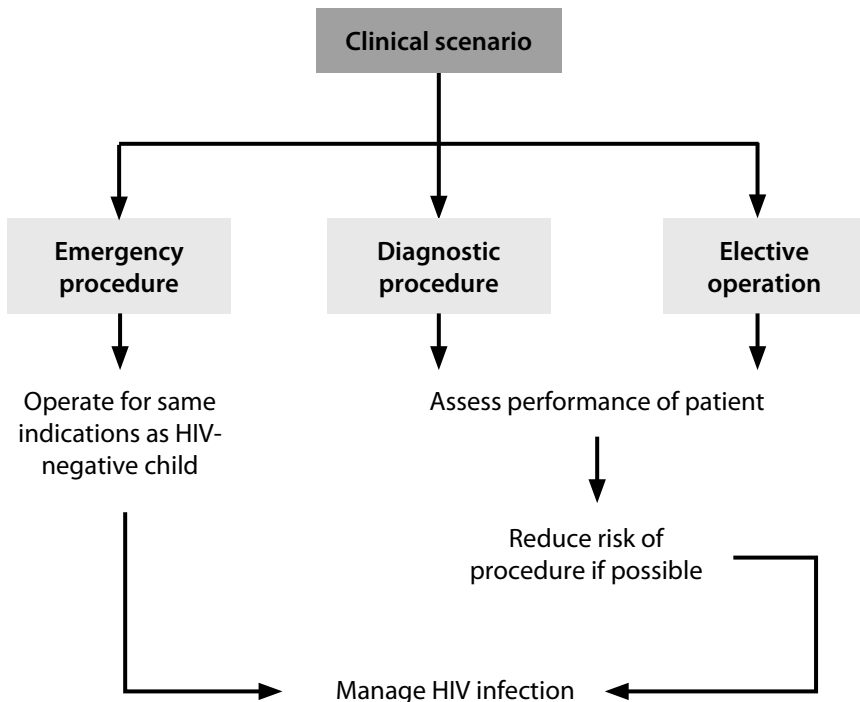


Figure 8.5 Surgical decision making in an HIV-positive child.

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The emergent nature of these cases does not allow preoperative correction of the nutrition deficits or management of the HIV infection. As with any emergency case, time must be taken to correct fluid and electrolyte balance and haematological abnormalities before the procedure. Postoperative complications (e.g. wound infections, anastomotic leaks and wound healing problems) are common in HIV-positive patients. Whether the higher complications relate directly to the HIV infection or the nutritional consequences of the disease is unknown. Consequently, conservative surgical procedures are preferred.

Non-emergency operations to diagnose HIV/AIDS complications

Most of these procedures do not need to be done as an emergency and there is therefore an opportunity to assess, and sometimes improve, the performance status of the patient. Consideration should be given to the patient's nutritional status, immune competence and other comorbidities.

Routine paediatric surgical procedures

As the number of HIV-positive children increases, those requiring routine paediatric surgical procedures is also increasing. Children with HIV infection develop the same surgical conditions as the non-infected population (e.g. inguinal hernia). When contemplating elective surgery, it is important to consider the performance status of patient and their life expectancy. In our experience, the complication rate in HIV-positive children who have not progressed to AIDS is similar to that in non-infected patients.

Indications for referral

The most critical aspect of managing a child with a surgical complication of HIV/AIDS is to ensure that the patient is part of an organized HIV treatment programme.

▶▶ 8.11 Surgical complications of common parasitic infections

Key points

- ◆ Parasitic infections are common in the tropics.
- ◆ Every clinician should have a working knowledge of the surgical complications associated with the most common parasitic infections.

8.11.1 Ascariasis

Ascaris lumbricoides may cause serious complications in the gastrointestinal tract. Small-bowel obstruction is the most common complication, which may be associated with gangrene of the bowel and intestinal perforation. Worms may also migrate outside the bowel and obstruct the bile and pancreatic ducts. The diagnosis of an intestinal obstruction from worms is usually made on clinical grounds.

- The most common complaints are abdominal pain, nausea, vomiting and constipation. There may be a history of a recent purgative or a cidal medication.
- Worms may be found in the vomit, or passed *per rectum*, but neither is diagnostic of worm obstruction.
- Generalized abdominal tenderness is a universal finding. A tangled ball of live worms within the intestine would be palpated as a mass, but much of the length of the small intestine may be filled with worms, giving the gut the feel of a thick cord. Consideration should be given to other common causes of abdominal masses in children, such as intussusception and appendicitis.
- Plain radiograph may show the shadow of the worms in a small proportion of cases – the shadows appear as wispy radiolucent lines in a somewhat parallel manner within a more dense shadow representing a mass of *Ascaris*, or more commonly a whirlpool pattern. Diagnosis is virtually certain if these shadows correspond to a palpable abdominal mass.
- Stool examination for ova is not helpful where infestation rates are high.

Treatment

- ▶ Non-surgical management in the form of gastrointestinal decompression and rehydration with IV fluids usually reduces colic and abdominal distension and leads to resolution of the previously palpable mass.
- ▶ Anthelmintic drugs should be avoided, as they may lead to more clumping of worms and more intestinal obstruction.
- ▶ If non-surgical management fails to produce clinical improvement or if signs of peritonitis develop, surgery should be performed as soon as possible to avoid gangrene. At the time of surgery, the worms are removed either by antegrade milking of the worms and extraction via enterotomy or by resection of the bowel segment where the mass of worms is very tightly packed. The bowel should be closed in two layers, the outer layer with a non-absorbable suture material, to keep the remaining worms from disrupting the repair.
- ▶ When intestinal function has returned, the child should be treated with an anti-helminth drugs.

8.11.2 Onchocerciasis

Onchocerciasis is a chronic progressive disease characterized by skin changes, formation of subcutaneous fibrous nodules, and eye lesions that can result in blindness. It is caused by the filaria *Onchocerca volvulus* transmitted by Simulium flies found near fast-running streams. The larvae of the worms are ingested when the fly feeds on the skin of an infected person. Onchocerciasis produces two characteristic findings in children:

- onchocercoma (subcutaneous nodules)
- eye lesions.

Onchocercoma

These are subcutaneous nodules that contain the adult worms and are the most common clinical finding in children. The nodules may occur alone or may be multiple. The most common sites are around the pelvis, legs and lateral thoracic wall. Nodules vary in size from 5 to 30 mm. They are firm and mobile but may be fixed to the surrounding tissues by fibrosis. Except for the discomfort from pressure over bones and when they become secondarily infected, they produce few symptoms. They rarely liquefy, never suppurate and never become malignant. In late cases, the worms may die and the nodule will calcify.

Eye lesions

Blindness is the most serious complication of onchocerciasis. The most common findings in the eyes of affected children include chronic conjunctivitis, sclerosing keratitis, 'fluffy' corneal opacities and anterior uveitis.

8.11.3 Guinea worm disease (dracunculiasis)

Guinea worm disease is caused by the adult female Guinea worm (*Dracunculus medinensis*). It is most common among the poor who are obliged to drink from ponds and small stagnant pools infested by a water flea (cyclops), the intermediate host of the parasite. Guinea worm disease is associated with two lesions:

- cutaneous discharging ulcers (sinus)
- extracutaneous (cryptic) lesions.

Cutaneous discharging ulcers (sinus)

The subcutaneous tissue around the head of the worm becomes swollen and hard. Secondary infection results in cellulitis. The mature female Guinea worm lying in the subcutaneous tissues finds its way to the skin surface through a cutaneous sinus in over 90% of cases. This sinus may open below the knee (the classic site) or at unusual sites, including the scrotum, head and neck, shoulder, pelvis and groins. The typical chronic lesion is a sinus that discharges a milky fluid.

Extracutaneous lesions

If the worm dies before it matures or reaches its destination, it disintegrates and will be absorbed, calcify or form a cyst. An abscess will form if the cyst becomes infected. The common sites are retroperitoneal tissues, the pelvis and joint spaces, particularly the knee.

8.11.4 Hydatid cyst

Ecchinococcus disease, also known as hydatid cyst, is caused by the cestode worm *Echinococcus granulosus*. The adult worms and their ova are shed in the faeces of infected animals such as dogs. It is spread to humans by the enteral route. The ovum finds its way into the gastrointestinal system of the human host and travels via the portal venous system to the liver or via lymphatic channels to the lungs.

Hydatid disease should be suspected in a patient who has lived in an endemic area and who presents with a space-occupying lesion in either the liver or lung. Cysts in the lung may be silent for years and are sometimes detected only by routine chest radiograph. Manifestations may include a non-productive cough, chest pain and shortness of breath. Liver cysts present as an intra-abdominal mass, and their symptoms relate to the size and location of the cyst.

8.11.5 Bilharzia (schistosomiasis)

Bilharzia is caused by the trematode *Schistosoma*. Several species of *Schistosoma* are of surgical importance including *S. haematobium* and *S. mansoni*. The urinary system and gastrointestinal tract are the main sites of infection, although the hepatobiliary system and nervous system can also be affected.

Urinary tract

The entire genitourinary tract is susceptible to bilharzia. Infestation of the urinary tract is almost entirely due to *S. haematobium*. Haematuria is the most common presentation.

Gastrointestinal tract

Manifestations of intestinal bilharzia of surgical interest include appendicitis, colonic polyposis, rectal prolapse and mesenteric bilharzioma. The latter can present as a painless abdominal mass.

8.11.6 Amoebiasis

This disease is caused by the protozoa, *Entamoeba histolytica*. Bloody diarrhoea (dysentery) is the most common presentation. The most common complications of amoebiasis that might come to the attention of a surgeon are amoebic liver abscess, amoeboma and extensive destructive lesions of the colon.

Amoeboma

Amoeboma presents as a firm granulomatous mass containing multiple abscesses. It is most common in the caecum and rectosigmoid region.

Amoebic liver abscess

Liver abscess is the most common complication of amoebiasis. When the organism reaches the liver, it proliferates and destroys a localized area of the organ, forming a spherical lesion with walls of granulation tissue only a few millimetres thick, with remarkably little fibrous tissue reaction, outside of which lies normal liver. Amoebic abscesses are more common in the right lobe of the liver than the left. Multiple abscesses are more common in children than adults.

▶▶ CHAPTER 9: Chronic Musculoskeletal Disabilities

9.1 Limping

9.1.1 Diagnosis

9.1.2 Treatment

9.2 Bowing of the legs

9.2.1 Diagnosis

9.2.2 Treatment

9.3 Burn contractures

9.3.1 General principles

9.3.2 Releasing common contractures

9.4 Polio-related disabilities

9.4.1 Diagnosis

9.4.2 Treatment

▶▶ 9.1 Limping

Key points

- ◆ The differential diagnoses of a limp in a child are broad and depend on the age of the patient.
- ◆ Examine the child from head to toe to ensure that common problems are not missed.

9.1.1 Diagnosis

- A limp is defined as any asymmetric deviation from a normal gait. It is usually observed as an uneven, jerky or laborious gait, and is usually caused by pain, weakness or deformity.
- A limp can be caused by abnormalities of the nervous system, back, leg, abdomen or genitourinary tract. The location of pain does not always reflect the location of pathology; problems in the hip can cause pain in the knee or thigh. A useful approach is to consider the child from head to foot, to avoid overlooking common underlying conditions such as diskitis, psoas abscess or septic hip, which are less obvious than conditions involving the legs and feet.
- Pain in the leg or foot is the most common cause of a limp, termed 'antalgic gait'; time spent with the foot on the ground (stance phase of gait) is minimized in order to avoid discomfort.
- Patients with a short leg will compensate by walking on the toes on the short side or by flexing the knee and hip on the longer side. Patients with an unstable hip (dislocated) will exhibit weakness or insufficiency of the hip abductors, and will lean over the affected hip while weight is placed on the limb in the stance phase.

- Radiographic studies are often necessary to confirm clinical suspicions, but diagnostic procedures are rarely required.

Warning!

Always make sure that the child does not have a septic hip, which requires emergency treatment (see Section 8.4, page 207).

- The differential diagnosis depends on the age of the patient.

Toddler (1–3 years)

Causes of a limp in a toddler include injury (splinter in the skin, minor fracture), infection (osteomyelitis, septic arthritis, tuberculosis), inflammatory conditions (synovitis, juvenile idiopathic arthritis), neuromuscular conditions (cerebral palsy, muscular dystrophy, tethered spinal cord), developmental conditions (hip dysplasia), spinal conditions (diskitis) and neoplasms (leukaemia).

Children (4–10 years)

Common causes of a limp in this age group include injuries and infections, hip problems such as transient synovitis (irritable hip, cause unknown) or Perthes disease, and leg-length discrepancy.

Adolescents (11–15 years old)

In addition to injuries and infection, the differential diagnosis should include hip problems (slipped capital femoral epiphysis, developmental dysplasia), knee problems (osteochondritis dissecans, overuse syndromes) and foot problems (tarsal coalition).

9.1.2 Treatment

Therapy is directed at the underlying cause.

Indications for referral

If possible, have children with a chronic limp seen by an orthopaedic specialist.

▶▶ 9.2 Bowling of the legs

Key points ◀◀

- ◆ Bowling of the legs may be part of normal growth (physiological bowing) or secondary to a disease process (pathological bowing).
- ◆ Physiological bowing improves as the child gets older and does not require treatment.
- ◆ Pathological bowing can be caused by nutritional or metabolic abnormalities such as rickets.
- ◆ Plain radiographs can be helpful in making the diagnosis.

Bowing of the legs is a common problem in infants and children. Most cases are part of normal growth and resolve with time. The goal at the primary referral hospital is to identify the subset of patients who may benefit from referral to a higher level facility.

Bowing can involve the entire leg or one or more segments (femur or tibia/fibula). The most common types of bowing are:

- **Genu varum:** outward bowing (knees bent outwards)
- **Genu valgum:** inward bowing (knees bent inwards, 'knock knees')
- **Bowing of the lower part of the leg:**
 - **anterior medial bowing:** associated with congenital longitudinal deficiency of the fibula (partial or complete absence of the fibula)
 - **anterolateral bowing:** the most worrisome type of bowing, as it can progress to a 'congenital' pseudarthrosis (false joint) of the tibia
 - **posteromedial bowing:** the foot is bent upwards and outwards, often lying on the lateral aspect of the lower leg; this type of bowing may improve with time but is usually associated with a leg-length discrepancy.

9.2.1 Diagnosis

- Babies typically have genu varum at birth but the outward bowing resolves at about 2 years of age. If genu varum persists beyond this age, radiographs should be obtained of both legs (hip to ankle) with the patella facing forward and while the child is standing.
- By age 2–3 years normal children have some degree of valgus. Genu valgus typically peaks by 3–4 years of age, and the limb reaches its final alignment at or after 6 years of age.

9.2.2 Treatment

The treatment depends on whether the condition is part of normal growth (observation only) or pathological (requiring surgery to realign the bone). The differential diagnosis of pathological bowing includes nutritional and metabolic abnormalities such as rickets. Plain radiographs are helpful in establishing the diagnosis.

Treatment of any underlying disease process is essential, as the deformity may recur following realignment. Patients with nutritional rickets should receive vitamin D and calcium (usually for 3–4 months). Any surgery should be delayed until metabolic correction is achieved.

Indications for referral

Surgical repair of pathological bowing can be complex and should be done by someone with specialized training in paediatric orthopaedics.

▶▶ 9.3 Burn contractures

Key points ◀◀

- ◆ Burn contractures can occur even with the best treatment, and are almost inevitable with poor treatment.
- ◆ Most burn contractures in children are treatable.
- ◆ Because children's joints do not become stiff as easily as an adult's, release of contractures can restore function in most instances.

Burn contractures describe a permanent shortening of burn scar tissue that pulls joints out of position and results in physical impairment. Some examples of severe burn contractures are shown in Figure 9.1.

9.3.1 General principles

- A large number of children in low- and middle-income countries develop burn contractures, making this an important procedure for the primary referral hospital. It is rarely possible for all burn contractures to be treated at the specialty hospital,

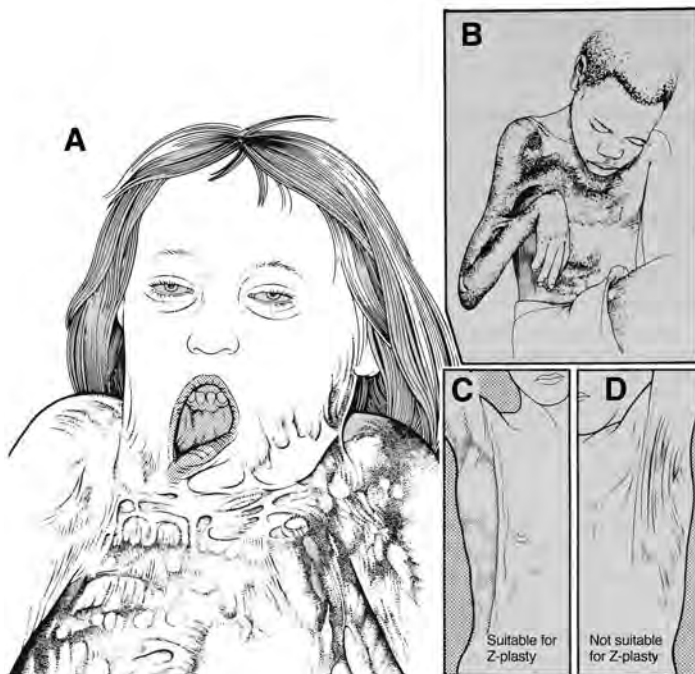


Figure 9.1 Examples of severe burn contractures. (A) severe contracture of the neck; (B) contractures of axilla, elbow and wrist; (C) narrow burn contracture of axilla, suitable for Z-plasty; (D) broad burn contracture of axilla; requires release and skin grafting (not suitable for Z-plasty).

9 Chronic musculoskeletal disabilities

so if the procedure is not done at the primary referral hospital it is unlikely that it will ever be done.

- Release of contracture should be done under general anaesthesia in the main operating theatre, with blood for transfusion available.
- The type of release depends on the nature of the contracture. Contractures may be linear or, more commonly, broad. Linear contractures can usually be treated with Z-plasty. Broad contractures should be released and then the exposed area grafted with a split-thickness skin graft.
- We usually do the first dressing change 5–7 days after the skin graft, and treat the patient with antibiotics until then.
- Postoperative splinting is imperative to keep the contracture from recurring. The limb should be splinted in a position opposite from the contracture. Exercises should be started as soon as the graft has taken, usually about a week after the graft is placed.

9.3.2 Releasing common contractures (Figure 9.2)

Neck contracture

- ▶ Refer children with severe neck contractures whenever possible.
- ▶ Alternatively, infiltrate the contracture with local anaesthetic, release the contracture under ketamine general anaesthesia and then intubate the patient.

Warning!

In the severest form, the chin is contracted down to the sternum, making it impossible to intubate the patient.

- ▶ To release the contracture, make a transverse incision from ear to ear, being careful not to go too deeply into the neck.
- ▶ Apply a split-thickness skin graft.
- ▶ Splint the neck in the extended position. Once the graft has taken, the patient should wear a soft collar for at least 6 months.

Elbow contracture

A severe contracture at the elbow can render the patient's arm useless.

- ▶ To release the contracture, make a transverse incision extending into the healthy tissue on each side of the contracture. Make your incision deep enough to release the scar, but not so deep as to divide the veins of the arm.
- ▶ Apply a split-thickness skin graft.
- ▶ Change the dressing at 7 days. When the graft has taken, splint the extremity in extension.

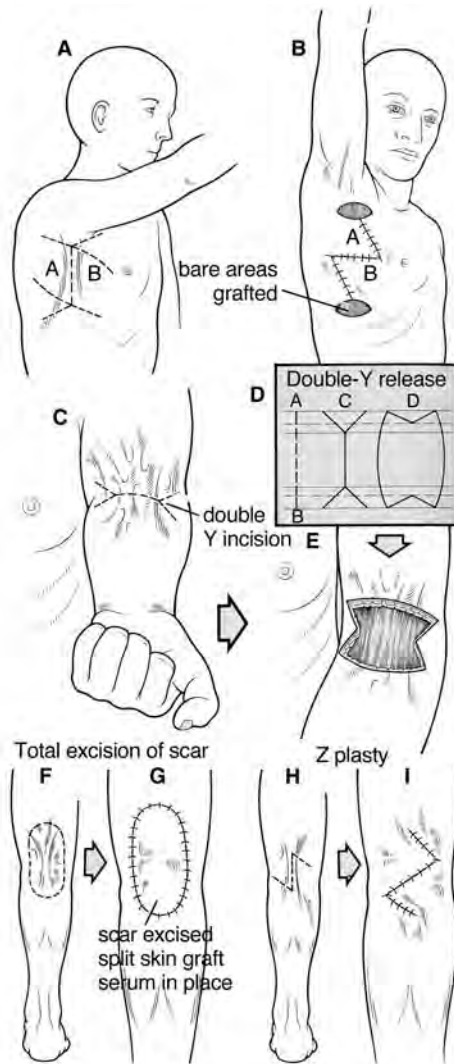


Figure 9.2 Methods for releasing some common burn contractures. (A, B) Combined Z-plasty and skin grafting: a Z-plasty has been made with transverse incisions at each end, which have been opened to leave raw surfaces ready for grafting. (C) A contracture of the elbow, showing a 'double-Y' release incision. (D) A 'double-Y' release, which provides maximum release of the ends of the contracture without increasing its length (A–B, width of the scar; C, the 'double-Y' drawn to cover its full width; D, full release of the incision). (E) A 'double-Y' incision ready for grafting. (F, G) total excision of a scar with a split-thickness skin graft sewn in place. (H, I) Treatment of a narrow popliteal contracture by Z-plasty.

Axillary contracture

The goal is to restore abduction and elevation in a single operation.

- ▶ If the contracture is broad, incise and apply a split-thickness skin graft.
- ▶ If the contracture is narrow, a Z-plasty will suffice.

Warning!

Be careful not to make the axillary incision too deep, to avoid injuring vessels and nerves.

- ▶ Splint the upper arm 90 degrees from the chest wall, with the elbow flexed and the wrist dorsiflexed.

Palm contracture

- ▶ Contractures of the fingers can sometimes be treated with dynamic splints.
- ▶ If the contracture is fixed, skin transplants are required. The treatment should be followed by physiotherapy to stretch the joints.

Indications for referral

Refer children with severe burn contractures of the neck to a specialist centre, as intubation will be difficult.

▶▶ **9.4 Polio-related disabilities**

Key points

- ◆ Although poliomyelitis has been eradicated in many low- and middle-income countries, there continue to be many children with deformities related to the disease.
- ◆ The goal of basic rehabilitation surgery is to help patients become independent and self-sufficient.

Poliomyelitis is an acute infectious disease caused by a group of neurotrophic viruses. The virus has a special affinity for the anterior horn cells of the spinal cord and for certain motor nuclei of the brain stem. The affected nerve cells undergo necrosis and the muscles that they supply become paralysed. The disease has three major stages: the acute illness, lasting 1–3 weeks, followed by the recovery stage, extending over 6–12 months and finally the chronic or residual stage.

9.4.1 Diagnosis

- Polio causes flaccid paralysis of muscles but there is no loss of sensation.
- The functional consequences of paralysis depend on the part(s) of the body affected and the extent and degree of paralysis.
- Paralysis affects the legs in the majority (80–90%) of children, although in a large proportion paralysis is limited to one leg. The trunk muscles may also be involved in some children, and the arms in a few.

- Muscle imbalance results in deformities. The resulting contractures limit or block joint movements and can result in axial deviations of the limb (e.g. valgus deformity of the knee). Any joint can be affected but deformities occur most frequently in the legs. In the absence of treatment, the deformity becomes fixed.

Warning!

Most children who do not receive adequate treatment early on in their disease will develop a deformity. Many deformities can be avoided, or kept to a minimum, by proper treatment in the acute and recovery stages.

9.4.2 Treatment

The specific aims of surgery are to:

- correct deformities that either interfere directly with daily activities, in particular with locomotion, or contribute to the development of further deformities
- stabilize unstable joints
- improve motor function of the affected part through tendon transfer.

More information on the management of children with polio-associated disabilities at the primary referral hospital can be found in *Rehabilitation surgery for deformities due to poliomyelitis* (WHO, 1995).

Indications for referral

Determine whether rehabilitation resources are available in your area. Consider transferring the patient if the needed services are available.

▶ APPENDIX 1: Normal vital signs

Age group	Weight (kg)	Heart rate (beats per min)	Systolic blood pressure (mmHg)	Respiratory rate (breaths per min)	Urine output (mL/kg per hour)
Newborn	2–3	120–160	50–70	30–50	2.0
Infant (1–12 months)	4–10	80–140	70–100	20–30	2.0
Toddler (1–3 years)	10–14	80–130	80–110	20–30	1.5
Preschool (3–5 years)	14–18	80–120	80–110	20–30	1.0
School age (6–12 years)	20–42	70–110	80–120	20–30	1.0
Adolescent (13+ years)	>50	55–105	110–120	12–20	0.5

▶▶ APPENDIX 2: Maintenance fluid requirements

Body weight (kg)	Maintenance fluid		125% Maintenance		150% Maintenance	
	mL/day	mL/hour	mL/day	mL/hour	mL/day	mL/hour
2	200	8	250	10	300	12
4	400	16	500	20	600	24
6	600	24	750	30	900	36
8	800	32	1000	40	1200	48
10	1000	40	1250	50	1500	60
12	1100	44	1375	55	1650	66
14	1200	48	1500	60	1800	72
16	1300	52	1625	65	1950	78
18	1400	56	1750	70	2100	84
20	1500	60	1875	75	2250	90
22	1550	62	1950	78	2325	93
24	1600	64	2000	80	2400	96
26	1650	66	2050	83	2475	99
28	1700	68	2125	85	2550	102
30	1750	70	2200	88	2625	105
40	2000	80	2500	100	3000	120
50	2250	90	2800	113	3400	135
60	2500	100	3100	125	3750	150

The total daily fluid requirement can be calculated from the child's body weight using the formula in Section 1.4.2, page 6.

▶ APPENDIX 3: Composition of intravenous fluids

	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Calcium (mmol/L)	Lactate (mmol/L)	Glucose (g/L)	Calories (per L)
Ringer's lactate (Hartmann's)	130	5.4	112	1.8	27	-	-
Normal saline (0.9% NaCl)	154	-	154	-	-	-	-
5% dextrose	-	-	-	-	-	50	170
10% dextrose	-	-	-	-	-	100	340
0.45% NaCl / 5% dextrose	77	-	77	-	-	50	170
0.18% NaCl / 4% dextrose	31	-	31	-	-	40	136
Darrow's solution	121	35	103	-	53	-	-
Half-strength Darrow's with 5% dextrose	61	17	52	-	27	50	170
Half-strength Ringer's lactate with 5% dextrose	65	2.7	56	1	14	50	130

(From the *Pocket Book of Hospital Care for Children*, WHO 2005).

▶ APPENDIX 4: Commonly used drugs

Adapted from the *Pocket Book of Hospital Care for Children*, WHO 2005.

Whenever possible, calculate the dose of a drug based on the child's weight. Where this is not possible, use the doses given below. Premature infants and low-birth-weight babies require special dosing.

We recommend that you check the product information and published information for currently recommended doses.

	Dosage	Form	Dose according to body weight (in kg)					
			3–<6	6–<10	10–<15	15–<20	20–29	
Adrenaline – see epinephrine								
Amoxicillin	15 mg/kg three times per day	250 mg tablet	¼	½	¾	1	1½	
		Syrup (containing 125 mg per 5 mL)	2.5 mL	5 mL	7.5 mL	10 mL	–	
	Oral: 25 mg/kg four times a day	250 mg tablet	½	1	1	1½	2	
Ampicillin <i>For mild disease</i>	IM/IV: 50 mg/kg every 6 hours (Every 12 hours during first week of life; every 8 hours during weeks 2–4 of life)	500 mg vial mixed with 2.1 mL sterile water to give 500 mg per 2.5 mL	1 mL	2 mL	3 mL	5 mL	6 mL	
Bupivacaine	Up to 1 mL/kg 0.25% solution (2.5 mg/kg)							
Ceftriaxone <i>For meningitis</i>	IM/IV: 100 mg/kg once daily (max single dose = 4 g)	1 g vial mixed with 9.6 mL sterile water to give 1 g/10 mL or 2 g vial mixed with 19 mL sterile water to give 2 g/20 mL	4 mL	8 mL	12 mL	18 mL	25 mL	

Appendix 4: Commonly used drugs

	Dosage	Form	Dose according to body weight (in kg)					
			3- <6	6- <10	10- <15	15- <20	20-29	
Cefalexin	12.5 mg/kg four times per day	250 mg tablet	¼	½	¾	1	1¼	
Chloramphenicol <i>For meningitis</i>	IV: 25 mg/kg every 6 hours (max 1 g per dose) (Every 12 hours during first month of life; DO NOT use in premature babies)	1 g vial mixed with 9.2 mL sterile water to give 1 g per 10 mL	0.75-1.25 mL	1.5-2.25 mL	2.5-3.5 mL	3.75-4.75 mL	5-7.25 mL	
Chlorpheniramine	IM/IV/SC 0.25 mg/kg once (can be repeated up to four times in 24 hours) Oral: 2 or 3 times daily	10 mg/mL IV solution Tablet: 4 mg	0.1 mL	0.2 mL	0.3 mL	0.5 mL	0.6 mL	
Ciprofloxacin <i>Use only if benefits outweigh risks of arthropathy</i>	Oral: 10-15 mg/kg, given twice a day for 5 days (max 500 mg per dose)	100 mg tablet 250 mg tablet	½	1	1½	2	3	
			¼	½	½	1	1½	

	Dosage	Form	Dose according to body weight (in kg)					
			3-<6	6-<10	10-<15	15-<20	20-29	
	IV: 10 mg/kg every 8 hours	Calculate EXACT dose based on weight of child, use doses given below only where this is not possible						
Clindamycin	First week of life: 5 mg/kg IM/IV every 12 hours Weeks 2-4 of life: 5 mg/kg IM/IV every 8 hours Oral: 10 mg/kg three times a day	Injection: 15 mg/mL 150 mg tablet	2-3.5 mL -	4-6.5 mL 1/2	7-10 mL 3/4	10.5-13 mL 1	14-19 mL 1 1/2	
Cloxacillin/ flucloxacillin/ oxacillin <i>For treatment of abscess</i>	IV: 25-50 mg/kg every 6 hours Oral: 15 mg/kg every 6 hours	500 mg vial mixed with 8 mL sterile water to give 500 mg per 10 mL (50 mg/mL) 250 mg capsule 15 mg tablet	2-(4) mL 1/4 1/4	4-(8) mL (50 mg/mL dose in brackets) 1/2 1/4	6-(12) mL 1 1/2	8-(16) mL 1 1/2 1	12-(24) mL 2 1/2 1	
Codiene <i>For analgesia</i>	Oral: 0.5-1mg/kg every 6-12 hours	Adult tablet (80 mg TMP + 400 mg SMX) Paediatric tablet (20 mg TMP + 100 mg SMX) Oral syrup: 40 mg TMP + 200 mg SMX per 5 mL	1 1 1	1/2 1/2 2	1 3 3	1 3 3	1 4 4	
Cotrimoxazole (trimethoprim [TMP] - sulfamethoxazole; [SMX])	Oral: TMP 4 mg/kg and SMX 20 mg/kg twice a day	Oral syrup: 40 mg TMP + 200 mg SMX per 5 mL	2 mL (1.25 mL if < 1 month)	3.5 mL	6 mL	8.5 mL	-	

Appendix 4: Commonly used drugs

	Dosage	Form	Dose according to body weight (in kg)				
			3- <6	6- <10	10- <15	15- <20	20-29
Dexamethasone <i>For severe viral croup</i>	Oral: 0.6 mg/kg single dose	0.5 mg tablet					
Diazepam <i>For sedation before procedures</i>	0.1 –0.2 mg/kg IV	IM: 5 mg/mL 10 mg per 2 mL solution	0.5 mL	0.9 mL	1.4 mL	2 mL	3 mL
Epinephrine (adrenalin) <i>For wheeze</i>	Calculate EXACT dose based on weight of child (as rapid-acting bronchodilator) 0.01 mL/kg (maximum 0.3 mL) of 1:1000 solution given SC with a 1 mL syringe OR 0.1 mL/kg of 1:10000 solution (make a 1:10000 solution by adding 1 ml of 1:1000 solution to 9 mL saline or 5% glucose)						
<i>For severe viral croup</i>	Trial of 2 mL 1:1000 nebulized solution		-	2 mL	2 mL	2 mL	2 mL
<i>For anaphylaxis</i>	0.01 mL/kg of 1:1000 solution (or 0.1 mL/kg of 1:10000 solution) given SC with a 1 mL syringe						

	Dosage	Form	Dose according to body weight (in kg)					
			3–<6	6–<10	10–<15	15–<20	20–29	
Gentamicin See Pocket Book of Hospital Care for Children (WHO) for dosing neonates and premature infants. Beware of risk of adverse effects when giving with theophylline.	Calculate EXACT dose based on weight of child; use doses given below only where this is not possible							
	7.5 mg/kg once a day	IM/IV: 20 mg vial (2 mL at 10 mg/mL) undiluted	2.25–3.75 mL	4.5–6.75 mL	7.5–10.5 mL	–	–	–
	First week of life: low-birth-weight babies: 3 mg/kg IM/IV once daily; normal-birth-weight babies: 5 mg/kg IM/IV once daily	IM/IV: 80 mg vial (2 mL at 40 mg/mL) mixed with 6 mL sterile water	2.25–3.75 mL	4.5–6.75 mL	7.5–10.5 mL	–	–	–
	Weeks 2–4 of life: 7.5 mg/kg IM/IV once daily	IM/IV: 80 mg vial (2 mL at 40 mg/mL) undiluted	0.5–0.9 mL	1.1–1.7 mL	1.9–2.6 mL	2.8–3.5 mL	3.75–5.4 mL	
Gentian violet	Topical application to skin							
Ibuprofen	Oral: 5–10 mg/kg every 6–8 hours; max dose 40 mg/kg per 24 hours	200 mg tablet	–	¼	¼	½	¾	
		400 mg tablet	–	–	–	¼	½	

Appendix 4: Commonly used drugs

	Dosage	Form	Dose according to body weight (in kg)				
			3- <6	6- <10	10- <15	15- <20	20-29
Iron	Once per day for 14 days	Iron/folate tablet (ferrous sulfate 200 mg + 250 microgram folate = 60 mg elemental iron)	-	-	½	½	1
		Iron syrup (ferrous fumarate, 100 mg per 5 mL = 20 mg/mL elemental iron)	1 mL	1.25 mL	2 mL	2.5 mL	4 mL
			Calculate EXACT dose based on weight of child				
Ketamine <i>For anaesthesia in major procedures</i>	IM loading dose: 5-8 mg/kg		20-35 mg	40-60 mg	60-100 mg	80-140 mg	125-200 mg
	IM further dose (if required): 1-2 mg/kg		5-10 mg	8-15 mg	12-25 mg	15-35 mg	25-50 mg
	IV loading dose: 1-2 mg/kg		5-10 mg	8-15 mg	12-25 mg	15-35 mg	25-50 mg
	IV further dose (if required): 0.5-1 mg/kg		2.5-5 mg	4-8 mg	6-12 mg	8-15 mg	12-25 mg

	Dosage	Form	Dose according to body weight (in kg)					
			3- <6	6- <10	10- <15	15- <20	20-29	
Ketamine <i>For light anaesthesia in minor procedures</i>	IM: 2-4 mg/kg							
	IV: 0.5-1 mg/kg							
Lidocaine (lignocaine)	Apply topically							
	Local injection: up to 0.45 mL/kg of 1% solution (4.5 mg/kg)							
Mebendazole	100 mg twice a day for 3 days	100 mg tablet	-	-	1	1	1	1
	500 mg once only	100 mg tablet	-	-	5	5	5	5
Metoclopramide <i>For nausea/vomiting</i>	0.1-0.2 mg/kg every 8 hours as required	10 mg tablet	-	-	1/4	1/4	1/2	
		Injection: 5 mg/mL	-	-	0.5 mL	0.7 mL	1 mL	1 mL
Metronidazole	Calculate EXACT dose based on weight of child; use doses given below only where this is not possible							
	IV: 7.5 mg/kg every 6 hours	500 mg/100 mL (5 mg/mL)	4.5-9 mL	10-15 mL	16-22 mL	23-30 mL	31-45 mL	
	Oral: 7.5 mg/kg three times a day	200 mg tablet	-	1/4	1/2	1/2	1	1
		400 mg tablet	-	-	1/4	1/4	1/4	1/2

Appendix 4: Commonly used drugs

	Dosage	Form	Dose according to body weight (in kg)				
			3–<6	6–<10	10–<15	15–<20	20–29
Morphine	<p>Calculate EXACT dose based on weight of child</p> <p>Oral: 0.2–0.4 mg/kg every 4–6 hours; increase if necessary for severe pain</p> <p>IM: 0.1–0.2 mg/kg every 4–6 hours</p> <p>IV: 0.05–0.1 mg/kg every 4–6 hours, or 0.005–0.01 mg/kg per hour by IV infusion</p>						
Oxacillin – see Cloxacillin							
Paracetamol (acetaminophen)	10–15 mg/kg, up to four times a day	100 mg tablet	–	1	1	2	3
		500 mg tablet	–	¼	¼	½	½
Penicillin (benzylpenicillin) <i>General dosage</i>	IV: 50 000 units / kg every 6 hours (Every 12 hour during first week of life; every 6 hours for weeks 2–4 and older)	600 mg vial (1 000 000 units) mixed with 9.6 mL sterile water to give 1 000 000 units per 10 mL	2 mL	3.75 mL	6 mL	8.5 mL	12.5 mL
	IM	600 mg vial (1 000 000 units) mixed with 1.6 mL sterile water to give 1 000 000 units per 2 mL	0.4 mL	0.75 mL	1.2 mL	1.7 mL	2.5 mL

	Dosage	Form	Dose according to body weight (in kg)				
			3-<6	6-<10	10-<15	15-<20	20-29
Penicillin (benzylpenicillin) <i>Meningitis</i>	100 000 units / kg every 6 hours	IV IM	4 mL 0.8 mL	7.5 mL 1.5 mL	12 mL 2.5 mL	17 mL 3.5 mL	25 mL 5 mL
Potassium	2-4 mmol/kg per day						
Prednisolone (1 mg prednisolone is equivalent to 5 mg hydrocortisone or 0.15 mg dexamethasone)	Oral: 1 mg/kg twice a day for 3 days	5 mg tablet	1	1	2	3	5
Silver sulfadiazine	Apply to affected area of skin						
Tetanus immunoglobulin (TIG)	Human TIG 250 units IM as a single dose. Where TIG is not available, give equine antitoxin (1500 units for child < 30 kg) after appropriate testing for sensitivity, and desensitization if necessary. Also consider Immunoglobulin Intravenous (IGIV), which contains antibodies to tetanus.						
Vitamin A	Once per day for 2 days	200 000 IU capsule	-	½	1	1	1
		100 000 IU capsule	½	1	2	2	2
		50 000 IU capsule	1	2	4	4	4

▶▶ APPENDIX 5: Immunization schedule for infants, recommended by the Expanded Programme on Immunization

Vaccine		Age				
		Birth	6 weeks	10 weeks	14 weeks	9 months
BCG		X				
Oral polio		X [†]	X	X	X	
DPT			X	X	X	
Hepatitis B*	Scheme A	X	X	X	X	
	Scheme B		X	X	X	
<i>Haemophilus influenzae</i> type B			X	X	X	
Yellow fever						X**
Measles						X***

BCG, bacille Calmette–Guèrin vs tuberculosis. DPT, diphtheria, pertussis, tetanus.

[†] In polio-endemic countries

* Scheme A is recommended in countries where perinatal transmission of hepatitis B is frequent (e.g. in South-East Asia). Scheme B may be used in countries where perinatal transmission is less frequent (e.g. in sub-Saharan Africa).

** In countries where yellow fever poses a risk.

*** In exceptional situations, where measles-related morbidity and mortality before 9 months of age represent more than 15% of cases and deaths, give an extra dose of measles vaccine at 6 months of age. The scheduled dose should also be given as soon as possible after 9 months of age. The extra measles dose is also recommended for groups at high risk for measles death, such as infants in refugee camps, infants admitted to hospitals, HIV-positive infants, and infants affected by disasters and during outbreaks of measles.

(From the *Pocket Book of Hospital Care for Children*, WHO 2005).

▶▶ APPENDIX 6: **Essential surgical supplies**

The basic surgical care of children requires specialized supplies and equipment. The following are the essential items needed for safe surgical care at the primary referral hospital. This equipment is for use in the emergency room, hospital ward and operating room.

Airway care and oxygen delivery

- Laryngoscope with paediatric size blades (including straight blades for neonates)
- Medium and large batteries (for laryngoscope and diagnostic set)
- Oropharyngeal airways (set of sizes for children and neonates)
- Paediatric-sized endotracheal tubes (sizes 2.5–10)
- Paediatric-sized face masks
- Oxygen cylinders and flow meters
- Oxygen concentrator as back-up source for oxygen supply
- Ambu bag (paediatric sizes with oxygen port)
- Suction machine
 - Electric powered
 - Manual (as back up)
- Suction tubes (various sizes)
- Nasal catheters

Venous access and blood transfusion

- Venous canulae (sizes 24G, 22G, 20G, 18G)
- Scalp vein (butterfly) needles (sizes 25G, 23G, 21G)
- Umbilical vein catheters
- Hypodermic needles (sizes 23G, 21G, 19G)
- Syringes (2 mL, 5 mL, 10 mL, 20 mL)
- Calibrated infusion sets (burette or Soluset) for neonates and infants
- Regular infusion-giving sets
- Blood-giving sets
- Blood and infusion warmer
- Intravenous fluids (see Appendix 3)
 - normal saline
 - Ringer's lactate
 - 5% dextrose in water, 10% dextrose in water, 50% dextrose

Maintaining warmth

- Radiant heater
- Electric room heater
- Hot-water bottles
- Large rolls of cotton wool
- Blankets (small, medium, large)

Wound care

- Antiseptics (chlorhexidine, etc.)
- Plain iodine (tincture of benzene compound)
- Fresh Eusol (Edinburgh University Solution)
- 1% silver sulfadiazine
- 5% povidone iodine
- Medical spirit
- Adhesive plasters/elastoplast
- Petroleum gauze
- Dressing materials
 - Cotton wool
 - Gauze
 - Cotton bandages
 - Crepe bandages
- Sutures (with atraumatic and cutting edge needles)
 - Vicryl (5/0, 4/0, 3/0, 2/0)
 - Nylon (4/0, 3/0, 2/0, 0)
 - PDS (4/0, 3/0, 2/0, 0)
 - Chromic catgut (5/0, 4/0, 3/0, 2/0)
 - Silk (4/0, 3/0, 2/0, 0)
- Tissue preservative: Formalin

Catheters and tubes

- Urethral catheters (6F, 8F, 10F, 12F, 14F): Foley or Nelaton
- Urine bags
- Feeding/nasogastric tubes (sizes 6, 8, 10, 12, 14, 16)
- Chest tubes of various sizes

Other

- Sphygmomanometer with paediatric cuffs (neonate, small, medium)
- Stethoscope

Appendix 6: Essential surgical supplies

- Diagnostic set (complete with auroscope, nasal speculum etc.)
- Splints of various sizes (preferably wooden or plastic) for fractures
- Skin traction kits
- Plaster of Paris
- Weighing scales: infant, standing
- Spinal needles
- Plastic bags (for covering eviscerated intestine)
- Disposable gloves (Latex)
- Sterile surgical gloves of various sizes
- K-Y lubricating gel
- Specimen bottles
 - Plain bottles for blood cross-matching
 - EDTA bottles for complete blood count
 - Urine bottles
 - Stool bottles
 - Tissue containers

▶▶ **Operating room**

These supplies are specific to the operating room, in addition to those listed above.

- Continuous-flow anaesthetic machine (Boyle's machine) equipped with oxygen and nitrous oxide
- Suction machines: electric-powered and manual
- Pulse oximeter
- Rechargeable light source (as standby if electric power fails or is not available).
- Surgical drains
 - tube drains
 - corrugated rubber
- 10% povidone iodine for skin preparation

▶▶ APPENDIX 7: **Further reading**

A Practical Guide to Paediatric Burns

J Thomas & H Rode

SAMA Health and Medical Publishing Group, South Africa, 2006

Clubfoot: Ponseti Management, third edition

L Staheli, I Ponseti et al.

Global Help (www.global-help.org), 2009

Guidelines For Essential Trauma Care

C Mock, JD Lormand, J Goosen, M Joshipura, M Peden

Geneva, World Health Organization, 2004

Paediatric Trauma and Child Abuse

S Van As, S Naidoo (eds)

Oxford University Press, 2006

Paediatric Trauma Care in Africa: a Practical Guide

EA Ameh, BC Nwomeh (eds)

Spectrum Books, 2006

Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Illnesses with Limited Resources

Geneva, World Health Organization, 2005

Primary Surgery Volume 1: Non-Trauma

MH King, PC Bewes, J Cairns, J Thornton (eds)

Oxford University Press, 1990

Primary Surgery Volume 2: Trauma

MH King

Oxford University Press, 1987

Rehabilitation surgery for deformities due to poliomyelitis: Techniques for the district hospital

J Krol (ed)

Geneva, World Health Organization, 1993

Surgical Care at the District Hospital

Geneva, World Health Organization, 2003

The Clinical Use of Blood in Medicine, Obstetrics, Paediatrics, Surgery & Anaesthesia, Trauma & Burns

Geneva, World Health Organization, 2002

Clinical Tuberculosis, 3rd edition

HL Reider, C Chen-Yuan, RP Gic, DA Enarson

Macmillan, Oxford, UK, 2009

WHO publications can be obtained via www.who.int/publications/en.

► Glossary

A

Abdomen: the portion of the body between the thorax and pelvis.

Abdominal wall defect: a birth defect where the abdominal wall does not close completely. *See* gastroschisis and exomphalus (omphalocele).

Abduction: movement of a limb (or other body part) away from the midline of the body.

Abscess: a collection of pus resulting from a bacterial infection.

Achilles tendon: The large tendon connecting the heel bone to the calf muscle of the leg.

Adduction: movement of a limb (or other body part) towards the midline of the body or from an adjacent part or limb.

Amniotic fluid: watery fluid within the amnion that surrounds the fetus.

Anaemia: a reduction in the quantity of haemoglobin, the oxygen-carrying pigment contained in red blood cells. The main symptoms are tiredness, breathlessness on exertion, pallor and poor resistance to infection.

Anaesthesia: loss of the ability to feel pain, caused by administration of a drug or other medical intervention.

Analgesic: a medicine that reduces pain.

Anal sphincter: a ring of muscle around the anus that controls emptying of the rectum.

Angular limb deformity: a limb that is no longer straight because of development problems in the angles of the joints.

Ankylosis: the stiffening and immobility of a joint.

Anorectal malformation: a birth defect where the anus and rectum do not develop normally.

Anorexia: loss of appetite.

Antegrade: moving or extending forwards.

Antenatal: before birth.

Antibiotic prophylaxis: the use of antibiotics to prevent infection.

Anthelmintic drug: medications used to treat worm infections.

Anxiolytic: a drug used to treat anxiety (acute or chronic).

Apical: situated at the top or highest position.

Apnoea: temporarily not breathing.

Appendectomy: surgical removal of the appendix.

Appendicitis: inflammation of the appendix.

Arthritis: inflammation of a joint, usually accompanied by pain, swelling and stiffness.

Arthrodesis: the surgical fixation of a joint, ultimately resulting in bone fusion.

Articular cartilage: cartilage that lines the joints.

Ascites: fluid in the abdominal cavity, most commonly resulting from liver failure.

Asphyxia: an extreme decrease in the concentration of oxygen in the body accompanied by an increase in the concentration of carbon dioxide, leading to loss of consciousness or death. Asphyxia can be induced by choking, drowning, electric shock, injury or the inhalation of toxic gases.

Aspiration: the entry of secretions or foreign material into the trachea and lungs.

Atelectasis: total or partial collapse of the lung.

Atlas: The first cervical vertebra of the neck, which supports the skull.

Atypical: unusual or irregular.

Auscultation: listening to the sounds produced by the movement of liquids or gases in the internal organs, such as the heart, lungs and intestines.

B

Bacteriuria: bacteria in the urine.

Balanitis: inflammation of the head of the penis.

Benign: not dangerous to health; usually used to describe a tumour that will not recur or progress.

Bilious: bile coloured (green).

Biopsy: the removal and examination of a sample of tissue from a living body for diagnostic purposes.

Bladder extrophy: a birth defect where the bladder is open on the abdominal wall.

Bone grafting: to transplant a piece of bone from one site to another.

Brachial cleft cyst: a cystic mass in the neck between the sternocleidomastoid muscle and the pharynx that results from abnormal embryonic development.

Bradycardia: slow beating of the heart.

Burkitt's lymphoma: a cancer of the lymphatic system, in particular B lymphocytes (named after Denis Parsons Burkitt, a surgeon who first described the disease in 1956 while working in equatorial Africa).

Burn contracture: reduced mobility of a joint due to scarring from a burn.

Burr hole: a hole drilled into the skull to decompress an epidural or subdural haematoma.

Buruli ulcer: an infectious disease caused by *Mycobacterium ulcerans*.

C

Calcification: the deposition of calcium in tissue.

Cancer: a group of diseases in which cells are aggressive (grow and divide without respect to normal limits), invasive (invade and destroy adjacent tissues), and/or metastatic (spread to other locations in the body).

Cancrum oris: a gangrenous disease that leads to destruction of the facial tissue, particularly the mouth and cheek; also known as noma.

Cannulation: insertion of a tube into a vein to either withdraw blood or give medication.

Capillary refill: the rate at which blood refills an empty capillary. Capillary refill time is a common measure of peripheral perfusion.

Caput medusae: the appearance of distended veins around the umbilicus. It is usually a sign of increased pressure in the portal vein, the main vein that takes blood from the bowel to the liver.

Cardiomyopathy: deterioration of the function of the myocardium (heart muscle).

Cellulitis: inflammation of the connective tissue underlying the skin, usually caused by a bacterial infection.

Cephalohaematoma: haemorrhage of blood between the skull and the periosteum of a newborn baby.

Cerebrospinal fluid (CSF): the clear fluid that surrounds the brain and spinal cord.

Chemotherapy: the use of drugs to treat disease; most commonly it refers to cytotoxic drugs used to treat cancer.

Choanal atresia: a birth defect where there is a blockage of the choana, the passageway from the back of one side of the nose to the throat.

Cholecystitis: inflammation of the gallbladder.

Cholesteatoma: a destructive and expanding sac in the middle ear and/or mastoid process.

Circumcision: an operation in which the foreskin is removed from the penis.

Clavicle: the bone that connects the arm to the body; also called the collar bone.

Cleft lip and palate: birth defects where there is abnormal development of the lip and palate (roof of mouth). They may occur separately or together.

Cloaca: a complex anorectal and genitourinary malformation in which the rectum, vagina and urinary tract meet and fuse, creating a single common channel.

Cloacae: a passage in a bone leading to a cavity containing a sequestrum.

Clonus: a series of alternating contractions and partial relaxations of a muscle that results from neurological disease.

Closed fracture: a fracture that does not cause little or no damage to the surrounding soft tissues and skin.

Clubfoot: a congenital deformity in which the foot is twisted out of shape or position; also known as talipes equinovarus.

Coagulopathy: a disorder in which blood is either too slow or too quick to coagulate (clot).

Colon: the part of the large intestine extending from the caecum to the rectum.

Colostomy: a surgical procedure in which a portion of the colon (large intestine) is brought through the abdominal wall to carry stool out of the body.

Comorbidity: a concomitant but unrelated disease process.

Compartment syndrome: a condition in which a muscle swells but is constricted by the connective tissue around it, cutting off blood supply to the muscle.

Condyloma: raised wartlike growth.

Congenital diaphragmatic hernia: a birth defect where there is no diaphragm, allowing protrusion of the abdominal organs into the chest.

Congenital: referring to conditions that are present at birth.

Contracture: an abnormal, often permanent, shortening of a muscle or scar tissue that results in the distortion or deformity of a joint.

Contrast enema: a type of radiographic examination to view the large intestine.

Cortex: the outer layer of an organ or other structure, as in the cortex of the brain.

Cranial suture: the lines of junction between the bones of the skull.

Craniofacial: the portion of the skull that contains the face and brain.

Cricoid cartilage: the lowest of the laryngeal cartilages, and the narrowest part of the trachea in a child.

Cricopharyngeal: relating to the cricoid cartilage and pharynx.

Cricothyrotomy: Incision through the skin and the cricothyroid membrane for emergency relief of upper respiratory obstruction.

Croup: a viral infection of the larynx (voice box) usually associated with mild upper respiratory symptoms such as a runny nose and cough. The key symptom is a harsh, barking cough.

Cryptomenorrhoea: menses without external blood flow.

Cyanosis: a bluish or purplish discolouring (of the skin, nail beds, lips) due to deficient oxygenation in the blood.

Cyst: an abnormal closed, epithelium-lined cavity in the body, containing liquid or semisolid material.

Cystic fibrosis: an inherited disease that affects the lungs, digestive system, sweat glands and male fertility.

Cystic hygroma: a lymphangioma usually occurring in the neck and composed of large, multilocular, thin-walled cysts.

Cystogram: a radiological examination used to evaluate the bladder.

Cystourethrogram: a type of radiological examination used to evaluate the bladder and urethra.

Cytology: the microscopic study of cells obtained from superficial or internal lesions by suction through a fine needle.

D

Debride: to remove non-living tissue from pressure ulcers, burns and other wounds.

Dens: a tooth-like process projecting upward from the body of the axis (second cervical vertebra) around which the atlas (second cervical vertebra) rotates; also known as odontoid.

Dermatitis: a general term used to describe inflammation of the skin.

Dermis: the layer of the skin deep to the epidermis.

Devitalized tissue: tissue that is no longer receiving blood flow.

Diagnosis: the process of identifying a disease from its signs and symptoms.

Diaphysis: the main or mid section (shaft) of a long bone.

Diskitis: inflammation of an intervertebral disk or disk space.

Dislocation: displacement of bones at a joint.

Doppler ultrasound: an imaging technique that uses ultrasound to detect blood flow.

Dorsiflexion: the turning of the foot or the toes upwards.

Duodenum: the first part of the small intestine, the segment of bowel between the stomach and jejunum.

Dysentery: a term for a group of gastrointestinal disorders characterized by inflammation of the intestines, particularly the colon. Characteristic features include abdominal pain and cramps, straining at stool (tenesmus), and frequent passage of diarrhoea or stools containing blood and mucus.

Dysplasia: abnormal development.

Dysuria: painful or difficult urination.

E

Eardrum: the thin semitransparent membrane in the middle ear that transmits sound vibrations to the internal ear; also called the tympanic membrane.

Ectopic: located away from the normal position.

Effusion: the escape of fluid from blood vessels or the lymphatic system and its collection in a cavity.

Elective surgery: a surgical procedure that does not need to be done as an emergency.

Electrolyte: various ions, such as sodium or chloride, required by cells to regulate the electric charge and flow of water molecules across the cell membrane.

Empyema: most often used to refer to collections of pus in the space around the lungs (pleural cavity).

Encephalopathy: any degenerative brain disease.

Endoscopy: visual examination of interior structures of the body with an endoscope.

Endotracheal tube: a tube inserted (through the nose or mouth) into the trachea to maintain an unobstructed passageway, especially to deliver oxygen or anaesthetic to the lungs; also called a breathing tube.

Enterocolitis: inflammation affecting both the large and small intestine.

Epidermis: the outer layer of the skin.

Epididymis: the system of ducts that hold sperm during development. The epididymis is situated next to the testicle and is continuous with the vas deferens.

Epididymitis: inflammation of the epididymis.

Epidural haematoma: a type of traumatic brain injury in which blood collects between the outer membrane of the brain and the inside of the skull.

Epiglottis: the cartilage that projects upwards behind the tongue and protects the airway during swallowing.

Epiglottitis: inflammation of the epiglottis.

Epiphyseal plate: an area at the end of a long bone where growth occurs; also called the growth plate.

Epiphysis: the end of a long bone.

Erb's palsy: paralysis of the arm resulting from injury to the brachial plexus (usually during birth).

Escharotomy: Incision into a burn eschar in order to lessen its pull on the surrounding tissue.

Excisional biopsy: surgical removal (of a cyst or tumour) without cutting into it.

Exomphalus: hernia of the abdominal viscera into the umbilical cord; also called omphalocele.

External fixation: The fixation of a fractured bone by application of an external device.

External rotation: The outward rotation of a limb or organ.

F

Faecal incontinence: inability to control bowel movements.

Fistula: an abnormal passageway between two organs in the body or between an organ and the exterior of the body.

Flatus: gas or air expelled through the anus.

Flexion: the act of bending a joint or limb.

Fluctuant: a physical exam finding suggesting that a mass is fluid filled.

Fluid deficit: a deficiency in fluid volume.

Fluoroscopy: a radiography procedure that produces immediate images and motion on a screen.

Foley catheter: a thin sterile tube inserted into the bladder to drain urine.

Fontanel: the soft spot on top of the baby's head where the skull bones come together.

Foreskin: the fold of skin covering the glans penis; also called the prepuce.

Fracture: a break in a bone.

Frozen section: a thin slice of tissue that is cut from a frozen specimen to enable rapid microscopic diagnosis.

G

Ganglion cell: a nerve cell that has its body outside the central nervous system. Ganglion cells in the intestine control contractility of the bowel.

Gangrene: death and decay of body tissue.

Gastroesophageal junction: the area where the oesophagus connects to the stomach.

Gastroschisis: a birth defect where the abdominal wall does not close completely, resulting in protrusion of the intestines.

Gavage: introduction of nutritive material into the stomach by means of a tube.

Germ cell tumour: a neoplasm derived from the cells involved in the production of gametes (ova or sperm).

Gerota's fascia: A fibrous envelope of tissue that surrounds the kidney.

Gibbus: a hump on the spine; usually used to describe a physical exam finding that occurs in tuberculosis of the spine.

Glasgow coma scale (GCS): a scale used to measure and monitor level of consciousness, especially after a head injury. The score is based on three factors: amount of eye opening, verbal responsiveness and motor responsiveness.

Granulation tissue: tissue formed during wound healing, with a rough or irregular surface and a rich supply of blood capillaries.

H

Haematocrit: The percentage by volume of packed red blood cells in a sample of blood after centrifugation.

Haematogenous: originating in or spread by the blood.

Haematoma: a collection of clotted blood.

Haematuria: blood in the urine.

Haemoglobinopathy: a blood disease characterized by the presence of abnormal haemoglobin in the blood.

Haemorrhage: the escape of blood, as from an injured vessel.

Haemothorax: a collection of blood in the pleural space (the space between the lung and inside of the chest wall).

Hepatoblastoma: a malignant tumour of the liver, occurring in infants and young children.

Hernia: a bulge or protrusion of an organ through the structure or muscle that usually contains it.

Hip dysplasia: abnormal development of the hip.

Hirschsprung's disease: an abnormality in which certain nerve fibres are absent from segments of the bowel, resulting in severe bowel obstruction; also known as congenital megacolon or aganglionic megacolon.

Hydrocele: a collection of fluid around a testicle.

Hydrocephalus: an excessive amount of cerebrospinal fluid in the brain.

Hydrocolpos: collection of watery fluid in the vagina.

Hydrometrocolpos: accumulation and distension of the uterus and vagina by fluid other than blood or pus.

Hydronephrosis: swelling of the kidneys when urine flow is obstructed in any part of the urinary tract.

Hypercapnia: an increased amount of carbon dioxide in the blood.

Hyperglycaemia: a higher than normal blood sugar.

Hyperreflexia: disordered response to stimuli characterized by exaggeration of reflexes.

Hypertension: higher than normal blood pressure.

Hypertonia: a condition of excessive tone of the skeletal muscles; increased resistance of muscle to passive stretching.

Hypoglycaemia: a lower than normal blood sugar.

Hypospadias: a congenital deformity of the penis in which the opening of the urinary tract is not at the tip of the glans.

Hypotension: lower than normal blood pressure.

Hypothermia: a body temperature below 35°C (95°F).

Hypotonia: decreased tone of the skeletal muscles.

Hypovolaemia: abnormally decreased volume of circulating fluid (plasma).

Hypoxia: reduced oxygen supply to tissues.

I

Idiopathic: no known cause.

Ileus: partial or complete non-mechanical blockage of the small and/or large intestine.

Immunosuppression: suppression of the immune response.

Imperforate anus: a birth defect in which the rectum ends in a blind alley and there is no anus.

Incarcerated hernia: a hernia that cannot be reduced (pushed back into place inside the intestinal wall).

Induration: hardening of a normally soft tissue or organ, especially the skin, because of inflammation, infiltration of a neoplasm or an accumulation of blood.

Inflammation: a protective tissue response to injury or destruction of tissues. The classic signs of acute inflammation are pain, heat, redness, swelling and loss of function.

Inguinal hernia: hernia in which a loop of intestine enters the inguinal canal.

Insidious: working in a subtle or apparently harmless way, but nevertheless dangerous or deadly.

Internal fixation: operative repair of a fracture.

Interspinous: between two spinous processes of the vertebral column.

Intramedullary: within the bone marrow of a bone.

Intramuscular (IM): used to describe injection into a muscle.

Intraosseous: used to describe the process of injecting directly into the marrow of the bone. The needle is injected through the bone's hard exterior (cortex) and into the soft marrow interior.

Intrauterine: within the uterus.

Intravascular space: the space occupied by the blood.

Intravenous (IV): placed into a vein.

Intubation: the insertion of a tube into a body canal or hollow organ, as into the trachea.

Intussusception: the enfolding (passing inside) of one segment of the intestine within another.

Involucrum: a layer of new bone growth outside existing bone seen in osteomyelitis.

Ischaemia: insufficient blood flow to a tissue.

J

Jejunum: the second part of the small bowel, located between the duodenum and ileum.

Joint capsule: the sleeve of connective tissue that connects two bones in a joint.

K

Kangaroo care: specialized care of newborns and premature babies where the naked baby is kept on the mother's chest; also known as skin-to-skin care.

Kaposi's sarcoma: a soft-tissue tumour (sarcoma) commonly associated with AIDS. It starts with purplish spots on the feet and legs and spreads from the skin to lymph nodes and internal organs.

Kyphosis: abnormal rearward curvature of the spine, resulting in protuberance of the upper back; hunchback.

L

Labia minora: the two inner folds of the vulva.

Laparotomy: surgical incision through the abdominal wall; often done to examine abdominal organs.

Laryngoscope: an instrument used to look at the larynx, it is commonly used to see the vocal cords when an endotracheal tube is passed into the trachea.

Laryngotracheobronchitis: inflammation of the larynx and trachea.

Lavage: to clean or rinse.

Leg-length discrepancy: one leg is longer than the other.

Lethargy: the state of being sluggish or indifferent.

Loculation: a collection of fluid or pus that is trapped.

Lymphadenitis: inflammation of a lymph node.

Lymphadenopathy: a disease process that involves a lymph node or nodes; enlarged lymph nodes.

Lymphangioma: a benign tumour composed of abnormal lymph vessels.

Lymphoma: any of the malignant tumours that arise in the lymph nodes or in other lymphoid tissue.

M

Malaise: a vague feeling of unwellness and discomfort, as occurs at the beginning of an illness.

Malignancy: a tumour that is cancerous and growing.

Malignant tumour: a cancerous growth with a tendency to metastasize (spread) and grow unchecked.

Medial: located in or directed toward the middle; closer to the body's midline.

Mediastinum: the area between the lungs, bounded by the spine, breastbone and diaphragm.

Meninges: the three membranes covering the brain and spinal cord: dura mater, arachnoid mater and pia mater.

Meningocele: protrusion of the meninges through a defect in the skull or vertebral column.

Meningomyelocele: hernial protrusion of the meninges and spinal cord through a defect in the vertebral column, often spina bifida; also called myelomeningocele.

Metabolism: the energy expended to maintain respiration, circulation, peristalsis, muscle tone, body temperature, glandular activity and the other vegetative functions of the body.

Metachronous: multiple separate occurrence; not synchronous.

Metaphysis: the portion of a long bone between the epiphyses and the diaphysis.

Micturition: the passing of urine.

Molluscum contagiosum: an infectious disease of the skin caused by a virus of the family Poxviridae and characterized by the appearance of small, pearly, umbilicated skin lesions.

Mucous fistula: the non-functional end of bowel that has been brought out as a stoma.

Myelomeningocele: Protrusion of the spinal membranes and spinal cord through a defect in the vertebral column; also called meningocele.

Myositis: inflammation of a muscle.

N

Nasogastric tube: a tube that is passed through the nose down into the stomach to keep the stomach empty.

Necrosis: death of cells or tissues through injury or disease, especially in a localized area of the body.

Neoadjuvant: referring to preliminary cancer therapy, usually chemotherapy or radiation therapy, that precedes a necessary second modality of treatment.

Neonate: an infant up to 28 days old.

Neoplasm: an abnormal new growth of tissue; a tumour.

Nephroblastoma: a malignant tumour of the kidney that chiefly affects young children; also called Wilms' tumour.

Neuroblastoma: a malignant tumour composed of neuroblasts, originating in the autonomic nervous system or the adrenal gland and occurring chiefly in infants and young children.

Neuromuscular: relating to or affecting both nerves and muscles.

Nodule: a small mass of tissue.

Noma: a gangrenous disease that leads to tissue destruction of the face, especially the mouth and cheek; also known as cancrum oris.

Nosocomial: originating in the hospital.

O

Odontoid: a small tooth-like upward projection from the second vertebra of the neck around which the first vertebra rotates; also known as dens.

Oedema: an excessive accumulation of serous fluid in tissue spaces or a body cavity.

Oesophageal atresia: a birth defect in which the oesophagus is blocked.

Oesophagitis: inflammation of the oesophagus.

Omentum: one of the folds of the peritoneum (lining of the abdominal cavity) that connect the stomach with other abdominal organs.

Omphalocele: a birth defect in which the abdominal contents herniate into the base of the umbilical cord; also called exomphalos.

Opacification: the process of something becoming opaque (unable to pass light).

Open fracture: a fracture in which the bone has broken the surface of the skin.

Orchidopexy: a surgical procedure in which an undescended testicle is placed in the scrotum.

Orchitis: inflammation of the testis.

Orthopaedic: the medical specialty that deals with deformities of the musculoskeletal system.

Osmotic diuresis: discharge of urine, especially in unusually large amounts.

Ossification centre: the area where bone formation occurs. In a long bone there is a primary centre for the diaphysis and one secondary centre for each epiphysis.

Osteomyelitis: infection in the bone.

Osteotomy: incision or division of a bone.

P

Paralysis: complete loss of strength in an affected limb or muscle group.

Paraphimosis: entrapment of a retracted foreskin behind the coronal sulcus, a groove that separates the shaft and head of the penis.

Paravertebral: located along a vertebra or the vertebral column.

Percutaneous: passing through the skin without making an incision.

Perfusion: blood flow to organs and tissue that delivers oxygen and nutrients.

Perineum: the diamond-shaped region of the body between the pubic arch and the anus.

Periosteum: the thick fibrous membrane covering the entire surface of a bone except its articular cartilage and serving as an attachment for muscles and tendons.

Peritonitis: inflammation of the inside lining of the abdominal cavity.

Phimosis: tightening of the foreskin of the penis that may close the opening of the penis.

Phlebitis: inflammation of a vein.

Physis: a term sometime used for the epiphyseal plate; also called the growth plate.

Plantar: pertaining to the sole of the foot.

Pleural space: the space between the outside of the lungs and the inside of the chest wall.

Pneumothorax: a punctured lung.

Ponseti method: a method for repairing clubfoot.

Posterior sagittal anorectoplasty (PSARP): surgical repair of an anorectal malformation.

Posterior urethral valves: a birth defect in the male urethra that obstructs urinary flow.

Posthitis: inflammation of the prepuce (foreskin).

Premature: used to describe an infant born before 37 weeks' gestation.

Prenatal: preceding birth; antenatal.

Prepuce: the fold of skin covering the glans penis; also called the foreskin.

Prophylaxis: a measure taken to maintain health and prevent the spread of disease; antibiotic prophylaxis refers to the use of antibiotics to prevent infections.

Pseudosubluxation: a normal variant that gives the appearance of a dislocation (subluxation).

Psoas abscess: an abscess in the iliopsoas muscle.

Pull-through operation: a surgical procedure used to repair Hirschsprung's disease.

Pyelonephritis: inflammation of the kidney and upper urinary tract that usually results from a non-contiguous bacterial infection of the bladder (cystitis).

Pyogenic: producing pus.

Pyomyositis: a collection of pus in a muscle.

Pyuria: white blood cells in the urine.

R

Radiograph: the picture or film produced using X-rays.

Radiolucent: characterized by allowing passage of X-rays or other radiation; not radiopaque.

Radiopaque: the capability of a substance to hinder or completely stop the passage of X-rays, such as lead and bones, thus producing a light image on film.

Rectal prolapse: protrusion of rectal tissue through the anus to the exterior of the body.

Rectosigmoid: the rectum and sigmoid colon.

Rectovaginal fistula: an abnormal connection between the rectum and vagina.

Rehabilitation: treatment to facilitate the process of recovery from injury, illness or disease to as normal a condition as possible.

Retinal haemorrhage: haemorrhage into the light-sensitive layer of the eye.

Retroperitoneal: the area behind the abdominal cavity that contains the kidneys, pancreas and parts of the colon.

Retropharyngeal: posterior to the pharynx.

Rhabdomyosarcoma: a highly malignant tumour that begins in striated muscle.

Rotational misalignment: a deformity produced by twisting.

S

SCIWRA: spinal cord injury without radiological abnormality.

Sepsis: a bacterial infection in the bloodstream or body tissues.

Septic arthritis: infection in a joint.

Sequestrectomy: removal of a sequestrum.

Sequestrum: a piece of dead and infected bone that occurs in osteomyelitis (bone infection).

Seroma: a mass or swelling caused by the localized accumulation of serum within a tissue or organ.

Shock: a medical emergency in which the organs and tissues of the body are not receiving adequate flow of blood.

Sialoadenitis: inflammation of a salivary gland.

Skin-to-skin care: specialized care of newborns and premature babies where the naked baby is kept on the mother's chest; also known as kangaroo care.

Spasm: sudden, violent, involuntary muscular contraction.

Spina bifida: a birth defect in which the spinal cord is malformed and lacks its usual protective skeletal and soft tissue coverings.

Spina lamina: either of the pair of broad plates of bone flaring out from the pedicles of the vertebral arches and fusing at the midline to complete the dorsal part of the arch and providing a base for the spinous process.

Spinous process: the dorsal projection from the centre of a vertebral arch.

Spleen: a large gland-like organ situated in the upper left part of the abdominal cavity.

Sternocleidomastoid muscle: a large muscle in the neck that turns the head obliquely to the opposite side and flexes the neck.

Stoma: the artificial opening of a tube such as the colon that has been brought to the abdominal surface.

Stridor: describes noisy breathing in general, and specifically refers to a high-pitched sound associated with croup, respiratory infection and airway obstruction.

Stroke volume: the amount of blood the heart pumps per beat.

Subcutaneous: located or found just beneath the skin.

Subcutaneous emphysema: the presence of air or gas in subcutaneous tissues.

Subdural haematoma: a type of traumatic brain injury in which blood collects between the dura (the outer protective covering of the brain) and the arachnoid mater (the middle layer of the meninges).

Subgaleal haematoma: bleeding in the potential space between the periosteum of the skull and scalp galea aponeurosis.

Subluxation: incomplete or partial dislocation, as of a bone in a joint.

Suppuration: the formation or discharge of pus.

Synchondrosis: cartilaginous joint between two immovable bones such as the union between the sternum and ribs.

Synchronous: occurring or existing at the same time.

Synovitis: inflammation of the synovium, the membrane that lines the joint.

T

Tachycardia: rapid beating of the heart.

Tachypnoea: rapid breathing rate.

Talipes equinovarus: a foot deformity in which the heel is turned inwards and the foot is plantar flexed; also known as clubfoot.

Talus: the bone of the ankle that connects with the tibia and fibula to form the ankle joint.

Tenotomy: the surgical division of a tendon to correct a deformity caused by congenital or acquired shortening of a muscle.

Teratoma: a tumour consisting of different types of tissue, as of skin, hair and muscle, caused by the development of independent germ cells.

Therapeutic: curative or healing.

Thoracotomy: surgical incision through the chest wall.

Thrombocytopenia: reduced number of platelets. Platelets have an important role in stopping bleeding.

Thyroglossal duct cyst: a midline cyst in the neck related to an embryonic duct extending between the thyroid gland and the posterior tongue.

Tibialis anterior: a muscle in the lower leg that brings the foot upwards.

Torsion of the testicle: twisting of the spermatic cord, cutting off the blood supply to the testicle.

Torticollis: a contracted state of the neck muscles producing an unnatural position of the head.

Total parenteral nutrition: provision of all nutrition by the intravenous route.

Tracheoesophageal fistula: a birth defect in which there is an abnormal connection between the trachea and oesophagus.

Tracheostomy: surgical construction of a respiratory opening in the trachea.

Traction: a pulling force.

Transition zone: the area between normal and abnormal bowel in Hirschsprung's disease.

Tuberculosis: a bacterial infection caused by *Mycobacterium tuberculosis*.

Tumour: a new growth of tissue in which cell multiplication is uncontrolled and progressive.

Turgor: the normal resiliency of the skin. Dehydration results in decreased skin turgor, manifested by lax skin that, when grasped and raised between two fingers, slowly returns to its normal position.

Typhoid fever: a severe infection caused by the bacterium *Salmonella typhi*.

U

Ultrasonography: A non-invasive study using ultrasound to visualize an internal body structure or to monitor a developing fetus.

Umbilical hernia: a hernia occurring at the belly button (umbilicus).

Umbilicus: the circular depression in the centre of the abdomen marking the site of attachment of the umbilical cord in the fetus; also known as the navel or belly button.

Undescended testicle: a testicle that has never been in the scrotum.

Unilateral: affecting only one side.

Urethra: the canal through which urine is discharged from the bladder to the exterior of the body.

Urinary frequency: urination at short intervals without an increase in daily volume or urinary output.

Urinary retention: inability to pass urine, resulting in a painful distended bladder.

Urinary urgency: a sudden and powerful need to urinate.

Urology: the medical specialty concerned with the urinary system and the male genital organs.

V

Vaginal atresia: a birth defect in which the vagina does not develop.

Vaginal septum: a developmental abnormality in which the vagina is blocked.

Glossary

Valgus: a deformity in which the angulation of the body part is away from the midline of the body (bent outwards).

Varus: a deformity in which the angulation of the body part is towards the midline of the body (bent inwards).

Vas deferens: the main secretory duct of the testicle, through which semen is carried from the epididymis to the prostatic urethra, where it ends as the ejaculatory duct.

Vena cava: the large vein that drains directly into the heart after gathering blood from the entire body.

Venipuncture: puncture of a vein for drawing blood, giving intravenous fluid or administration of medicine.

Ventral: the anterior part of a structure, or the part opposite the anatomical back.

Ventriculo–peritoneal shunt: a tube placed from the ventricles of the brain to the abdominal cavity in order to drain excess cerebrospinal fluid in hydrocephalus.

Vertebral body: any of the 33 bones of the vertebral (spinal) column, comprising seven cervical, 12 thoracic, five lumbar, five sacral, and four fused coccygeal vertebrae.

Vesicostomy: Surgical creation of a stoma between the anterior bladder wall and the skin of the lower abdomen, for temporary or permanent lower urinary tract diversion.

Vesicoureteral reflux: backflow of urine from the bladder into the ureters or kidneys.

Voiding problem: difficulty passing urine.

Vulva: the external parts of the female genitalia.

W

Wilms' tumour: a rapidly growing cancer of the kidneys; also called nephroblastoma.

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Surgical Care for Children

This comprehensive guide will support specialist and non-specialist practitioners in paediatric surgery, particularly where they are working in difficult conditions with restricted resources. Dr Bickler has drawn together an excellent team of experts in paediatric surgery and has ensured good coverage of all the commonest conditions. The writing is succinct and accessible, so that this book can be used as a handbook in all types of primary referral facilities.

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