

## 2 The surgical infrastructure

*"It is one thing to operate with the chief at your elbow on a patient whose vital functions are being monitored by an expert anaesthetist at the head of the table. It is quite another to be almost alone at midnight, struggling with a patient in shock from a ruptured ectopic pregnancy, as the light fades in and out while a superannuated generator tries to function on adulterated diesel oil. Then is the moment of truth when you realize that an excellent theoretical foundation is not the only thing you need."*  
Hankins GW, the former Shanta Bhawan Hospital, Kathmandu, Nepal, Annals Roy Coll Surg Engl 1980; 62(6):439-44

### 2.1 The major theatre

Although aseptic surgery has been done in a tent, under a tree, or on a kitchen table, it is safer if it is done in a room which has been designed to preserve the sterility of the surgical field, to make surgical routines easier, and to prevent mistakes. The difficulty with aseptic methods is that they require an autoclave. If you don't have one, we describe an antiseptic method that you can use instead (2.6).

Do all you can to prevent nosocomial infections, *i.e.* those reaching the patient whilst he is in hospital. Such infection may come from himself, other staff, equipment and instruments, linen, furniture, floors, walls, water, toilets and insects. Things that come in contact with sterile internal parts of a patient need **sterilization** (2.4) whilst those that come in contact with intact mucous membrane need **disinfecting** (2.5). Other items need simple cleaning.

You will need 2 theatres at least: a major one and a minor septic one (2.2). We are concerned here with the major one. When you start work in a theatre, look at it carefully. How many of the desirable features that we are about to describe does it have? Is there anything which you could do to make it safer or more efficient?

The operating team should be as small as possible. It consists of:

- (1) Yourself, the surgeon.
- (2) Your assistant(s), when you need one or two.
- (3) The scrub nurse responsible for the instruments.
- (4) The circulating nurse to fetch and carry.
- (5) The anaesthetist.
- (6) His assistant, if he has one.

Two other people are important:

- (a) the theatre charge nurse responsible for organizing the theatre, and who in a smaller hospital will usually take turns being on call,
- (b) the 'theatre assistant' who, unlike the nurses who come and go, may have spent his whole career in the theatre and in that case will know its routines and where things are.

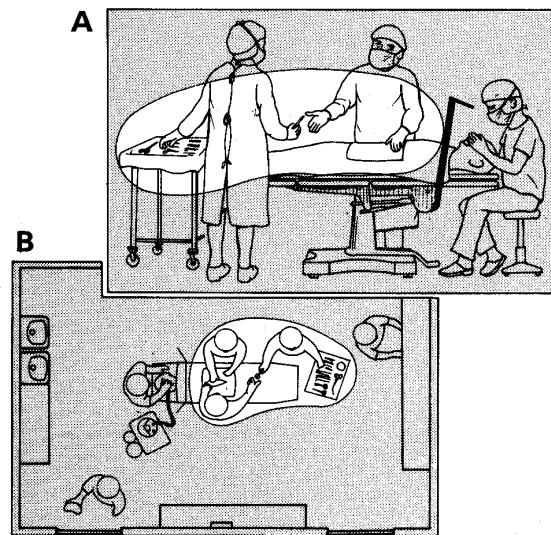
In an emergency, roles (2) and (3) can be combined in an efficient nurse or medical assistant, and so can roles (4) and (6). The first 3 members of the team are clothed in sterile gowns, the last three are not. An important part of the drill in theatre is to prevent the last 3 from contaminating the surgical field and the first 3.

Two zones in the theatre ensure this:

(1) A sterile zone which includes the operation site, the first 3 members of the team, and that part of the theatre immediately around them.

(2) An unsterile zone which usually includes the head end of the patient, separated from the surgeon by a towel rest, and the remainder of the theatre. The last 3 members of the team can move freely within this zone. The patient's entrance and the access to the sluice room are continuous with it. A separate room for scrubbing up is not essential; scrubbing is possible in the theatre in two domestic pattern sinks with draining boards. They should be fitted with elbow taps which are very highly desirable, although you can, if necessary, scrub up from a bucket or use spirit-based cleansing solutions. The boiler, autoclave, preparation room, and store rooms should be outside the theatre.

#### THE STERILE ZONE



**Fig. 2-1 STERILE AND UNSTERILE ZONES IN A THEATRE.**  
A, sterile zone (white) in a vertical dimension. B, sterile zone in a horizontal dimension. The sterile zone contains the operation site, the instrument trolley and the three scrubbed-up members of the surgical team. The unsterile zone comprises everything else in the theatre. The sterile zone is separated from the unsterile zone by a towel rest. The great danger, when technique is poor, is for the sterile zone to become smaller and smaller as the operation progresses.

Adequate space is essential, so that staff can move freely within their zones, and without touching one another. Space is needed for manoeuvring and parking the patient's stretcher next to the operating table, and for parking trolleys without congestion. The absolute minimum is 25m<sup>2</sup>; a room 5x6.5m (32m<sup>2</sup>) is better, and 42m<sup>2</sup> is ideal. The more equipment you have in the theatre, the more space you need, and in ideal conditions 64m<sup>2</sup> is normal.

If the case load is heavy, a 2<sup>nd</sup> theatre is more useful than making the 1<sup>st</sup> one unduly large, unless you plan to run 2 operating tables in the same theatre; this is useful if you have only one anaesthetist to supervise cases. A *large operating theatre with areas not used will not be properly cleaned.*

Straightforward physical cleanliness is important. Sophisticated methods are unnecessary. Sluicing the floor between cases, washing the walls weekly and mobile equipment daily will ensure a high enough standard without using antiseptics on the theatre itself.

The floor is important. The most dangerous sources of infection are pus and excreta from the patients, which must be cleared away between every operation, and must not be allowed to contaminate the theatre. To make this easier, it should have a terrazzo floor, but a smooth concrete finish is almost as good and much cheaper. To make it easier to wash down, it should have a 1:1000 slope towards an open channel along the foot of the wall at the unsterile end of the theatre. This channel should have a plugged outlet leading directly outside to an open gully. Fit a sparge pipe to the wall at the sterile end 150mm above the floor, so that the whole floor can be flooded by turning a tap. A little dust on trolley wheels or shoes, or from open windows, is less dangerous than is generally believed, but remember hair, fibres and fluff tend to get caught in wheels and need to be periodically removed.

The walls of the theatre should be smooth, but they need not be tiled. A sand and cement backwash application painted with one coat of emulsion and two coats of eggshell gloss is adequate. Gloss paint is satisfactory for the walls, and the fewer the doors, sills, ledges, crevices, mouldings, architraves, and window boards, the better. The main point is that the walls must be washable preferably up to 3m.

Every time a door is opened, dust from the floor is whirled into the room. There is no need for a door between the changing rooms and the theatre. A door is only needed between the sluice and sterilizing room, if these rooms will be used when the theatre is not.

The ceiling should be at least 3.5m high and the roof timbers solid enough to support an operating light. It should also have a pair of 2m fluorescent tubes or LED lights. The ambient level of illumination should be high, so make the windows big enough. They may enable most operations to be done by daylight. A suitably placed mobile mirror to catch the bright sunlight is very useful. There should be a window of 5m<sup>2</sup> at the head and the foot ends, facing north and south shaded by a roof overhang of at least 800mm. Even better are windows on three sides. Fit ordinary low windows, and frost only the panes below eye level, so that the staff can look out (which improves morale), but that anyone looking in can only see their heads, not the patient.

In the tropics avoid windows in the roof. You may need fans to reduce the temperature, but *remember they can blow dirt and dust into wounds! Electrical air conditioning is notorious for collecting dust and transmitting bacteria:* it should not be a high priority; use an alternative (1.11). Make sure the theatre still remains warm enough: hypothermia due to exposure still occurs in tropical regions, especially at night. *It is comfort of the patient, who is practically naked, not of the surgeon, that is important.*

*Don't have more shelves than you need, but keep the things you need daily nearby; use trolleys where you can. When shelves are needed, set them 50mm away from the wall on metal rods, so that they can be lifted away for ease of cleaning. All shelves should be at least 1m high so that trolleys can be pushed under them. The glove shelf should be at least 1.2m high, so that you can keep your hands higher than your elbows to prevent water running back down over your now dry hands. The anaesthetist needs a lockable cupboard, a trolley, and a worktop near the patient's head.*

Electric sockets should be 1.5m above the floor to minimize the danger of igniting explosive gases, and damage from moving beds and trolleys. Make sure your electric sockets are uniform, and you have equipment working with the hospital voltage. You can easily overload the system if you have lights, a sterilizer, suction machines, lights, fans and diathermy all working at the same time. Make sure you have an emergency power source. A foot suction pump and hand-torches are useful in a crisis.

Basic requirements are:

*OPERATING TABLE, simple pattern.* The minimum requirements of an operating table are that: (1) you must be able to tilt the patient's head down rapidly for the Trendelenburg position, and if he vomits (2) you should be able to adjust its height. This table does these things at a fraction of the cost of the standard hydraulic ones, which need careful maintenance and are useless when their hydraulic seals perish. However, if a simple general purpose hydraulic table is well maintained, it lasts a long time. A really sophisticated one can cost as much as the entire building of the theatre. A dirty table is a menace, so make sure yours is kept clean.

If the head of your table does not tilt head down, get one that does. Meanwhile, in an emergency, you can put a low stool under the bar at its foot. If it does not tilt from side to side, make a wooden wedge to fit under the mattress. If it does not have a kidney bridge and you need one, use folded plastic covered pillows.

Locally made 'Chogoria' supports (19-3) are a useful addition to a standard table. They are made of 2 suitably bent pieces of pipe which fit into the holes for ordinary stirrups and keep the patient's hips widely abducted, and the hips and knees moderately flexed, so that the lower legs are horizontal. The legs rest on boards attached to these pipes. These supports are more comfortable than stirrups and are particularly useful for such operations as tubal ligation.

*ALTERNATIVE OPERATING TABLE, Seward minor or equivalent.* This is slightly more versatile and considerably more expensive than the table above.

*MATTRESS, for operating table, with three or more mackintosh covers.* A dirty mattress is a potentially serious source of infection. So swab the cover after each patient, and replace it regularly.

*ARM BOARDS (2), for operating table, locally made.* These are simply pieces of hardwood about 20x120x1000mm, which you push under the mattress to rest the patient's arm.

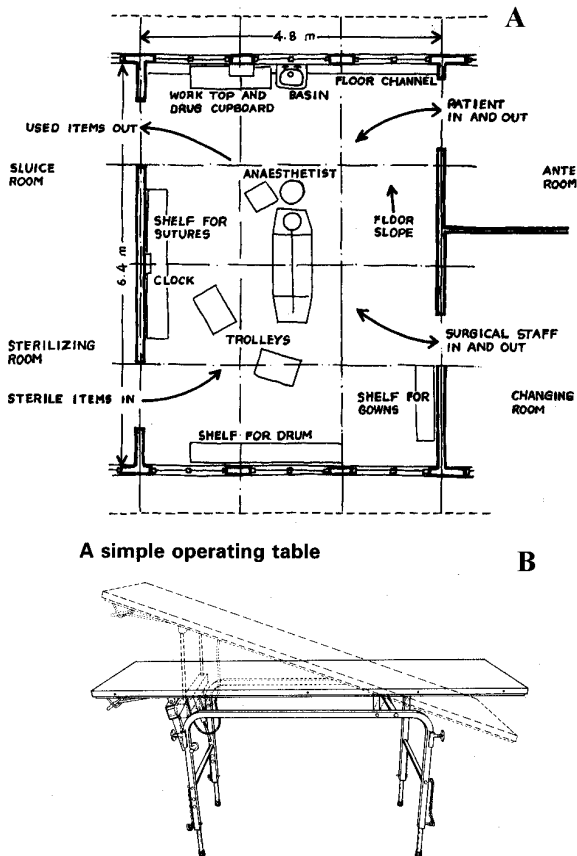
*STOOLS (2), operating, adjustable for height, local manufacture.* If you do much operating, a chair with a padded seat, wheels, and a back greatly reduces fatigue.

*LIGHT, operating theatre, simple pattern, preferably with sockets to take bayonet or screw fitting domestic pattern light bulbs, in addition to special bulbs.* Most operating theatre lights take bulbs which are irreplaceable locally, and may cost US\$70 each, so find out what bulbs your light takes, and try to keep at least three spares. Record their specification and catalogue number somewhere on the lamp casing. When new lights are ordered, they should have fittings that can, if necessary, take ordinary domestic bulbs. An LED operating or head light is a very useful help or alternative.

The preparation room should lead off the theatre. A big one is desirable, because it needs to contain 2 autoclaves, a large and a small sterilizer, sterile packs, instrument cupboards and space to lay out instrument

trolleys. Ideally, it should be 64m<sup>2</sup> and serve 2 theatres. About 25m<sup>2</sup> is the absolute minimum, with a terrazzo shelf round most of two walls, a sink, a draining board, a single vertical autoclave (preferably two), a large boiling water sterilizer standing on the floor, and a small one on the bench.

## THE THEATRE AND ITS TABLE



**Fig. 2-2 A SIMPLE THEATRE AND ITS TABLE.**

**A**, this is about the smallest practical theatre possible. **B**, simple pattern operating table described.

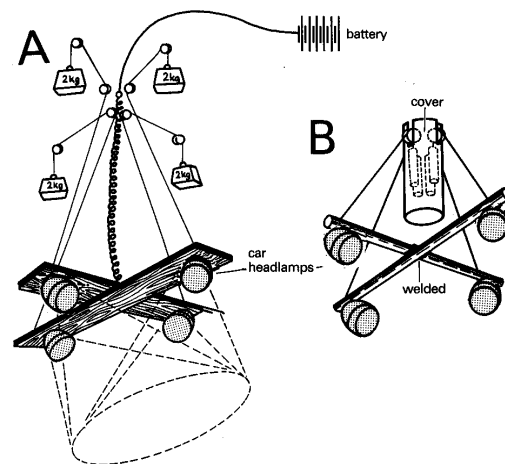
*A*, adapted from Mein P, Jorgensen T, *Design from Medical Building*, AMREF, Nairobi, 1975 with kind permission.

**SPOTLIGHTS** (2), free standing on the floor, 'Anglepoise' type, to take ordinary domestic pattern bulbs. Also, high efficiency internally reflecting bulbs (5) to give a parallel beam. These are necessary, both as a standby to the main theatre lamp, and to illuminate positions that the main theatre light cannot reach. A normal spotlight can direct an undesirable amount of heat into the wound, so, if possible, get LED lights which produce little heat. These are more expensive initially, but have a longer life. You can improvise a spotlight by removing the headlight of a car, especially the sealed beam type, and attaching it to a drip stand in the theatre. Connect it with a long lead to the battery of a car outside. Or use a slide projector held by an assistant. If the level of illumination is not enough, especially for eye surgery, you can increase the contrast by blacking out the theatre.

**SOLAR PANEL**, charger, and battery. A single solar panel will collect a useful quantity of electricity and enable you to light two wards in the evenings.

**BATTERY CHARGER** for the common sizes of rechargeable dry batteries, and five rechargeable batteries of each size. This will enable you to recharge batteries for your torches and laryngoscopes etc.

## IMPROVISED LIGHTING



**Fig. 2-3 IMPROVISED LIGHTING.**

**A**, if you have to make a light locally, suspend 4 car headlamps on a cross, and suspend each end of it on a pulley counterbalanced with a weight. **B**, better, put the counterweights in a metal casing which will be easier to keep clean. Or, less satisfactorily, hang three fluorescent tubes from the ceiling in the form of a triangle. This is basic but significantly better than nothing!

**CLOCK**, wall, electric, with second hand. This is essential; you must have a proper awareness of time, especially when you apply a tourniquet (3-6), and without a clock you can readily forget it. The instructions given here for controlling bleeding by applying pressure sometimes tell you to wait 5mins by the clock.

**INSTRUMENT CABINET**, glass door, sides and shelves, 1300x600x400mm, local manufacture.

**RADIOGRAPH VIEWING BOX**, standard pattern, local manufacture.

**INSTRUMENT TROLLEYS** (4) without guard rail, with two stainless steel shelves, antistatic rubber castors, (a) 600x450mm and (b) 900x450mm. Glass shelves ultimately break, so stainless steel ones are better. A larger table will make it easier to lay up for larger cases, especially orthopaedic ones.

**STAND**, solution, with antistatic rubber-tyred castors, complete with two 350mm stainless steel bowls, side by side. Put water in one bowl, and use the other for spare instruments and the sucker. The bowls can be sterilized in the autoclave or in a boiling water sterilizer.

**DRIP STANDS**, telescopic. Or, less satisfactorily, use long wire hooks suspended from the ceiling near the head of the table. Hooks for drips sticking out from the wall are useful above some beds in the wards.

**SUCTION PUMP**, operating theatre, electric with 2 1l unbreakable plastic bottles and tubing. These are always breaking down, so the model chosen must be easy to service and spares should be available. If you are going to depend on an electric sucker, make sure it can actually suck before the operation starts. A sucker which makes a noise may not necessarily suck. **SUCTION PUMP**, foot operated, with 2 wide mouthed 1l unbreakable plastic bottles, rubber bungs and metal tubes.

This is an automobile pump with the valves in it arranged to suck instead of pumping. Both the surgeon and the anaesthetist need a sucker, so you need 2 at least. A hospital workshop may be able to make one of these suckers by altering the valves of a truck tyre pump.

A foot sucker is much more reliable and more easily repaired than an electric one. If you use an electric sucker, make sure you have a foot sucker also.

**SUCTION TUBES**, metal, Poole's abdominal, wide bore, with guard. The standard laryngeal suction, the Yankauer type, is used by the anaesthetist at almost every operation, but not so useful for the surgeon. A small Gilles suction tube is useful for fine operations. Connect it through a piece of sterilized rubber tube to one of the suction pumps.

(If you don't have a suction tube, suck using the rubber end on its own, but beware of damaging bowel if the suction pressure is high.)

**DIATHERMY**. Bipolar diathermy is only useful for fine surgery; otherwise a simple unipolar diathermy is sufficient.

**MONITORING EQUIPMENT**. A pulse oximeter is very useful; a continuous ECG monitor is valuable but less essential. Expensive continuous blood pressure recording equipment is desirable but unnecessary, and if faulty may give a false sense of security.

**SUITS, theatre, cotton, with short-sleeved shirt, and long trousers, assorted sizes, local manufacture.** The purpose of these is to make sure that nobody enters the theatre in ordinary clothes, or in clothes worn elsewhere in the hospital. Everyone entering a theatre should put on a theatre suit in the changing room, having taken off their outside clothes. These suits should be laundered, and if possible ironed, but need not normally be sterilized each time they are used, unless they have been used for septic cases. You should discourage the habit of staff who have been out of theatre in their theatre suits, coming back without changing.

### SOME SURGICAL LAYOUTS

The bare minimum with ante-room and changing room

The recommended pattern

The recommended pattern with a minor theatre

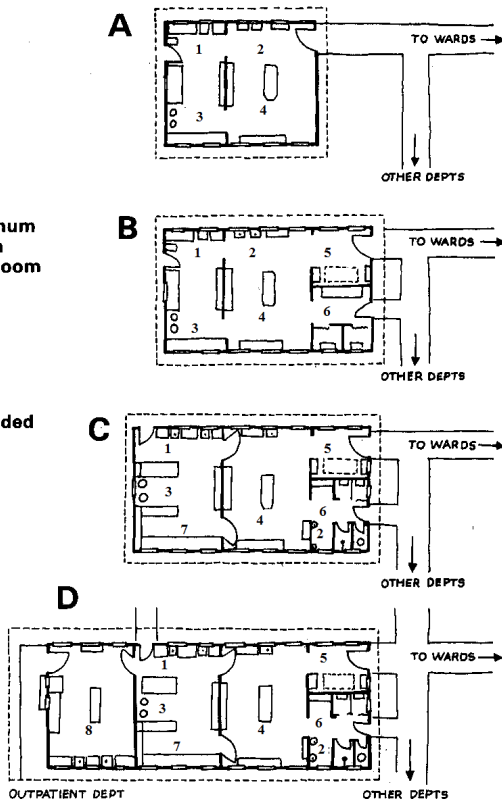


Fig. 2-4 SOME SURGICAL LAYOUTS.

This incorporates the theatre in 2-2 in progressively more developed settings. A, the absolute minimum. The changing is done in the sterilizing room. B, similar but has an anteroom and staff changing room. C, the arrangement recommended, which is 2-3x the cost of A. (1) sluce. (2) scrub up. (3) sterilizing room large enough to prepare sterile items for the rest of the hospital. (4) theatre table. (5) anteroom. (6) changing room with shower and toilet. (7) cupboard. D, further addition of (8), a minor (clean) theatre. Adapted from Mein P. Jorgensen T. 'Design from Medical Buildings' AMREF, Nairobi, 1975 with kind permission.

**CLOGS, assorted sizes.** Rubber boots are outmoded; sandals are less easy to keep clean and as they are open, provide inadequate protection. Use them only at the barrier between the theatre and the rest of the hospital.

**APRONS, mackintosh, assorted sizes, local manufacture.** These protect the suits and are worn under a theatre gown. If they are merely hung up in the changing room after use, they become progressively more contaminated and more dangerous. So, make sure that they are at least washed and regularly swabbed down with an antiseptic solution, and are always swabbed after septic cases. Keep two for special clean cases only.

**CAPS, cotton.** Put on a cap before you enter the theatre, and make sure it completely covers your hair (scalp and beard)!

**MASKS, theatre.** The use of these is controversial: if the surgeon has a bad cold, he should better not operate. Most masks don't prevent passage of air-borne bacteria, and cotton muslin masks are useless. They do protect against blood splashes, and should be used to cover a surgeon's beard!

**GOGGLES, wrap-around, industrial.** These should be used when drilling or splashes are expected.

**GOWNS, cotton.** These should go right round the wearer and cover the back. They should have long enough sleeves to reach the surgeon's wrists. Before sterilization they must always be folded so that the inner surface on the wearer is exposed to the outside in the drum.

**GLOVES, operating, sizes 6 to 8.** Remember that gloves are designed to protect the surgeon as much as the patient. The type of gloves you buy is critically important, and so is the relative number of the various sizes. It is useful if they can be re-sterilized, when not soiled by their first use. Most females wear sizes 6 to 7 and most males sizes 7 to 8. Pack each pair in a cloth or paper envelope, one glove on each side with its cuff turned outwards. Gloves are more useful to protect you and the next patient, than the patient you are actually operating on. Long arm-length gloves are useful for septic or bloody laparotomy cases.

**GLOVES, industrial.** These are useful for picking up hot objects and cleaning floors and surfaces; used on the correct indications, they will save many pairs of surgical gloves.

*N.B. Avoid glove powder, especially starch or talc because it causes granulomas particularly in the abdomen, and also is prone to produce allergic reactions. Never use it when preparing equipment for auto-transfusion.*

**SOAP, hexachlorophene, carbolic.** If necessary, the cheapest soap that does not irritate the skin will do. A liquid soap dispenser may prove not only more efficient but more economical. Spirit disinfectants between clean cases are effective and save on soap.

**BRUSHES, nylon, nesting, autoclaveable.** Autoclave several of these each operating day and store them between cases in a bowl of antiseptic solution. They will last longer if you merely keep them clean and immerse them in an antiseptic solution.

**TOWELS, cotton, green, theatre.** (a) Hand towels 25cm square. (b) Theatre drapes 100x75 cm. (c) Abdominal sheets. An abdominal sheet covers a patient completely from head to foot and has a slit in it through which the operation is done. The upper end acts as a guard which keeps the patient's head and the anaesthetist out of the operative field.

**GASES.** Cylinders need to be re-filled; if this is not possible, for a reliable oxygen supply, an oxygen concentrator, which extracts the gas from the air, is very useful. Note that oxygen cylinders are black with a white top, whereas nitrous oxide cylinders are completely black.

**ANAESTHESIA DELIVERY SYSTEM.** A 'draw-over' low pressure system which is leak-tolerant and uses air is far more reliable than a sophisticated Boyle's machine. Make sure equipment for airway management (ambubag, mask, Guedel airways, ET tubes, laryngoscope with working batteries and bulbs, and stethoscope) is always available.

**HEATER** to warm the theatre when it is cold (especially at night), and to warm IV fluids and lavage fluid. Even in tropical climates, patients (especially babies) can become hypothermic!

Other supplies: (1) Pyjamas and pyjama trousers. (2) Dresses. (3) Macintosh drapes, 75x100cm. (4) Squeegees. (5) Bucket and mop.

*N.B. Make sure extra staff can be found and called in case of complications or emergencies.*

## 2.2 The minor theatre

A minor theatre for septic cases will help to maintain the sterility of the major theatre. Use it for draining all abscesses, and for the closed reduction of fractures. It will need a simple operating table which tips, and a second set of basic anaesthetic equipment, including especially a sucker and the equipment for resuscitation. It will also need at least two minor sets (4.13), three incision and drainage sets. If possible, the minor theatre should have its own instruments and not be supplied from the main one.

*Don't use this minor theatre for general anaesthesia (GA) cases.*

*N.B. Remember there is really no such thing as minor surgery for the patient!*

## 2.3 Aseptic safe theatre technique

In order of importance, the most serious sources of infection in a theatre are bacteria from:

- (1) the pus and excreta left behind by previous patients, especially on equipment or towels, etc.
- (2) the clothes, hands, skin, mouths, or perineal regions of the staff; the bacteria on them may have been derived from other patients.
- (3) the patient himself.

Minimize the risk of infection by:

- (1) following the design rules (2.1) as far as you can,
- (2) washing your hands between patients,
- (3) keeping the theatre as clean as possible, so that the pus and excreta of previous patients are removed,
- (4) making sure that all the autoclaving is done conscientiously,
- (5) following the rules about the indications for operating, the timing of operations, wound closure, and careful tissue handling,
- (6) creating and maintaining the sterile zone in 2-1.

This sterile zone has to be created anew for each patient in a theatre in which the risk of infection has been reduced as much as possible. Its creation starts when a nurse swabs the top of a trolley with antiseptic, puts two sterile towels on it and lays out sterile gowns and gloves. The sterile zone grows as the surgeon, the assistant and the scrub nurse put on their gowns. The operation site joins the sterile zone as it is prepared with an antiseptic solution and draped. Thereafter, nothing which is contaminated must touch anything in this zone until the end of the operation. If the technique of the team is poor, the sterile zone becomes smaller and smaller as the operation proceeds.

If you work on two sites on the body at the same operation, start on the less septic site, and preferably use a separate set of instruments for each procedure.

As well as protecting the patient from sepsis, be sure to protect yourself! Hepatitis B and C and HIV (5.3) are serious risks, and transmission of these infections cannot be prevented by screening every patient or using special precautions in individual 'high-risk' cases. Always adopt danger-free zones for sharps. Be sure there is no direct handling of sharps nurse to doctor, or *vice versa*. Place knives and needles on syringes in a kidney dish in a 'no-man's land' where scrub nurse and surgeon *never* put their hands at the same time. Remove sharps by instruments and not by hand, and dispose them in specially designated containers for incineration. You should try to avoid using sharp retractors, skin hooks, and cutting needles wherever possible. *Don't use your hands as retractors. Don't try to find a needle lost in the tissues with your fingers.*

Handle needles with instruments; cut the needle off before tying a suture, or hold it at its sharp point with the needle-holder.

## SCRUBBING AND GOWNING

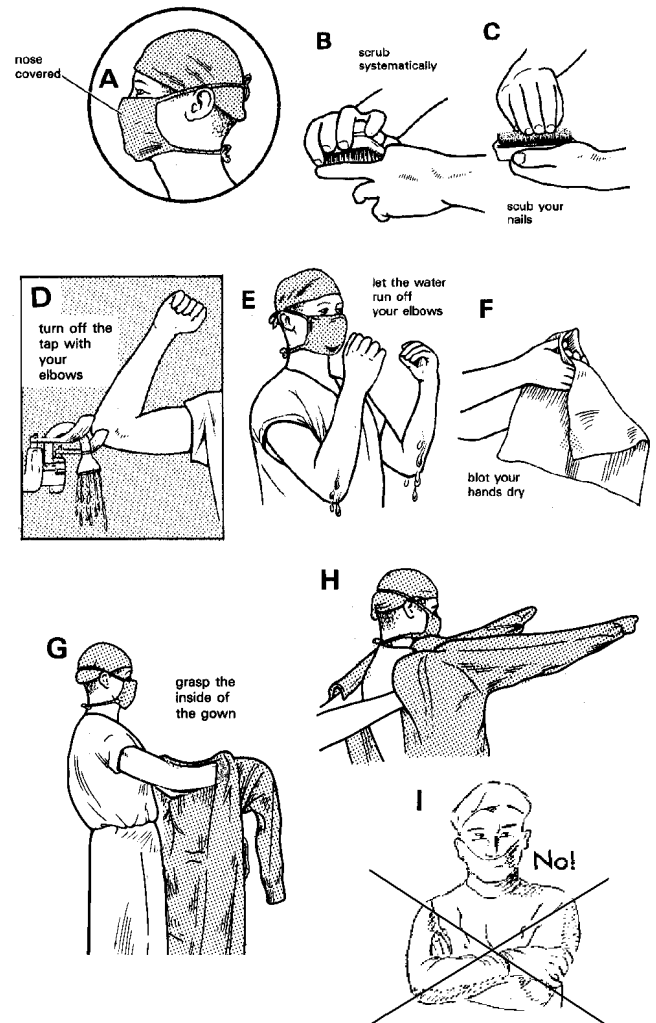


Fig. 2-5 SCRUBBING AND GOWNING.

A, make sure your mask covers your nose (if you wear one at all). B, scrub your hands in a systematic manner. C, scrub your nails. D, turn off the taps with your elbow. E, while your hands are wet, hold them higher than your elbows. F, blot your hands on one corner of the towel, then dry your forearms. G, hold the gown away from your body, high enough not to touch the floor. H, ask the circulating nurse to grasp the inner sides of the gown at each shoulder and pull it over your shoulders. I, how *not* to wear your mask! *Don't put your hand in your axilla: it is not a sterile area, even after gowning!*

Wear wrap-around goggles when using high-speed drills, and where large quantities of contaminated fluid are expected.

Double-gloving decreases the risk of needle-stick injury, but does not eliminate it. You can use re-sterilized gloves for the first layer to reduce costs. Some surgeons prefer to put on one pair  $\frac{1}{2}$  a size larger on the outside, or on the inside.

Different coloured gloves may show up an accidental perforation more easily.

You can wear special Kevlar needle-proof gloves inside, but they tend to be cumbersome, especially for fine surgery (5.3).

**(a) Entering the theatre.** Anyone entering the theatre must change, in the changing room, into clogs and into theatre pyjamas or dress. This is important also when someone has left the theatre (in theatre attire) for the wards or casualty (accident and emergency) department, and returns. (Many hospital routines concentrate on putting on overshoes, gowns etc. on leaving the theatre; *more important is to change again on re-entering.*)

You must insist that *theatre clothing is not just worn over ordinary outside clothes*. Clogs are better than boots, which become sweaty and smelly. Tennis shoes are an alternative to clogs but get soaked by fluids. However, you can likewise soak them to clean them!

*There is no proof that masks are helpful, except in protecting the surgeon (or nurse) from splashes. A sneeze passes through all masks; a person with a bad respiratory infection should not be in theatre at all! Masks are an unnecessary expense.*

### **(b) Positioning the patient**

Do this carefully before you scrub, so that you don't have to disturb him by altering the drapes or lights during the operation. Make sure IV lines, catheter and nasogastric tube are in place and functioning. Check that there is sufficient room for you, the anaesthetist, the scrub sister and an assistant (or two).

**If you use diathermy**, place the earth plate in contact with the skin of the buttock or leg *before* draping. Make sure it has been tested, *e.g.* on a bar of soap.

Pay close attention to pressure points, particularly in emaciated patients, and when legs are put in lithotomy position.

**If a patient is in the lithotomy position**, make sure he is pulled down sufficiently so that the perineum is then quite free from the end of the bed. *Make sure the legs don't fall out of the stirrups!*

**If a patient is prone**, make sure the abdomen is free to move with respiration. Fold the arms under a pillow on which the head, turned to one side, is resting.

**If a patient is in the lateral position**, make sure he is cushioned and supported, and there is a pillow between the knees.

Make sure the theatre lights are directed correctly once you have pumped the theatre table to an agreeable height.

**(c) Scrubbing up.** Remove any jewelry. Open a gown pack without touching the inside of the pack. Check that it is properly autoclaved. Adjust the taps to deliver water at a comfortable temperature. In most tropical countries only a cold water tap is necessary. Wet your hands, apply a little soap or detergent, and work up a good lather.

Rub your hands and forearms to 5cm above your elbows thoroughly. Wash your forearms and your hands. Then take a sterile brush and put soap on it. Scrub your nails (2-5C), thoroughly for the first case in the day.

*N.B. Make sure all surgical staff keep their fingernails short, and have long hair tucked away!*

Rinse the suds from your hands while holding them high, so the water runs off your elbows (2-5E).

Turn off the taps with your elbows, if this is possible (2-5D); otherwise ask someone else to do it. Blot your hands dry on one corner of a sterile towel (2-5F), taken from the gown pack without contaminating the gown itself. Then dry your forearms, using a different (dry) part of the sterile towel.

If you can get disinfecting spirit for the hands, you only need wash with soap initially or after septic cases; it is easy to become slack with any method.

**(d) Gowning.** Hold the gown away from your body, high enough to be well above the floor (2-5G). Allow it to drop open, put your arms into the arm holes while keeping your arms extended. Then flex your elbows and abduct your arms. Wait for the circulating nurse to help you. She will grasp the inner sides of the gown at each shoulder and pull them over your shoulders, and tie it at the back (2-5H). *Don't touch the outside of your gown till you have sterile gloves on.*

**(e) Gloving.** *Try to avoid using glove powder even if you are using re-sterilized gloves.* Be careful to touch only the inner surface of the gloves. Grasp the palmar aspect of the turned-down cuff of a glove, and pull it on to your opposite hand (2-6A). Leave its cuff for the moment. Put the fingers of your already gloved hand under the inverted cuff of the other glove, and pull it on to your bare hand (2-6B). Holding the sleeves of your gown tightly folded against your body, pull the glove over the wrist. Then do the same for the other hand.

*N.B.* If you do use powder, always wash it off your gloved hands with sterile water to remove it completely.

Now help the next person who has gowned on with the gloves.

(If you wear 2 pairs of gloves, you may prefer to put the first pair on before gowning. The first pair could be one that has been re-sterilized.)

You may prefer to ask the already scrubbed, gowned and gloved theatre nurse to hold open the gloves, with the cuffs everted, for you to slip your hands inside. This is easier and a safer method, but relies on the scrub nurse's gloves being sterile!

### **MAKE SURE YOU HAVE FOLLOWED THE CAUTIONS LISTED (1.8)**

*It is a good idea if using local anaesthetic to infiltrate before scrubbing, in order to allow it time to take effect.*

**(f) The operation site**

Make sure the patient has bathed before the operation and the operation site is clean. Remove any jewelry or skin piercing.

Check the side to be operated upon. *Make sure it is marked with a permanent marker.* If not, confirm the side with the anaesthetist and scrub nurse.

Put a septic limb to be amputated in a plastic bag already on the ward and seal the bag with wide tapes onto the leg. In the theatre cover the bag with sterile towels. Take the amputated limb out of the theatre before recovering the towels.

Check the position of the patient on the table yourself.

**(g) Shaving.** The operation site should be socially clean before the operation, and you may have to check this. There is usually no absolute need to shave a patient. If you shave or clip the hair, do so on the morning of the operation, or as part of the operation, and limit this to a narrow zone (2-5cm) around the planned incision. Make sure you remove the cut-off hair (this can be done with an adhesive tape and washing); otherwise the hair will end up in the wound.

If you do the shaving a day or two before, minute abrasions in the skin will become infected and the risk of wound infection will increase. Betadine shampoo, especially of the head and groin, is particularly useful after shaving.

**(h) Skin preparation.** Do this as soon as the patient is anaesthetized. Use an alcohol-based solution, preferably iodine, if possible: check for the patient's sensitivity. Take a sterile swab on a holder, start in the middle of the operation site, and work outwards. Be sure to prepare a wide enough area of skin, including any additional areas needed for example in skin grafting. In an abdominal operation this should extend from the patient's nipple line to below the groin.

*N.B. Make sure the alcohol-based solution dries because of potential burn hazard if you use diathermy. Avoid spillage under towels and seepage under a tourniquet where it may remain in contact with skin for a long time and cause irritation.*

*N.B. There is no justification for using skin preparation twice.*

**(i) Catheterization.** For major abdominal and pelvic operations, catheterize the bladder using an aseptic technique (27.2) before draping. *Don't catheterize routinely for other abdominal procedures.* Change your (outer) gloves: these can then be re-sterilized.

**(j) Draping.** Wait until the patient is anaesthetized. Aim to leave the operation site alone exposed and all other parts covered. Place the first towel across the lower end of the operation site. Place another across its nearer edge. Apply a towel clip at their intersection, under the folds of the drapes. Place another towel across the opposite edge of the site, and finally one across its upper edge.

Clip them at their intersections. If the towels are in danger of falling off, secure them with a stitch. *Don't clip the skin with clips as this may cause skin necrosis.* For an abdominal operation, cover the whole abdomen with an abdominal sheet with a narrow quadrangular hole in its centre.

Remember to complete the draping at the beginning of the operation if you need more than one operation site, e.g. for skin grafting. Make sure the perineum is securely covered, and that drapes round limbs are secured snugly with clips or bandages. You can cover a hand or foot by putting on an extra large sterile glove and inverting it over the extremity.

If the patient is awake (e.g. with spinal anaesthesia), put drapes across two drip stands to separate the head from the operative field. If important areas near the surgeon become contaminated, remove them and cover the patient with fresh sterile towels.

**(k) Suction tubing and diathermy.** Secure these to the drapes securely with towel clips, so they don't fall off during the operation.

**(l) Swabs and packs.** Use 10cm gauze squares on sponge-holding forceps ('swabs on sticks'). You will also need abdominal packs. *Make sure these are counted* and checked at the end of each operation, and then disposed of quickly in the sluice.

**(m) Cleaning the theatre.** Remove clutter. Wash the floor and clean the table and accessories after each operation. Clean the theatre thoroughly after each day's list, and completely every week. Fumigate after a septic procedure with formalin.

**(n) Cleaning instruments.** Use an old nail-brush. Open hinged instruments fully, scrub them, and take special care to clean their jaws and serrations. *Beware of sharps!*

#### DIFFICULTIES WITH ASEPTIC METHODS

**If you have no gloves or very few gloves,** scrub up and then rinse your hands and arms in alcoholic chlorhexidine (2.5). The alcohol will dehydrate your skin. You can reduce this by adding 1% glycerol to the solution. Unfortunately, although antiseptics may help to protect the patient, they are not effective in protecting you from HIV (5.3) so use a 'no-touch' technique, using instruments between you and the patient. Limit your operating to emergencies.

*N.B. If you tear or contaminate a glove during an operation,* remove it. Grasp its cuff from the outside, and pull it down over your palm. Alternatively, if it is not soiled, put on another sterile glove on top over it, in the same way as described above.

**If you have no drapes or gowns or very few of them,** use plastic sheets and aprons and soak them in an antiseptic solution (2.5).

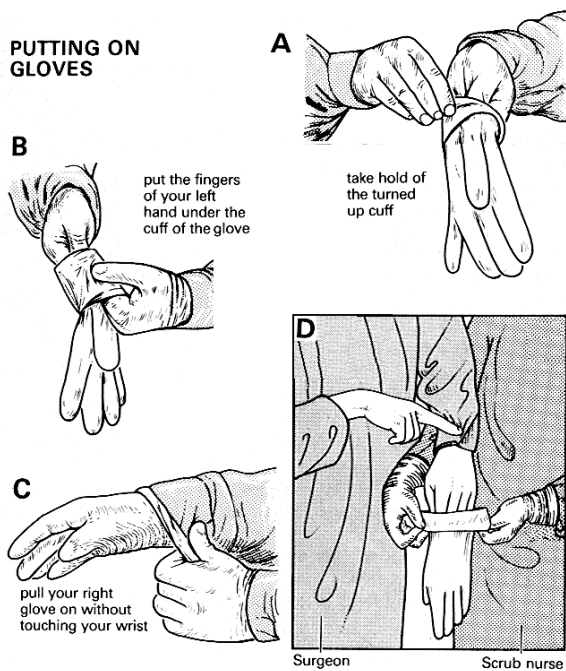


Fig. 2-6 PUTTING ON GLOVES.

**A**, take hold of the inside of the glove with your right hand, and put your left hand into it. **B**, put the fingers of your left hand under the cuff of the glove. **C**, pull your right glove on without touching your wrist. **D**, the first person to glove up (usually the scrub nurse) now gloves the second person (usually the surgeon), by holding out the gloves for him like this.

#### WOUND SEPSIS AND THE ART OF SURGERY

"In summary, I believe that regard for tissue is the foremost of our priorities. Let us strive to become first class surgeons, and let us train considerate disciplined theatre staff. Let us have plenty of soap and water, or some not too corrosive detergent. We do need sterilizers and autoclaves. We need well ventilated rooms which are light and easy to clean, and where the number of additional items is kept low. We should don theatre attire, should indeed change frequently, and should certainly change our masks. Gloves are important though not indispensable. Use sharp knives, few instruments and keep things neat and clean. *Don't bury undue amounts of biologically irritating material in the tissues.* Beware of haematomas and lymph collections. Use suction drains frequently. Use delayed primary closure where this is indicated. In the wounds you make yourself, bring the skin edges together carefully so that the wound is sealed in a few hours. Hydrate your patient, and *don't oversedate him.* Avoid stasis by elevation and movement. Use dressings sparingly, and observe the wound. If you find a haematoma and evacuate it speedily you will prevent sepsis." *Loefler IJP, Wound sepsis and the art of surgery. Proc Assoc Surg E Africa 1979;2:172-180.*

## 2.4 Autoclaving

Sterilization literally means destroying the fertility of organisms; in the hospital context it describes the elimination of all forms of contaminating organisms, including bacterial spores. Nitrogen dioxide (NO<sub>2</sub>) is best; otherwise use heat, either dry heat in an oven, or steam under pressure in an autoclave. Processes (usually chemical) which don't destroy spores are termed 'disinfection'. Some of the most important agents to be removed by disinfection are HIV, HBV and HCV (hepatitis B and C virus). All the disinfectants mentioned (2.5) will do this if used as directed. If no alternative is available, hypochlorite is suitable for most purposes (5.4).

The basis of aseptic surgery is to kill all micro-organisms on all instruments and dressings, preferably by exposure to steam under pressure. If this is impractical, immersion in boiling water for 10mins at sea level will kill all viruses and all vegetative bacteria, but not spores, particularly those of tetanus and gas gangrene. A boiling water 'sterilizer' is therefore badly named. At a height of 3,000m above sea level, water boils at 90°C and is much less effective.

Steam is simply the gaseous form of water; if it is to sterilize effectively, which means killing all spores:

- (1) It must be at an appropriate temperature (which implies an appropriate pressure).
- (2) It must be saturated with water.
- (3) *It must not be mixed with air*, so it must displace all the air in the chamber of the autoclave.
- (4) It must reach all parts of the load.

If it contains droplets of water, it will soak into porous materials. If, on the other hand, it is superheated and therefore too dry, it will be less effective as a sterilizing agent. If air is mixed with steam:

- (1) The temperature of the mixture at a given pressure will be lower,
- (2) It will penetrate less well into porous materials,
- (3) The air may separate as a lower, cooler layer in the bottom of the chamber, so that the contents are not sterilized. If no air is discharged, the bottom of the chamber may be much cooler than the top.

As soon as the chamber of an autoclave is full of steam at the desired temperature and pressure, it must be held there for a critical time, the holding time. The standard holding time is 15mins, at 121°C, but you will need to vary it as described below. This temperature is reached at a pressure of about 1kg/cm<sup>2</sup> (15psi). An easy minimum figure to remember is '1kg/cm<sup>2</sup> for 15mins' ('15lbs for 15mins'). If your autoclave is rated to 1.3kg/cm<sup>2</sup>, you can shorten the sterilizing time to 10mins.

Here we only discuss the simpler forms of autoclave; high vacuum autoclaves are beyond the scope of this manual. Single walled autoclaves are strong metal chambers with water in the bottom, similar to large pressure cookers. They have several disadvantages:

- (1) The air in the chamber is removed by steam rising from the bottom. This is inefficient, so that an undesirable quantity of air remains.
- (2) They don't have thermometers at the bottom of the chamber, so you never know what the temperature there is.
- (3) The load remains moist after sterilization, which can be dangerous, because bacteria can more easily enter through moist wrappings.

Double walled autoclaves can be vertical, but are much better horizontal. They should either have an effective pre-vacuum or a pulsing system (neither described here), or rely entirely on gravity to displace the air. A partial pre-vacuum at the start of the sterilizing cycle (which used to be the practice in some older autoclaves) causes turbulence when air is admitted, so that the gravity displacement of air cannot take place satisfactorily.

Steam is generated in, or admitted to, a jacket round the chamber, rather than in the chamber itself. This jacket keeps the walls of the chamber hot, which prevents condensation and helps to dry the load. Steam enters the chamber through a pipe at the top and displaces the air it contains. Air, condensate, and excess steam escape through a pipe at the bottom. This pipe has a thermometer in it to record the temperature in the bottom of the autoclave.

In some autoclaves a water pump, which works on the same principle as an ordinary laboratory water pump, sucks out some of the steam afterwards (post-vacuum). There is also a means of admitting sterile air to break the vacuum at the end of the cycle.

The drain at the bottom of the chamber should have a 'near-to-steam trap', which will allow the discharge of condensate and air, and will close automatically when they have been discharged, and the trap meets live steam, thus avoiding the need to close valve 13 (2-7) manually, which could spoil sterilization.

The thermometer records the temperature in the chamber drain, which is the coolest part of the autoclave. When this reaches the operating temperature, the timing of sterilization can begin.

More sophisticated autoclaves have better pumps, a recording thermometer, a thermocouple to measure the temperature of the load, and an automatic control system.

**AUTOCLAVE, horizontal, downward displacement with near-to-steam trap in the chamber drain, post vacuum, six spare gaskets, three spare bellows for the steam trap, and a triple set of other spares.** If you have a steam supply, this is the autoclave you need. Horizontal autoclaves are easier to use, but are more expensive. You will need a standby, in case the electricity fails, so you should have an autoclave that can be heated by kerosene or gas somewhere in the hospital (see below).

**AUTOCLAVE, vertical, downward displacement, 350 mm, 2½ drum, electric, 6kW, state voltage, manual operation, with six spare elements, six spare gaskets, and a triple set of other spares as necessary.** (A variation powered by gas is available.)

**AUTOCLAVE, vertical, 'pressure cooker', 47L, UNICEF.** This is a large autoclave which can be heated on a stove and has a machined lid so that it needs no gaskets. It is large enough for 5l of intravenous solution, or one laparotomy pack. It is a useful standby. It has an air exhaust tube which leads from the exhaust port to the bottom of the sterilizer. If you use it, you can start timing as soon as steam comes from the exhaust.

**TUBES, Browne's, for testing autoclaves, Type 1 (black spot), for use with ordinary steam sterilizers below 126°C.** These change colour on the basis of time and temperature, and are reliable, provided that there is not a long drying cycle, when prolonged heat in a jacketed sterilizer could change their colour.

Or, **CARDS, autoclave testing, ATI 'Steam-clox'.** This brand of tape changes colour on the basis of moisture and temperature, to indicate that something has been autoclaved. Most other brands of autoclave tape are only suitable for high pre-vacuum autoclaves, not for the downward displacement ones described here. Another alternative is 'Diack® Control', a pellet in a glass tube which melts at 121 or 126°C.

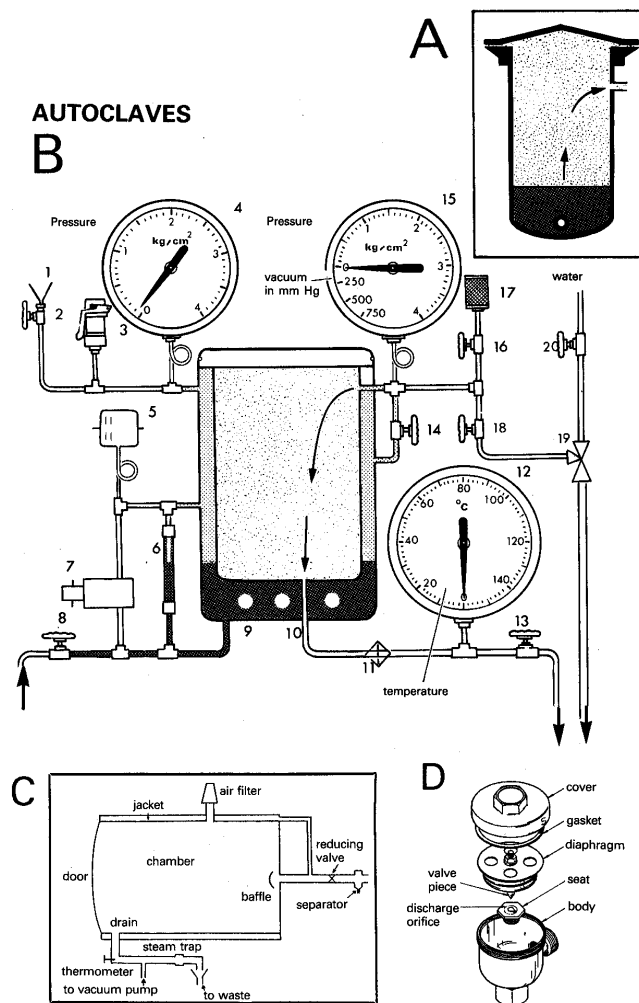
**DRUMS, deep, 340x230mm.** This is the standard size of drum.

**DRUMS, shallow, 340x120mm.** These are half-size drums. You may have difficulty getting drums because they are no longer used in the developed world. If you are short of drums, sterilize your equipment in packs, covered by two layers of towelling and preferably an outer layer of paper. If you are sterilizing without paper, use all equipment warm straight from the autoclave.

**DRESSING BOXES, stainless steel, with hinged lid and perforated sliding shutters at front and back, 250x200x150mm.** Use these for sterilizing gloves and dressings.

**TRAYS, dressing, without lids, stainless steel, 275x320x50mm.** Use these to prepare sterile sets for the wards. Boil a tray and the instruments, lay a sterile towel on the tray, put the instruments on it and fold it over them. Better, autoclave the tray.

*Inadequate sterilization is an important cause of wound sepsis in poorly maintained theatres.*



**Fig. 2-7 AUTOCLAVES.**

**A, simple autoclave is a strong metal chamber with water in the bottom, like a large pressure cooker.**

**B, jacketed vertical gravity displacement autoclave. This is filled through a tundish (open funnel) (1) and a filling valve (2). On the same pipe there is a safety valve (3) and a pressure gauge (4) to measure the pressure in the jacket. A pressure switch (5) controls the pressure in the jacket and an indicator (6) monitors its water level. A float switch (7) cuts off the power if the water level is too low, and a drain tap (8) lets water out of the jacket. Several heating elements (9) heat it. The chamber is drained through a pipe (10) and a strainer (11). A thermometer (12) and a valve (13) are fitted to the drain pipe (the valve should be an automatic near-to-steam trap, preceded by a non-return valve, to prevent dirty air and some water being sucked up during the vacuum). Steam from the jacket is admitted to the chamber through valve (14). Pressure and vacuum in the chamber are measured by a gauge (15). Air is admitted to the chamber through a valve (16) and an air filter (17). Air and steam are discharged from the chamber through valve (18) by means of the water-operated ejector pump (19) operated by tap (20).**

**C, vertical gravity displacement autoclave. Steam is admitted fairly high up the sterilizer. The drain with the thermometer is as near the chamber as possible. There is a near-to-steam trap separated from the drains by a tundish, which prevents dirty water being sucked back up the waste pipe into the autoclave during a vacuum phase.**

**D, 'near-to-steam trap' (valve) in the waste line remains open, until steam following the air heats the bellows under the diaphragm and closes the trap automatically. C, D kindly contributed by Ronald Fallon.**

**STERILIZER, boiling water, electric:** (a) 'Bowl sterilizer', 450x350x380mm, with counterbalanced lid, 6 kW, with six spare elements, state voltage. (b) Instrument sterilizer, 350x160x120mm, 1.2kW, with 6 spare elements, state voltage. One of these is for trays and bowls, and the other for instruments. Keep them both in the preparation room. *Never try to sterilize anything contaminated with faeces with boiling water in a sterilizer – it does not destroy spores.*

**FORCEPS (2) sterilizer, Cheate's, 267mm,**

**FORCEPS (2) sterilizer, Cheate's, extra large, 279mm, complete with can of appropriate size for antiseptic fluid.** These are useful for bowls and utensils, and will also pick up small objects.

**FORCEPS, bowl sterilizing, Harrison's double jawed, complete with can of appropriate size for antiseptic fluid.** Autoclave these and Cheate's forceps and their cans after each day's use, then fill them with fresh antiseptic fluid.

Many hospitals don't have piped steam supplies. If so, use a vertical autoclave. Your electricity supply may be unreliable; think about using an alternative such as gas.

*There are many pitfalls.* Start by inspecting your equipment and taking an interest in it. Read the maker's instructions carefully, and make sure that:

(1) it has been properly fitted and tested. For example, if a water ejector pump is fitted, it is likely to need a water pressure of 1.5kg/cm<sup>2</sup>.

(2) all the staff who use it understand how it works, and how to use it effectively. They must realize the importance of packing the drums loosely, the need to discharge the air, and the correct holding time.

#### (a) Sterilizing with moist heat

##### (1) Boiling water

Make sure that every article for sterilization is cleaned thoroughly to remove dried blood, pus or secretions before it is sterilized. Remove instruments from boiling water with long-handled Cheate's forceps which have been in saponated cresol ('Lysol') up to their handles. If you are not wearing sterile gloves, make sure you let the instruments dry. If you use them wet, bacteria from your hands may flow down from your fingers in drops of water.

##### (2) Packing any autoclave

Sterilization is impaired by anything which hinders the removal of air, so arrange the contents loosely; a drum which can only be closed with difficulty is grossly overpacked. Place the contents so that air can readily be displaced downwards: the principles are the same in horizontal and vertical autoclaves. This means packing the items vertically rather than horizontally. To avoid air pockets, interleave sheets of mackintosh or jaconet with some permeable fabric, so that no two surfaces of the non-permeable material are in contact.

##### (3) A simple autoclave (or pressure cooker) (2-7A)

Make sure there is enough water in the bottom of the autoclave. Insert the drums to be sterilized, and turn on the heater. See that the discharge tap is open, and then screw down the lid. As the water boils the steam will rise and carry away the air in the autoclave.

**CAUTION!** Let the air and the steam escape freely until there is no more air in the autoclave; this usually takes about 10mins. To test this, lead a rubber tube from the discharge tap into a bucket of water.

When air no longer bubbles to the surface, there is no more air. After some trials, you will learn how long to allow for this to happen.

Close the discharge tap. Let the temperature rise until it reaches 121°C. The safety valve will open and allow steam to escape. It should come out with a pure hissing sound rather than gurgling indicating the presence of air.

Now start to measure the holding period and continue this for 15mins. Then, turn off the heater and allow the autoclave to cool, until the pressure gauge records zero pressure. *Don't open the autoclave whilst the pressure is still high:* you might be badly burnt! Then open the discharge tap and allow air to enter the autoclave. Remove the load.

**CAUTION!** If anything in the load has paper or cloth wrappings, *don't allow them to touch anything unsterile*, until they have dried, because microbes can penetrate wet paper.

##### (4) Jacketed autoclave (2-7B)

Keep the jacket full of steam at 121°C throughout the working day. Drain the chamber to remove any water that may gather in it. Load the heated chamber, close the lid, and *open valve* (13).

**Sterilizing.** Open valve (14). When the temperature on thermometer (12) has reached the sterilizing temperature (usually 121°C), the holding time can start. Close valve (13). If it is letting much steam through, the temperature will not reach 121°C, until it is closed. So, close it as soon as no further air and condensate come out of the chamber. If you still don't get the temperature you need (usually 121°C), open valve (13) for a minute or two and try again (a near-to-steam trap does this automatically). When the temperature has been reached, start timing.

**CAUTION!** *Don't infer the temperature from the reading of the pressure gauge.* This may give you an inaccurate indication of its temperature and is a common cause of sterilization failure.

For drying (post-vacuum), open valve (20), then valve (18). Leave them open for 15-20mins. Close valve (18) then valve (20). Break the vacuum by opening valve (16).

##### (5) Testing autoclaves

**If you are using Browne's tubes,** put a tube in the centre of the load, with, if possible, one on the outside to show that the autoclave has indeed been switched on!

**If you don't have Browne's tubes,** put some dry earth in an envelope, autoclave this and then culture it in a bottle or tube of nutrient broth. Spores may be slow to grow, so incubate it for a week. If even this is impossible, put an egg in the middle of a drum to see if it is hard-boiled!

##### (6) Particular procedures for autoclaving

The following figures are guidelines only and vary with the type of autoclave and the size of the load. They apply to a sterilizing temperature of 121°C.

**Empty glassware and unwrapped instruments.** Sterilizing time 15mins, drying 10mins.

### Wrapped instruments, rubber gloves, tubes and catheters, and sutures being re-autoclaved.

A common regime is 0.7kg/cm<sup>2</sup> (10psi) for 20mins.

**Fabrics and dressings.** Sterilizing time 20mins, drying time 15mins.

### Liquids in flasks and bottles.

Sterilize bottles according to size and time as follows:

mls	100	300	500	1000	3000
mins	20	30	35	40	50

Switch off the heat and let the autoclave cool down. *Don't open it until the pressure is zero*, as the bottles may burst.

### (7) Preventive maintenance

Follow the maker's instructions carefully. *Don't miss out on this for reasons of false economy or 'permanent' need!*

*Make sure you make periodic checks by taking swabs for microscopy and culture. This is vital: <10% of hospital sterilizers work properly in LMICs.*

### (8) Difficulties with downward displacement autoclaves

**If the temperature falls <121°C, while the pressure remains at 1 kg/cm<sup>2</sup> (15psi)**, the outlet from the chamber may be blocked, and the chamber full of air. Check it daily.

**If you work at high altitudes**, for each 300m (1000 feet) you are above sea level, increase the time you immerse things in boiling water by 5mins, and increase the pressure of your autoclave by 0.03 kg/cm<sup>2</sup> (½psi). Water above 80°C will kill all vegetative organisms and viruses; boiling water is still effective at 4,000m (13,200 feet).

**If dressings are wet after autoclaving**, the steam is probably wet, due to: (1) inadequate lagging of the steam supply pipe, or (2) inadequate tapping of condensate.

**If you have reason to suspect imperfect sterilization**, run the tests above. Also check that:

- (1) The drums are packed properly.
- (2) The correct temperature and sterilizing times are used.
- (3) The chamber drain is not blocked.
- (4) The drums are not being re-contaminated after sterilization.

### (b) Sterilizing with dry heat

Use this for laboratory items, knives, and drills which don't tolerate steam well. You need a higher temperature (160°C) for 1h. Although heat is the best way of killing micro-organisms, *it is not appropriate for delicate instruments, rubber or a person's skin. Heat also destroys a cutting edge*, so store your scissors in a chemical solution which will destroy bacteria. Classically, these chemicals are either antiseptics, which are safe to use on the surfaces of the body, or disinfectants, which are not. In practice, the distinction is not precise, but the only substances which you cannot apply to the body are: (1) saponated cresol ('Lysol'), (2) formalin, and (3) glutaraldehyde. There is an optimum antiseptic for each purpose, so try to use the right one.

*Disinfectants have serious limitations and only work when the object they are disinfecting is clean: they are ineffective in the presence of blood or pus. So wash scissors and fine instruments carefully before you store them in an antiseptic solution.*

If possible, drains and other heavily contaminated pieces of equipment should be boiled or autoclaved after washing and before being immersed in these solutions. Afterwards, wash them well in sterile water before you use them.

*N.B. Catheters and tubes etc. deteriorate in antiseptic solutions and are better autoclaved before use.*

*Avoid cetrimide: it is mainly a detergent; chlorhexidine is better.*

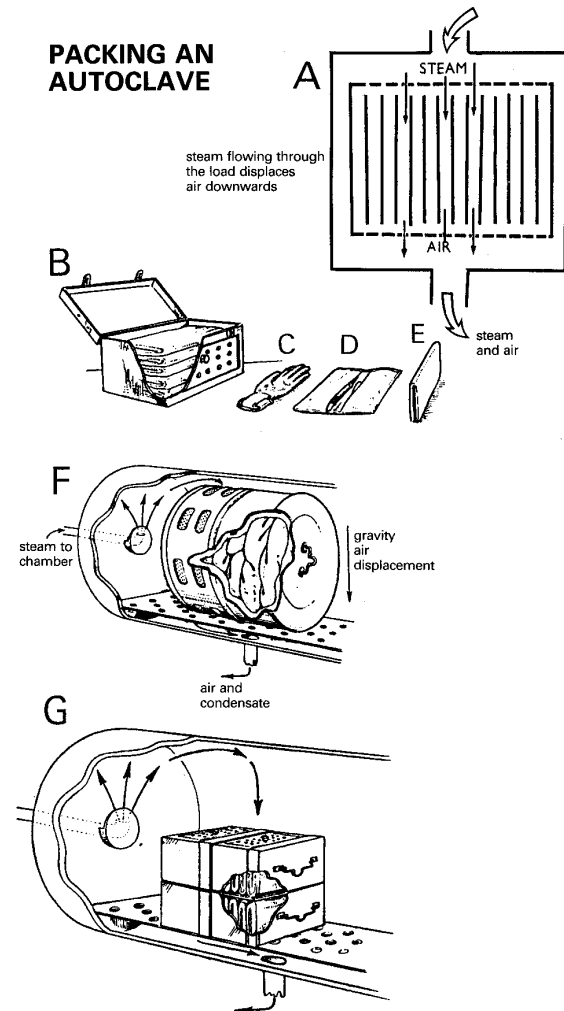


Fig. 2-8 PACKING AN AUTOCLAVE.

A, orientate a load to facilitate the escape of air in a gravity displacement sterilizer. Steam enters from the top, flows downwards through the load and displaces the air in it. B, pack a glove container properly. C, folded glove lined with gauze. D, a pair of gloves packed in a fabric envelope. E, fabric envelope on edge to show its correct position during sterilization. F, pack the drum correctly with open ports positioned to allow air to be displaced by gravity. G, turn glove containers in an autoclave on edge so that steam can displace air through them.

*After Sterilisation by steam under increased pressure; a report to the Medical Research Council by the Working Party on Pressure-Steam Sterilisers. Lancet 1959;7070:425-35, with kind permission.*

## 2.5 Disinfectants and antiseptics

**(a) Skin.** Any alcoholic solution will do. Alcoholic iodine is best: use it routinely, except in children, on the scrotum, and in allergic patients. Chlorhexidine 0.5% in spirit is a less satisfactory alternative. Apply it to the skin after removing all traces of soap.

**(b) Wounds.** There is no substitute for a scrubbing brush, plenty of water from a jug, and a thorough surgical toilet. Chlorhexidine is useful for cleaning the skin round a wound.

### (c) Instruments, suture materials, and drains

The following agents are effective against HIV and HBV, in addition to the classical pathogens (5.4).

- (1) 0.55% orthophthalaldehyde.
- (2) 2% alkaline buffered glutaraldehyde.
- (3) 8% formalin in 70% spirit or as a tablet.
- (4) A 0.5% solution of chlorhexidine in 70% spirit with 0.5% sodium nitrite. (*This is in terms of the active agent.*)
- (5) Plain 70% spirit.

The first two, 'Cidex OPA' and 'Cidex', are the best; glutaraldehyde needs to be activated before use but orthophthalaldehyde does not.

10mins is the absolute minimum time in these solutions, provided instruments are scrupulously clean, 24h is safer. Ideally, nothing should be considered 'sterilized' until it has been immersed for 24h. Wash all equipment well before using it.

#### CAUTION!

(1) Except for glutaraldehyde (which can be used for 14-28 days depending on the brand), you must prepare these solutions freshly every week, and keep them covered to prevent the alcohol evaporating.

(2) A 'wipe' is not nearly as good as a soak!

*N.B.* Formalin tablets can be vaporized in special chambers and used to sterilize endoscopes over 12h. It is irritant to the eyes and nose, and toxic to the tissues. It is useful for fumigating the theatre after a septic procedure.

### (d) Furniture, doors, windows and other fixtures

5% phenol (carbolic acid) is a satisfactory cleaning agent; you can use a 10% solution for very soiled surfaces.

## 2.6 Antiseptic surgery

This used to be standard practice before aseptic methods made it more or less obsolete. But it may still be useful when power supplies have failed or your autoclave breaks, or an important operation has to be done in some remote place. *It has been said that a first-class surgeon can operate in any theatre in any clothes in any situation.* However, even if you are not an expert, *don't deny someone life-saving surgery if your autoclave has stopped functioning!*

Aim to sterilize everything coming into contact with the wound by soaking it for a sufficient time in an antiseptic solution.

Unfortunately:

- (1) An antiseptic solution leaves everything wet.
- (2) Sterilization is slow so that you may only be able to do one operation at a time.
- (3) Wide areas of the body are exposed to the antiseptic, which causes much exudation from the wound.

Even so, antiseptic surgery is simple, and makes many kinds of operation possible. If necessary, you can combine antiseptic and aseptic methods, and sterilize smaller instruments in a pressure cooker. Chlorhexidine is the most practical antiseptic, but is far from perfect.

ANTISEPTIC SURGERY UNDER ADVERSE CONDITIONS. "The only means of access to our hospital at present is by walking over the mountains for a week. All supplies have to be carried in by porters who take two weeks for the journey. For the first 2½yrs, we worked in a traditional Nepali house with a thatched roof and a floor made of mud and cow dung. In it we did over 100 operations by the antiseptic method, without serious mishap. Later, limited space became available, so that although we enjoyed the advantages of tap water, a concrete floor, a clean ceiling, and adequate window ventilation, we still had to operate on a light outpatient type of table and in the same room in which the outpatients received all their medicines, injections, dressings, incisions, and dental extractions. We almost always used epidural or local anaesthesia". *Dick JF, Surgery under adverse conditions, Lancet 1966;7469:900.*

### (a) Antiseptic solutions

Use chlorhexidine 5% concentrate to make two solutions:

- (1) A weak solution of 1/2000 of the active agent in water. Use this for soaking towels, etc.
- (2) A strong solution for instruments, as described (2.5). Make up small quantities of solutions frequently, make them up hot, and clean out the containers well between batches.

### (b) Sterilizing equipment and drapes

Soak everything which will come into contact with the wound in one of these solutions for at least 30mins. Soak sutures and gloves in this solution overnight. Use monofilament (4.6) for ligatures and sutures, and the minimum number of simple instruments.

The most appropriate drape, for a tubal ligation, for example, may be a single solution soaked plastic sheet long enough, and wide enough, to cover the whole patient, with a hole in the middle through which to operate. If you have 2 such drapes, one can be in use while the other is being soaked in a flat container of solution.

*CAUTION! Don't use syringes and needles soaked in antiseptic to give a subarachnoid or epidural anaesthetic.*

**(c) While operating,** treat the patient's skin with the solution for at least 2mins before the operation.

Wash your hands as usual and put on the wet gloves. Wring out the soaked drapes as dry as you can, and apply them as near as possible to the operation site. Clean the patient's skin with the same solution.

**If there is a danger that he might get cold,** cover him with a dry blanket in a plastic sheet, and put this between the skin and the wet towels above and below the operation site, where it will not get in the way.

Swab the trolley with the solution, or put the instruments on a solution-soaked towel. Keep 2 bowls near the operating table, one containing water and the other antiseptic solution.

When instruments have been used, wash them in water and keep them in the solution until you use them again. Shake off the excess solution before you use them. Handle the tissues as little as you can, and try to keep the solution out of the wound as much as possible.

*Don't let cleaning solution get into the body cavities.*

**(d) After operating**, rinse everything free of blood. Rinse the instruments, and put them away. If the wound is well sutured and is not expected to discharge, leave it open to the air.

## 2.7 Antibiotics in surgery

Antibiotics have 2 uses in surgery:

- (1) To treat invasive sepsis.
- (2) In certain circumstances only, and when used in a very particular way, as prophylaxis to prevent post-operative infection.

They are less important than:

- (1) Careful aseptic theatre routines.
- (2) A thorough wound toilet.
- (3) Delayed primary closure.
- (4) Making sure there are no foreign bodies, dead tissue, excessive blood clots, or faeces in the wound.

In preventing sepsis, *antibiotics give you no licence to neglect the classical rules of good surgery*, especially if the patient is diabetic, very old, has HIV and is very ill, and so is less able to overcome any bacteria that cause infection.

Antibiotics will represent a very large part of your pharmacy's budget, so use them wisely *and not indiscriminately*. Generally speaking, antibiotics are prescribed far too often, far too long, and with far too little thought.

So:

- (1) Handle the tissues gently; take care to avoid spillage and contamination of the wound.
- (2) *Don't leave large pieces of dead tissue in the wound*, such as huge, massively ligated pedicles, or with excessive use of diathermy.
- (3) *Don't put tissues or skin under tension*.
- (4) Make sure there is secure haemostasis.
- (5) Divert faeces if they risk contaminating a wound, by temporary colostomy.

Differentiate between *prophylactic* use of antibiotics (2.9) and the treatment of *invasive sepsis* (e.g. cellulitis, septicaemia).

For prophylaxis use a *single dose* of antibiotic: this is indicated in 'clean, contaminated' (category 2) cases such as hysterectomy, Caesarean section, appendicectomy, and cholecystectomy.

*N.B. Clean uncontaminated wounds (category 1) don't benefit from antibiotic prophylaxis. Even with immunocompromised patients you should not change this principle.*

That said, how can you use antibiotics for invasive sepsis to the best advantage, when your laboratory staff cannot culture bacteria, or at least not reliably? You can learn much, however, from a simple Gram stain. Nonetheless, encourage the laboratory to examine blood cultures, which are not difficult technically, and, when these are positive, to isolate the organism responsible for septicaemia in pure culture.

If you are fortunate, you will be able to plan a logical antibiotic policy for your district, and keep some antibiotics for hospital use only, in the hope that the arrival of antibiotic-resistant strains from elsewhere in the world will be delayed as long as possible. In such an ideal situation you might decide, for example, that the clinics should use only penicillin and tetracycline, with perhaps a little ampicillin or trimethoprim; keep streptomycin for tuberculosis only. This will enable you to use chloramphenicol with metronidazole as your main surgical antibiotics, especially when the gut and the genital tract are involved. For other occasions you can use gentamicin, or a cephalosporin.

Unfortunately, you are more likely to work in a situation of antibiotic chaos, in which any antibiotic is obtainable over the counter without prescription, and where multiply resistant strains, particularly those resistant to chloramphenicol, are common. *Be sure to find out what are the sensitivities and so the antibiotics of choice for your area*. You should get a good idea of which antibiotic, out of those generally available, to use for which situation. You may have donations of expensive newer antibiotics: *don't waste them through ignorance of their benefits!*

## ANTIBIOTICS

Have their proper use



**Fig. 2-9 ANTIBIOTICS MUST GET TO THE PATIENTS AND THE DISEASES WHERE THEY CAN DO MOST GOOD.**

A poster from Oxfam's 'Rational Health Campaign' to show the enormous burden many communities bear in misused antibiotics that are bought in the market-place, or are prescribed by doctors on the wrong indications for the wrong patients. Kindly contributed by Oxfam.

## 2.8 Particular antibiotics

Some antibiotics are particularly important in district hospital surgery, either because they are life-saving, or because they are good value for money. *Don't, however, overuse them, particularly when there is no clear indication to do so!*

### (a) Penicillins

**Benzylpenicillin** (penicillin G) is cheap and safe. For *streptococci* and *meningococci*, it is the antibiotic of choice. There is little point in giving very high doses. If penicillin fails to cure a patient, this will probably be because the  $\beta$ -lactamase of penicillin-resistant bacteria is destroying it, not because you are not giving enough. For an adult, 1.2g (2MU) qds is the standard dose for a severe infection, such as spreading hand sepsis, cellulitis round an infected wound, gas gangrene (6.24) and tetanus. It is also effective against anthrax, *borrelia*, diphtheria, gonorrhoea, and leptospirosis. However, if drugs are scarce, 0.6g given to 4 people is likely to do more good than 2.4MU given to 1 person. In infants, and in patients with cardiac or renal disease, the sodium or potassium in the penicillin can cause undesirable side-effects, so be aware of this.

**Benzathine penicillin**, or **ultracillin** (1.4G), is used in venereal disease (syphilis, yaws, bejel, pinta and chancroid) and anthrax, but not acute surgical infections. Its use is in prophylaxis in rheumatic fever, and after splenectomy.

**Procainbenzylpenicillin** (3G) may be used as a once daily dosage instead of benzylpenicillin, particularly in children.

**Flucloxacillin** or **cloxacillin** (500mg qds) are not inactivated by penicillinases and so are very useful against most *staphylococci* which are now generally resistant to benzyl- or phenoxymethyl-penicillin (penicillin V).

**Ampicillin** (250-500mg qds) and **amoxicillin** (250mg tds) are inactivated by penicillinases and so ineffective against *staphylococci* and common Gram-negative organisms such as *E. coli*; they are useful against chest infections and otitis media caused by *Haem. influenzae* and *Streptococcus*, as well as endocarditis prophylaxis, but less so against urinary infections. The combination with clavulanic acid, **co-amoxiclav**, is effective against  $\beta$ -lactamase producing bacteria, and so has a broader spectrum. Amoxicillin is better absorbed orally than ampicillin.

(Use **ticarcillin** and **piperacillin** against *Pseudomonas septicaemia*.)

### (b) Macrolides

**Erythromycin** (500 mg qds) is the standard alternative where there is penicillin allergy. It is the drug of choice for *mycoplasma pneumoniae*, Legionnaire's disease, and chlamydial infections. It has a useful secondary effect of stimulating gastric emptying.

The others – **azithromycin**, **clarithromycin**, **roxithromycin** – have slightly better activity against Gram-ve organisms, but are expensive.

**Metronidazole** (400mg tds) is effective against anaerobes (which far exceed aerobes in the gut, and are the cause of foul faecal odour), especially *Bacteroides fragilis*, and *protozoa*. It is the drug of choice for amoebiasis, balanitis, giardiasis, Guinea worm infection, tetanus, and trichomonal vaginitis. Resistance to it is unknown. Alcohol should not be taken with it but otherwise it has few side-effects. Use it, blindly if necessary, for all patients who are severely ill with an infection that might be caused by anaerobes, and particularly for patients with intra-abdominal sepsis. Intravenous metronidazole (500mg tds) is expensive, but you can achieve adequate blood levels by using suppositories, or as oral tablets inserted rectally. Like this, it is only  $1/10$  the price. Metronidazole is one of the drugs that no surgeon should be without. **Ornidazole** and **tinidazole** are similar.

**Chloramphenicol** (500-1000mg qds) is cheap, and has a broad spectrum of activity against aerobic Gram-ve bacilli and Gram+ve cocci. Also, if you do not have metronidazole for anaerobic infections, chloramphenicol is next best. It has good *in vitro* activity against anaerobes from most parts of the world. It also enters the eye (28.3). *Its life-saving properties outweigh the very small risk of aplastic anaemia*. It is the drug of choice in bubonic plague. *You cannot administer it IM*. Chloramphenicol with metronidazole is an excellent combination for established or expected peritonitis (10.1). However, resistance will be common if the drug is much used in the community. **Thiamphenicol** is similar. They enhance anticoagulants, anticonvulsants and the sulphonylurea hypoglycaemics (glibenclamide etc.).

### (c) Cephalosporins

There are 4 'generations' of these drugs with increasing spectrum *and* cost:

1<sup>st</sup>: **Cefradine** (250-500mg qds),  
**cefazolin** (500mg qds), **cefalexin** (250mg qds),  
**cefadroxil** (500mg bd)  
 2<sup>nd</sup>: **Cefaclor** (250mg tds), **cefprozil** (500mg od),  
**cefuroxime** (750mg tds),  
**cefamandole** (500mg qds)

(less inactivated by  $\beta$ -lactamases than 1<sup>st</sup> generation, so cover some Gram+ve bacteria)

3<sup>rd</sup>: **Cefotaxime** (1g bd), **ceftazidime** (1g tds),  
**ceftriaxone** (1g od), **cefsulodin** (1g bd)

(broader spectrum, but less good against Gram+ve bacteria than 2<sup>nd</sup> generation)

4<sup>th</sup>: **Cefoxitin** (active against bowel flora).

They are useful to treat severe Gram-ve infection, and with metronidazole as prophylaxis in bowel surgery.

Remember that 10% of penicillin-sensitive patients are also allergic to cephalosporins, especially if they have had an immediate reaction to one or the other.

*Beware!* Alas, more and more Gram-ve organisms are becoming resistant to cephalosporins!

#### (d) Aminoglycosides

**Gentamicin** (80mg tds, or 240mg od) is a very valuable broad-spectrum antibiotic, used IV or IM, often effective against *Pseudomonas*. For the 'blind' treatment of a serious infection, especially one due to intestinal bacteria, use gentamicin and ampicillin or penicillin with metronidazole. Gentamicin is toxic to the ears and kidneys if its use is prolonged; *don't use it at the same time as the diuretic furosemide*.

Other costlier similar aminoglycosides are **amikacin**, **kanamycin**, **netilmicin** and **tobramycin**; you can use **neomycin** orally but it is too toxic; use **spectinomycin** against gonorrhoea; reserve **streptomycin** for *tuberculosis* treatment; use **spiramycin** against *toxoplasmosis*.

#### (e) Sulphonamides

**Trimethoprim** (200mg bd) alone is preferable to cotrimoxazole, which is a combination of trimethoprim and sulfamethoxazole. The latter is rather toxic and not very effective. Sulphur sensitivity is common with HIV disease, and the resulting Stevens-Johnson syndrome is often fatal. Trimethoprim is also used for *pneumocystis*, *toxoplasma*, and *isospora*.

#### (f) Tetracyclines

Tetracyclines have broad spectrum activity, but bacterial resistance is a problem. They are the drug of choice in *chlamydia* infections (donovanosis, trachoma, salpingitis, urethritis, LGV), *rickettsia* (tick typhus), *treponema* (syphilis) and *brucella*. They also protect against malaria. They are deposited in growing bone and teeth, so *don't use them in children <12yrs, or pregnant and breastfeeding women*. Absorption of **doxycycline** (100mg bd), unlike **tetracycline** (250mg qds), is not decreased in effect by milk, antacids or calcium, iron and magnesium salts, and is safe in renal disease.

#### (g) Quinolones

**Ciprofloxacin** (500mg bd) is active against Gram-ve and +ve bacteria (but not usually *Strep pneumoniae* and *Enterococcus faecalis*) and is particularly active against *salmonella*, *shigella*, *campylobacter*, *Neisseria*, *pseudomonas*, and *chlamydia*.

**Nalidixic acid** (1g qds), **norfloxacin** (400mg bd), **ofloxacin**, **enoxacin**, **cinoxacin**, **pefloxacin**, and **sparfloxacin** are useful in urinary tract infections.

*Don't use them in epileptics, for children, in pregnancy, and breastfeeding*. They enhance the effect of anticoagulants.

#### (h) Others

**Fusidic acid** (500mg tds) should be specifically reserved for penicillin-resistant *staphylococcal* osteomyelitis; as a cream (2%), it is useful for impetigo, but should not be used for simple skin ulcers, because of the problem of resistance.

**Nitrofurantoin** (50mg qds) is useful in uncomplicated urinary tract infection.

**Mupirocin** (2% cream) is also useful in impetigo and secondarily *staphylococcal* infected fungal skin infections.

**Pivmecillinam** is active against many Gram-negative bacteria, but not *Pseudomonas*.

**Aztreonam** (not active against Gram+ve), **imipenem** with **cilastin**, **meropenem**, and **moxalactam** are powerful broad-spectrum  $\beta$ -lactam antibiotics.

**Clindamycin** is useful against *staphylococci* and many anaerobes, but can produce fatal pseudomembranous colitis.

**Vancomycin** and **teicoplanin** are used against multi-resistant *staphylococci*, and *clostridium difficile*.

## 2.9 Methods for using antibiotics

Antibiotics for treating established infection call for little comment, and are described in many places in this manual. Antibiotics to prevent infection need to be used wisely, in ways in which their benefits outweigh their risks.

An operation site which was clean to start with can become contaminated with bacteria from:

(1) **Outside the patient**, in which case they will probably be *staphylococci*. Preventing such infection is the purpose of the ordinary aseptic routines, and prophylactic antibiotics are no substitute for them. Most surgical patients don't need antibiotic cover for sepsis of this kind. The only absolute indication for it is to cover the implantation of prostheses, which you are unlikely to do.

(2) **Inside the patient**, when you operate on the colon or the lower urinary tract, or on a woman's genital tract.

When you use antibiotics prophylactically, aim to provide a concentration in the blood that will kill any bacteria introduced into the wound at the time of the operation. To minimize the risk of peritonitis, it is important to protect against *enterobacteria* (mostly *E. coli*), as well as aerobic and anaerobic *streptococci*, *bacterioides*, and *clostridia*. A single broad-spectrum antibiotic with good tissue penetration and long half-life is ideal.

Use the antibiotics IV pre-operatively (especially with the premedication or the start of surgery), so that high concentrations are reached in the wound at the time of surgery. Starting them a day or more before the operation, or continuing them unnecessarily afterwards, promotes the selection of resistant organisms and the risk of side-effects, and *has been shown to confer no extra benefit*.

**If you forgot to give the antibiotic before the operation**, it is still worthwhile to do so before closing the skin, *but not afterwards*. (*That would be like washing your dirty hands after eating a meal!*)

There are several unacceptable methods:

(1) *Don't put topical antibiotics into a patient's wound.*

(2) *Don't use them in the hope of 'sterilizing the colon'.*

(3) *Don't use antibiotics for longer than a specified period in the vain hope that infection or fever might finally be controlled.*

As to the antibiotics to use, you will see from the list of indications below that, if chloramphenicol is not much used in the community, chloramphenicol with metronidazole is likely to be the most cost-effective combination. Otherwise, use cefradine (or some other cephalosporin) with metronidazole, which are much better than penicillin and streptomycin.

*Always differentiate prophylaxis from treatment.* Using your more expensive antibiotics in life-threatening sepsis makes more sense than wasting them in dubious prophylaxis. If you are treating septicaemia, aim to continue the antibiotic regime until the illness is under control (usually 5-7 days). Once a patient can take drugs orally, there is usually no longer any need to give them IV.

**THE DOSE AND THE TIMING ARE CRITICAL:  
MAKE SURE THERE ARE ADEQUATE LEVELS  
AT THE TIME OF SURGERY**

**Perioperative prophylaxis**

**INDICATIONS**

- (1) Peritonitis (but antibiotic use here is likely to be therapeutic rather than prophylactic)
- (2) Operations likely to contaminate the peritoneal cavity, especially with spillage from the colon, appendix, bile duct or stomach.
- (3) Operations on the urinary tract when the urine is already contaminated, including bouginage, cystoscopy, and prostatectomy.
- (4) Hysterectomy.
- (5) Emergency Caesarean section.
- (6) Intracranial explorations.
- (7) Open fracture surgery, and amputations.
- (8) Re-opening haematomas.
- (9) Splenectomy.
- (10) Dental or oral surgery with known heart valve disease.

**CAUTION!**

Gentamicin and other aminoglycosides may seriously prolong the action of long-acting (non-depolarizing) relaxants, and may prevent the establishment of spontaneous ventilation. Avoid them unless your anaesthetist is experienced.

*N.B. Prophylactic antibiotics will probably not cover the perioperative risk of respiratory infections.* Physiotherapy is far more likely to be effective, both pre- and post-operatively.

**CONTRAINDICATIONS.** Antibiotics are not needed for:

- (1) Already well-localized infections.
- (2) Clean category 1 operations (hernia repair, ovarian cystectomy, etc)
- (3) Burns (initial treatment)
- (4) Tracheostomy, intercostal drainage, simple lacerations.

If you are using a tourniquet, time the injection to provide the maximum concentration about the time that you release it, so that the clot which forms in the wound will be heavily loaded with drug.

**ONLY A FEW HIGH-RISK PATIENTS NEED  
PROPHYLACTIC ANTIBIOTICS**

*"We may look back on the antibiotic era as a passing phase, an age in which a great natural resource was squandered."*

**2.10 When prevention fails: wound infection**

If a wound discharges pus, this may mean that the aseptic routines described earlier in this chapter have broken down. Although this is not the only cause of a wound infection, it is the most unnecessary one.

Keep a record of your wound infections. They are most likely to occur if:

- (1) You are operating for some infective condition, such as acute appendicitis.
- (2) The operation is long and difficult.
- (3) You leave dead tissues, foreign bodies, dirt, or clot, or an excessive number of sutures (especially non-absorbable) in the wound.
- (4) You create dead tissue by operating clumsily.
- (5) You do an unnecessary un-clean procedure at the same time as the clean surgery.
- (6) You close a wound by immediate primary closure, when delayed primary closure would have been wiser.
- (7) You leave IV cannulae, chest drains or other drains in longer than necessary.

**SURGICAL SEPSIS**

(1) A theatre had extractor fans installed, but the only inlets for fresh air were under the doors, so that dust from the corridor was drawn into the theatre continually. Only when three patients had died of tetanus was the flow of the fans reversed.

LESSON Keep dust out of the theatre.

(2) In a certain teaching hospital, there were two minor theatres in which many septic operations were done. On 2 mornings a week the same equipment was used for a list of circumcisions. One circumcised child acquired erysipelas which spread from the umbilicus to the toes and killed him.

LESSON Where possible, *don't do clean cases in a theatre which normally does septic ones.*

(3) An eminent professor electively resected an appendix at the same time as cholecystectomy. The patient developed an anaerobic wound infection and later a faecal fistula.

LESSON *Don't do unnecessary procedures which increase the risk of infection.*

(4) Hamilton Bailey, subsequently a distinguished surgeon, but then a registrar in the 1930s, was deputizing for the chief. Having done an elective list which began at 1.30p.m., he insisted on continuing with a non-stop flood of emergencies which continued rolling in all evening. At 3 a.m. the following morning, 'dead on the feet', he pricked himself when operating on a patient with streptococcal peritonitis. Bailey insisted that the finger be amputated, and survived. The patient died.

LESSON Accidents, including those which increase the risk of sepsis, hepatitis and HIV transmission, are particularly likely if you are overtired.

If >5% of your clean cases become infected, something has gone wrong. Prophylactic antibiotics are not the answer! *The chances are that the aseptic technique (2.3) is not being followed, or you are making the errors 3, 4, and 5 above.*

### (a) The prevention of wound infections

#### AUTOCLAVING

(1) Check that your autoclave does reach  $1 \text{ kg/cm}^2$  (2.4), that the air is being discharged, and that the holding time is being maintained.

(2) Check that the drums are not being overpacked, that they are labelled after autoclaving, and that the label includes the date.

**THEATRE DISCIPLINE.** Check that you and *all* your staff are following all the aseptic disciplines (2.3) carefully. If you set an example, your staff will follow. Check that:

(1) the theatre table and especially the plastic cover on its mattress, are being properly cleaned,

(2) there is no infected member of staff: check for nasal and skin carriers of *staphylococcus* especially if an outbreak of hospital infections occurs.

Examine yourself. Are you committing errors 3, 4, or 5 above?

### (b) The treatment of wound infections

Sedate the patient with morphine, pethidine, diazepam or ketamine, if necessary. In infected sutured wounds the pus usually tracks the whole length of the subcutaneous tissues. So remove all sutures and convert the wound into an open gutter. If possible, send a swab for culture. Clean the wound; use hydrogen peroxide if it is smelly. Establish free drainage, especially in the depths of the wound, keep it open so that it can heal from the bottom, and pack the wound daily with antiseptic dressings. Either allow it to granulate or close it by secondary suture when it is 100% clean. If sepsis is troublesome, consider the use of pure ghee (the clear liquid skimmed off the top of slowly heated butter) and pure honey in a ratio 1:2, sugar, pawpaw, or even sterile maggots. Use low-suction vacuum dressings, connected to collapsed urine bags or similar, if you do not have suction devices available.

*Antibiotics are only indicated if there is spreading infection (cellulitis) or septicaemia. There is no role for topical antibiotics.* If you have many septic wounds to deal with, or not enough staff or dressing materials, leave the wounds open and exposed to the sun for as long as possible. Check that there is no indiscriminate or undisciplined use of antibiotics.

**If there is oedema and a brownish discharge comes from the wound, and the patient is toxic and apathetic,** suspect *gas gangrene* (6.24); **if there are spreading purplish discolouration and signs of subcutaneous necrosis,** suspect *necrotizing fasciitis* (6.23). In both cases, immediate extensive debridement is necessary to save life.

**If a wound fails to heal,** think of diabetes mellitus, HIV (5.6), anaemia, malnutrition, the presence of cancer or a foreign body.

**If a sinus develops from a wound,** suspect an infected buried non-absorbable suture knot (a *stitch sinus*); sterilize a crochet needle and use this to try to hook the knot out of the wound.

If you are successful, the wound will heal spontaneously. Otherwise, you will have to open around the sinus and extract the foreign material.

**If a growth develops from the wound,** this is a *pyogenic granuloma* (34.4): excise it and check for HIV disease.

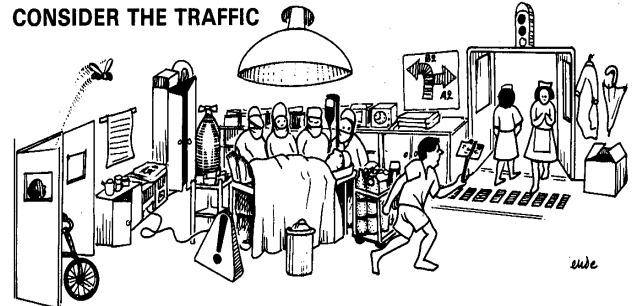


Fig. 2-10 CONSIDER THE TRAFFIC.

Wounds are less likely to become infected if the theatre is not used as a storeroom, and if there is a minimum of traffic in and out of it. So remove the teacups and cartons, the bicycle, the umbrella, and that coat! Close the doors! Drawn by Nette de Glanville.

## 2.11 Post-operative pain control

Your reputation will grow enormously if your patients don't suffer any discomfort after surgery; unfortunately much good pain management is hindered by myths, fear or ignorance. Unrelieved pain has significant effects on a patient's physiology as well as psychology. Pain scoring systems are very useful in establishing an objective measurement of analgesia:

VERBAL: NONE-MILD-MODERATE-SEVERE-EXTREME

NUMERICAL: INTENSITY 0 (no pain) – 10 (worst pain)

VISUAL: INTENSITY LINE ☺ (no pain) – † (want to die)

*N.B. The intensity of pain is what the patient says it is!*

The visual system is most useful in children. Since many patients after major surgery cannot speak well, you should have these scoring charts on a board ready to show them.

*Don't ignore the patient who complains of pain:* it may be a sign of a serious complication.

The aim should be to *prevent* pain: a patient should wake up after surgery with no pain, and be encouraged to ask for analgesia as soon as pain develops.

Combinations of analgesic drugs and of routes of delivery give the best results. You can provide much pain relief by putting large volumes of low concentration long-acting local anaesthetic (bupivacaine) into the wound at the end of the operation; *don't inject it into the surrounding tissues if the wound is infected:* you can then just drip it into the wound and leave it for 1 min to get absorbed.

The sad reality is that in present practice many patients wake up with pain, shout for help and are shouted at in turn, until eventually, they are given a large IM dose of opioid. They then go to sleep again. Later, when the analgesic effect wears off, the cycle repeats itself. This is not only unsatisfactory from the point of view of needless suffering but is often the cause of post-operative complications: atelectasis, deep vein thrombosis, vomiting, anorexia, constipation, dehydration, urinary retention, and it also prevents people from getting out of bed.

**(a) For severe pain**, morphine is preferable to pethidine, because it produces less respiratory depression, less nausea, and is less of a cerebral irritant. It also lasts longer. (Pethidine needs to be repeatedly given 3hrly to be effective.)

Because these are controlled drugs, nurses will often only give them at standard drug dosage times. Challenge your local regulations if these inhibit patients getting proper pain relief. Try to get solutions of oral morphine made locally. *This should not cost >1c.(US)/mg! Don't use injectable opioids SC or IM but always IV, injecting slowly: this way relief will be immediate and the dose received will be less.* Small, frequent IV opioids will prevent pain and it will be possible to switch to the oral or rectal route within 24h in most cases. Apart from being much more effective if given IV, either as boluses or better as an IV infusion, they are safer given this way as you thereby *must watch the patient's response*.

*A calculated IV infusion of opioid is not dangerous!* (If the IV infusion has accidentally run in fast with all of its added 10mg of morphine, simply omit the dose with the next litre of IV fluid.) Arrange the infusion in theatre with the cooperation of the anaesthetist.

In children, tilidine oral drops (x1 per year of age up to 10) are very useful indeed.

Ketamine gives good post-operative pain relief; its hallucinatory effects are diminished by giving diazepam *before* the operation, *i.e.* with the ketamine.

Remember that opioids occasionally cause hyperalgesia (especially if used for non-malignant causes); but beware of the patient with chronic pain who regularly refuses opioids (*he probably needs them*) and the patient with aberrant behaviour who demands them (*he does not need them*)!

**(b) For moderate pain**, the choice is paracetamol-with-codeine and/or a non-steroidal anti-inflammatory drug. The latter have considerable side-effects: peptic ulceration, renal impairment, and coagulation problems. They can be given rectally if a patient is not taking in orally. The evidence that they are any more effective than paracetamol-with-codeine is not convincing, but *it is always best to ask the patient which drug he finds best!*

If you know that an operation will give considerable pain, prescribe *regular* analgesia for the first 2-3 days, not 'PRN' (which stands for *pro re nata* = as required, but often in practice implies 'presumably rarely needed')!

**(c) For mild pain**, paracetamol is ideal. It can be given as a syrup for children or those who have difficulty swallowing.

Trans-cutaneous electrical nerve stimulation and neuro-acupuncture can give added relief if you have these facilities.

## 2.12 Records

Keep meticulous records of operations performed: train the theatre staff to fill in the book immediately and keep these records accurately. Bad records are almost as good as no records at all! You should have *all* the following information in the theatre book (which obviously should be fairly large, and preferably hard-backed):

DATE  
OPERATION NUMBER  
PATIENT'S NAME  
PATIENT'S AGE/SEX  
PATIENT'S HOSPITAL NUMBER  
DIAGNOSIS  
OPERATION PERFORMED  
EMERGENCY/ELECTIVE  
SURGEON  
ASSISTANT(S)  
ANAESTHETIST  
ANAESTHETIC USED  
SCRUB SISTER  
TIME STARTED & TIME FINISHED  
COMPLICATIONS  
HISTOLOGY/PUS SWAB RESULT

Keep your book neat: if necessary, fill in details initially in pencil. Keep to the columns drawn in the book.

It is important to use the same nomenclature throughout, *e.g.* 12 Feb 2004 for the date (and then not use 12/02/04 or, worse, 02/12/04), and particularly consistency in abbreviations (*e.g.* I&D for incision and drainage, MUA for manipulation under anaesthetic etc). Try to keep names consistent, using the family name first in CAPITALS and then the first (and second) names. The more detail you can put, the better will be your records, and your ability to do research.

Under 'Diagnosis', be sure to put the correct diagnosis (which may differ from the pre-operative diagnosis).

Under 'Anaesthetic Used', you should put *at least* GA for general anaesthetic, Sedation, or LA for local anaesthetic. You could put Thio/O<sub>2</sub>/N<sub>2</sub>O if using thiopentone, oxygen and nitrous oxide, or Ket if using ketamine, but the more detail in the records, the more diligence is required in keeping them. Often there are *no records at all*, which is a disastrous and unacceptable state of affairs.

You should come back and check the theatre records, in case details are filled in incorrectly. Get your nurses to write details in pencil for you to correct, if necessary, later. Make a particular note of complications. This includes not only immediate problems (like bleeding or a death on the table), but also later ones such as wound infections.

If you direct laboratory results of histology and pus swabs to theatre so that they are recorded there in the book, they are much less likely to get lost and can be much more easily referred to.

Some details are optional, *e.g.* indication for operation, grade of operation (minor, intermediate, or major), and type of procedure (endoscopy, orthopaedic, ENT etc). The grade of operation is notoriously subjective; if you do record this, we suggest using the grades described in Appendix A of this manual.

You should keep a separate book for deliveries of babies, and decide whether you should enter operative deliveries with the other operations, or separately. *It doesn't matter as long as they are properly recorded!*

If you keep good records, you will be able to highlight problems when things go wrong. You can keep an audit on how much work you are doing, what your requirements are likely to be, and therefore your costs. You will have a valuable resource for research. This is very important. You will also derive satisfaction from a job well done, and leave a functioning system in place for your successor.