



UPDATE IN ANAESTHESIA



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EDITORIAL

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The Role of Spinal Anaesthesia in Developing Countries.

Professor Nicholas M Greene, Dept. of Anaesthesiology, School of Medicine, Yale University, USA

Regional anaesthesia, although popular in certain centres in developing countries, is generally poorly accepted in these areas as a reliable, economical means for providing operative anaesthesia. Perhaps this is understandable in the case of complicated nerve blocks such as ankle blocks and femoral and sciatic blocks for operations below the knee. This may also be understandable for blocks of lumbar plexus or of the brachial plexus using the supraclavicular approach. The same may be said for continuous spinal or epidural techniques that require catheters both hard to obtain and expensive. But failure of single-injection spinal anaesthetic techniques to achieve richly deserved popularity is difficult to understand given the obvious advantages with which such simple, straightforward, effective, safe and even inexpensive techniques are associated.

The present "mini-review" of spinal anaesthesia offered by Drs. Ankorn and Casey is such a paragon of lucidity, completeness, and good common sense as to be beyond the need for trivial tinkering or amplification. It says what needs to be said and leaves unsaid what needs not to be said. It is recommended for **close** reading by anaesthetists everywhere but perhaps especially those in developing areas where spinal is so infrequently employed.

There is, undeniably, an art, a skill associated with

Contents: No 3

Editorial
Spinal anaesthesia
Physiology - Control of Heart Rate
Drawover anaesthesia - Practical Aspects
- Equipment Care
Pharmacology - Morphine
Clinical Dilemma
Equipment - Aneroid Sphygmomanometer

spinal anaesthesia. There is an art, a skill associated with learning to ride a bicycle or learning any anaesthetic technique. But practice makes perfect. The more spinal anaesthetics one gives, the easier they are to give and the greater the level of success. Any truly competent anaesthetist, physician or paramedical, must be expert in spinal anaesthesia as well as in general anaesthesia if the manifest advantages of spinal anaesthesia are to be provided to all patients. The anaesthetist not fully comfortable with spinal anaesthesia should attain the requisite level of competence by purposefully giving spinals every time he or she can reasonably do so, even if spinal anaesthesia may not be the only anaesthetic technique indicated. By giving spinal anaesthesia even once or, better, twice a week, the anaesthetist will, by the end of the year, be an expert whose skill is requested for patients in whom spinal anaesthesia is the technique of choice. The anaesthetist who knows how to give a good spinal will also enjoy a more rewarding and professionally interesting day-to-day practice.

Instead of giving the same general anaesthetic 500 times a year, he or she will enjoy the professional stimulation of varying the type of anaesthesia based

Editors: Drs Iain Wilson, Roger Eltringham *Section Editors:* Drs Bill Casey, Ian Kestin, Mr Mike Yeats
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Illustrations & Graphics: Angela Frost

on patient condition, type of operation proposed, and the quiet self-confidence that comes with experience using the champagne of anaesthetics:

spinal anaesthesia. How to attain this requisite level of skill and art is neatly described in this update on the subject. Read it and believe it.

SPINAL ANAESTHESIA - A Practical Guide

Dr Chris Ankorn, Lecturer in Anaesthesia, Kumasi, Ghana

Dr William F Casey FRCA, Consultant Anaesthetist, Gloucestershire Royal Hospital, Gloucester, UK

Spinal anaesthesia is induced by injecting small amounts of local anaesthetic into the cerebro-spinal fluid (CSF). The injection is usually made in the lumbar spine below the level at which the spinal cord ends (L2). Spinal anaesthesia is easy to perform and has the potential to provide excellent operating conditions for surgery below the umbilicus.

If the anaesthetist has an adequate knowledge of the relevant anatomy, physiology and pharmacology, safe and satisfactory anaesthesia can easily be obtained to the mutual satisfaction of the patient, surgeon and anaesthetist.

The Advantages of Spinal Anaesthesia

Cost. Anaesthetic drugs and gases are costly and the latter often difficult to transport. The costs associated with spinal anaesthesia are minimal.

Patient satisfaction. If a spinal anaesthetic and the ensuing surgery are performed skillfully, the majority of patients are very happy with the technique and appreciate the rapid recovery and absence of side-effects.

Respiratory disease. Spinal anaesthesia produces few adverse effects on the respiratory system as long as unduly high blocks are avoided.

Patent airway. As control of the airway is not compromised, there is a reduced risk of airway obstruction or the aspiration of gastric contents. This advantage may be lost with too much sedation.

Diabetic patients. There is little risk of unrecognised hypoglycaemia in an awake patient. Diabetic patients can usually return to their normal food and insulin regime soon after surgery as there is less sedation, nausea and vomiting.

Muscle relaxation. Spinal anaesthesia provides excellent muscle relaxation for lower abdominal and lower limb surgery.

Bleeding. Blood loss during operation is less than when the same operation is done under general anaesthesia. This is as a result of a decreased blood pressure and heart rate, and improved venous drainage which results in less oozing.

Splanchnic blood flow. Because of its effect on increasing blood flow to the gut, spinal anaesthesia reduces the incidence of anastomotic dehiscence.

Visceral tone. The bowel is contracted by spinal anaesthesia and sphincters relaxed although peristalsis continues. Normal gut function rapidly returns following surgery.

Coagulation. Post-operative deep vein thromboses and pulmonary emboli are less common following spinal anaesthesia.

Disadvantages of Spinal Anaesthesia

1. When an anaesthetist is learning a new technique, it will take longer to perform than when he is more practised, and it would be wise to let the surgeon know that induction of anaesthesia may be longer than usual. Once competent, however, spinal anaesthesia can be very swiftly performed.
2. Occasionally, it is impossible to locate the dural space and obtain CSF and the technique has to be abandoned. Rarely, despite an apparently faultless technique, anaesthesia is not obtained.
3. Hypotension may occur with higher blocks and the anaesthetist must know how to manage this situation with the necessary resuscitative drugs and equipment immediately to hand. As with general anaesthesia, continuous, close monitoring of the patient is mandatory.
4. Some patients are not psychologically suited to be awake, even if sedated, during an operation. They should be identified during the preoperative assessment.
5. Even if a long-acting local anaesthetic is used, a spinal is not suitable for surgery lasting longer than approximately 2 hours. If an operation unexpectedly lasts longer than this, it may be necessary to convert to a general anaesthetic.

6. There is a theoretical risk of introducing infection into the subarachnoid space and causing meningitis. This should **never** happen if equipment is sterilised properly and an aseptic technique is used.

7. A postural headache may occur postoperatively. This should be rare: see later.

Indications for Spinal Anaesthesia

Spinal anaesthesia is best reserved for operations below the umbilicus e.g. hernia repairs, gynaecological and urological operations and any operation on the perineum or genitalia. All operations on the leg are possible, but an amputation, though painless, may be an unpleasant experience for an awake patient. In this situation it may be kinder to supplement the spinal with generous sedation or a light general anaesthetic.

Spinal anaesthesia is especially indicated for older patients and those with systemic disease such as chronic respiratory disease, hepatic, renal and endocrine disorders such as diabetes. Most patients with mild cardiac disease benefit from the vasodilation that accompanies spinal anaesthesia except those with stenotic valvular disease or uncontrolled hypertension.

It is suitable for managing patients with trauma if they have been adequately resuscitated and are not hypovolaemic. In obstetrics, it is ideal for manual removal of a retained placenta (again, provided there is no hypovolaemia). There are definite advantages for both mother and baby in using spinal anaesthesia for Caesarean section. However, special considerations apply to managing spinal anaesthesia in pregnant patients (see later) and it is best to become experienced in its use in the non-pregnant patient before using it for obstetrics.

Contra-indications to Spinal Anaesthesia

Most of the contra-indications to spinal anaesthesia apply equally to other forms of regional anaesthesia. These include:

Inadequate resuscitative drugs and equipment.

No regional anaesthetic technique should be attempted if drugs and equipment for resuscitation are not immediately to hand.

Clotting disorders. If bleeding occurs into the epidural space because an epidural vein has been punctured by the spinal needle, a haematoma could form and compress the spinal cord. Patients with a low platelet count or receiving anticoagulant drugs such as heparin or warfarin are at risk. Remember that patients with liver disease may have abnormal clotting profiles whilst low platelet counts as well as abnormal clotting can occur in pre-eclampsia.

Hypovolaemia from whatever cause e.g. bleeding, dehydration due to vomiting, diarrhoea or bowel obstruction. Patients must be adequately rehydrated or resuscitated before spinal anaesthesia or they will become very hypotensive.

Any **sepsis** on the back near the site of lumbar puncture.

Patient refusal. Patients may be understandably apprehensive and initially state a preference for general anaesthesia, but if the advantages of spinal anaesthesia are explained they may then agree to the procedure and be pleasantly surprised at the outcome. If, despite adequate explanation, the patient still refuses spinal anaesthesia, their wishes should be respected.

Uncooperative patients. Although spinal anaesthesia is suitable for children, their cooperation is necessary and this must be carefully assessed at the pre-operative visit. Likewise, mentally handicapped patients and those with psychiatric problems need careful pre-operative assessment.

Septicaemia. Due to the presence of infection in the blood there is a possibility of such patients developing meningitis if a haematoma forms at the site of lumbar puncture and becomes infected.

Anatomical deformities of the patient's back. This is a relative contraindication, as it will probably only serve to make the dural puncture more difficult.

Neurological disease. The advantages and disadvantages of spinal anaesthesia in the presence of neurological disease need careful assessment. Any worsening of the disease postoperatively may be blamed erroneously on the spinal anaesthetic. Raised intracranial pressure, however, is an absolute contra-indication as a dural puncture may precipitate coning of the brain stem.

Reluctant surgeon. If a surgeon is unhappy operating on an awake patient or if he is relatively unskilled, spinal anaesthesia may be better avoided.

Physiology of Spinal Anaesthesia

Local anaesthetic solution injected into the subarachnoid space blocks conduction of impulses along all nerves with which it comes in contact, although some nerves are more easily blocked than others.

There are three classes of nerve: motor, sensory and autonomic. The motor convey messages for muscles to contract and when they are blocked, muscle paralysis results. Sensory nerves transmit sensations such as touch and pain to the spinal cord and from there to the brain, whilst autonomic nerves control the calibre of blood vessels, heart rate, gut contraction and other functions not under conscious control.

Generally, autonomic and pain fibres are blocked first and motor fibres last. This has several important consequences. For example, vasodilation and a drop in blood pressure may occur when the autonomic fibres are blocked and the patient may be aware of touch and yet feel no pain when surgery starts.

There are practical implications associated with these physiological phenomena.

- The patient should be well hydrated before the local anaesthetic is injected and should have an intravenous infusion in place so that further fluids or vasoconstrictors can be given if hypotension occurs.

- The site to be operated on should not be repeatedly touched and the patient asked "Can you feel this?" as this increases the patient's anxiety. Often some sensation of touch or movement remains and yet no pain is felt. It is better to pinch the skin gently either with artery forceps or fingers and ask if it is painful. If it is not then surgery can begin.

Anatomy

The spinal cord usually ends at the level of L2 in adults and L3 in children. Dural puncture above these levels is associated with a slight risk of damaging the spinal cord and is best avoided. **An important landmark to remember is that a line joining the top of the iliac crests is at L4 to L4/5**

Remember the structures that the needle will pierce before reaching the CSF (fig 1.).

The **skin**. It is wise to inject a small bleb of local anaesthetic into the skin before inserting the spinal needle.

Subcutaneous fat. This, of course, is of variable thickness. Identifying the intervertebral spaces is far easier in thin patients.

The **supraspinous ligament** which joins the tips of the spinous processes together.

The **interspinous ligament** which is a thin flat band of ligament running between the spinous processes.

The **ligamentum flavum** is quite thick, up to about 1cm in the middle and is mostly composed of elastic tissue. It runs vertically from lamina to lamina. When the needle is within the ligaments it will feel gripped and a distinct "give" can often be felt as it passes through and into the epidural space.

The **epidural space** contains fat and blood vessels. If blood comes out of the spinal needle instead of CSF when the stylet is removed, it is likely that an epidural vein has been punctured. The needle should simply be advanced a little further.

The **dura**. After feeling a "give" as the needle passes through the ligamentum flavum, a similar sensation may be felt when the needle is advanced a short distance further and pierces the dural sac.

The **subarachnoid space**. This contains the spinal cord and nerve roots surrounded by CSF. An injection of local anaesthetic will mix with the CSF and rapidly block the nerve roots with which it comes in contact.

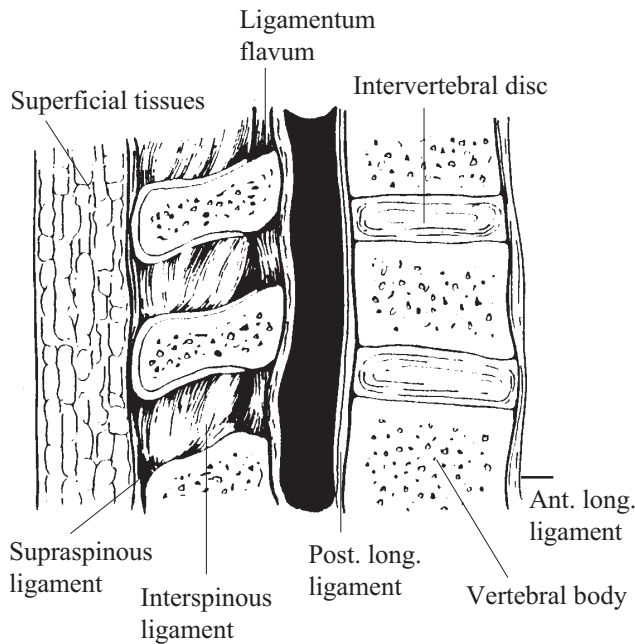


Figure 1. Section of lumbar vertebrae to show the ligaments.

Local Anaesthetics for Spinal Anaesthesia

Local anaesthetic agents are either heavier (hyperbaric), lighter (hypobaric), or have the same specific gravity (isobaric) as the CSF. Hyperbaric solutions tend to spread below the level of the injection, while isobaric solutions are not influenced in this way. It is easier to predict the spread of spinal anaesthesia when using a hyperbaric agent. Isobaric preparations may be made hyperbaric by the addition of dextrose. Hypobaric agents are not generally available. The other factors affecting the spread of local anaesthetic agents when used for spinal blocks are described later.

Bupivacaine (Marcaine). 0.5% hyperbaric (heavy) bupivacaine is the best agent to use if it is available. 0.5% plain bupivacaine is also popular. Bupivacaine lasts longer than most other spinal anaesthetics: usually 2-3 hours.

Lignocaine (Lidocaine/Xylocaine). Best results are obtained with 5% hyperbaric (heavy) lignocaine which lasts 45-90 minutes. 2% lignocaine can also be used but it has a much shorter duration of action. If 0.2ml of adrenaline 1:1000 is added to the lignocaine, it will usefully prolong its duration of

action. Lignocaine from multi-dose vials should not be used for intrathecal injection as it contains potentially harmful preservatives.

Cinchocaine (Nupercaine, Dibucaine, Percaine, Sovcaine). 0.5% hyperbaric (heavy) solution is similar to bupivacaine.

Amethocaine (Tetracaine, Pantocaine, Pontocaine, Decicain, Butethanol, Anethaine, Dikain). A 1% solution can be prepared with dextrose, saline or water for injection.

Mepivacaine (Scandicaine, Carbocaine, Meaverin). A 4% hyperbaric (heavy) solution is similar to lignocaine.

Spinal Anaesthesia and Common Medical

Conditions

Respiratory Disease. A low spinal block has no effect on the respiratory system and is therefore ideal for patients with respiratory disease unless they cough a lot. Frequent coughing results in less than ideal conditions for the surgeon. A high spinal block can produce intercostal muscle paralysis, but this does not usually create any problems, unless the patient is very limited by his respiratory disease.

Hypertension. Hypertension is not a contra-indication to spinal anaesthesia but, ideally, it should be controlled before any anaesthetic is administered. Hypertensive patients should have their blood pressure closely monitored during the anaesthetic and any episode of hypotension vigorously treated.

Sickle cell disease/trait. Spinal anaesthesia may be advantageous for patients with sickle cell disease. Follow the same rules as for general anaesthesia: ensure that the patient is well oxygenated, well hydrated and not allowed to become hypotensive. Consider warming the intravenous fluids and do not allow the patient to become cold. Avoid the use of tourniquets.

Pre-operative Visit

Patients should be told about their anaesthetic during the pre-operative visit. It is important to explain that although spinal anaesthesia abolishes pain, they may be aware of some sensation in the relevant area, but it will not be uncomfortable and is quite normal. It should also be explained that their legs

will become weak or feel as if they don't belong to them any more. They must be reassured that, if they feel pain they will be given a general anaesthetic.

Premedication is not always necessary, but if a patient is apprehensive, a benzodiazepine such as 5-10 mg of diazepam may be given orally 1 hour before the operation. Other sedative or narcotic agents may also be used. Anticholinergics such as atropine or scopolamine (hyoscine) are unnecessary.

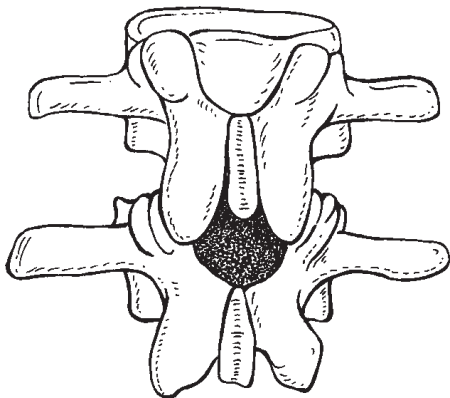
Pre-loading

All patients having spinal anaesthesia must have a large intravenous cannula inserted and be given intravenous fluids immediately before the spinal. The volume of fluid given will vary with the age of the patient and the extent of the proposed block. A young, fit man having a hernia repair may only need 500 mls. Older patients are not able to compensate as efficiently as the young for spinal-induced vasodilation and hypotension and may need 1000mls for a similar procedure. If a high block is planned, at least a 1000mls should be given to all patients. Caesarean section patients need at least 1500 mls.

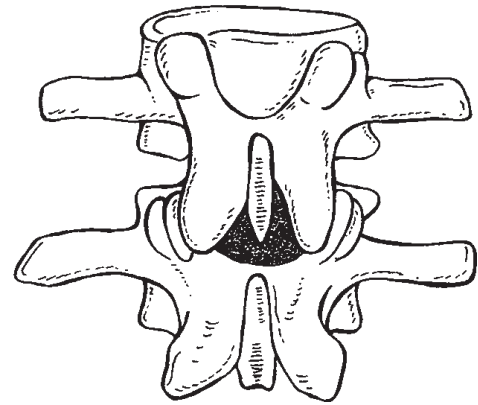
The fluid should preferably be normal saline or Hartmann's solution. 5% dextrose is readily metabolised and so is not effective in maintaining the blood pressure.

Positioning the Patient for Lumbar Puncture

Lumbar puncture is most easily performed when there is maximum flexion of the lumbar spine.



Flexion



Extension

Figure 2. Effect of flexion and extension on the lumbar intervertebral space in the lumbar region.

This can best be achieved by sitting the patient on the operating table and placing their feet on a stool. If they then rest their forearms on their thighs, they can maintain a stable and comfortable position.

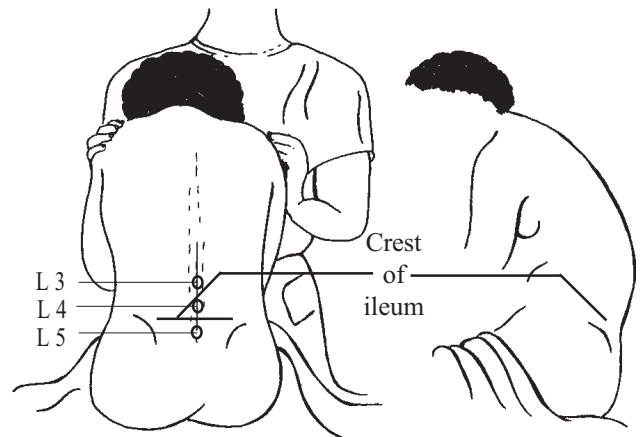


Figure 3. Ideal sitting position for spinal anaesthesia.

Alternatively, the procedure can be performed with the patient lying on their side with their hips and knees maximally flexed. An assistant may help to maintain the patient in a comfortable curled position. The sitting position is preferable in the obese whereas the lateral is better for uncooperative or sedated patients. The anaesthetist can either sit or kneel whilst performing the block.

Factors Effecting the Spread of the Local Anaesthetic Solution

A number of factors effect the spread of the injected local anaesthetic solution within the CSF and the ultimate extent of the block obtained. Among these are:

- the baricity of the local anaesthetic solution
- the position of the patient
- the concentration and volume injected
- the level of injection
- the speed of injection

The specific gravity of the local anaesthetic solution can be altered by the addition of dextrose. Concentrations of 7.5% dextrose make the local anaesthetic hyperbaric (heavy) relative to CSF and also reduce the rate at which it diffuses and mixes with the CSF. Isobaric and hyperbaric solutions both produce reliable blocks. The most controllable blocks are probably produced by injecting hyperbaric solutions and then altering the patient's position.

If a patient is kept sitting for several minutes after the injection of a small volume of a hyperbaric solution of local anaesthetic, a classical saddle block of the perineum will result. The spinal column of patients lying on their side is rarely truly horizontal. Males tend to have wider shoulders than hips and so are in a slight "head up" position when lying on their sides, whilst for females with their wider hips, the opposite is true. Regardless of the position of the patient at the time of injection and whatever the initial extent of the block obtained, the level of the block may change if the patient's position is altered within twenty minutes of the injection.

The quantity of local anaesthetic (in milligrams) injected will determine the quality of the block obtained whilst its extent will also be determined by the volume in which it is injected. Large volumes of concentrated solutions will, thus, produce dense blockade over a large area.

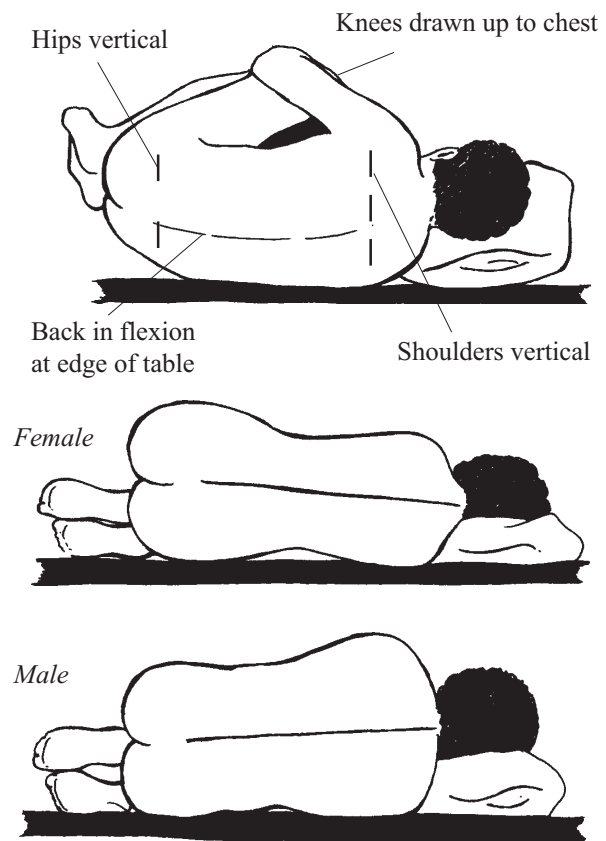


Figure 4. Note how the level of the subarachnoid space varies between male and female

Although the level of injection will obviously effect which dermatomes are blocked, spinal injections tend to be performed only in the lower lumbar region. The extent of the block is influenced more by the volume injected and the position of the patient than the actual interspace at which the injection occurs.

The speed of injection has a slight effect on the eventual extent of the block. Slow injections result in a more predictable spread while rapid injections produce eddy currents within the CSF and a somewhat less predictable outcome.

Finally, increased abdominal pressure from whatever cause (pregnancy, ascites etc) can lead to engorgement of the epidural veins, compression of the dura and hence a reduction in the volume of the CSF. A given quantity of local anaesthetic injected into the CSF might then be expected to produce a more extensive block.

Quantities of Local Anaesthetics to Use

The degree of spinal blockade needed, as measured by the height of the block, will depend on the operation to be performed.

Table 1.

Level	Surgical Procedure
T4-5 (Nipple) T6-8 (Xiphisternum)	Upper abdominal surgery Lower abdominal surgery incl. caesarean section, renal surgery, hernia
T10 (Umbilicus)	Prostatic and vaginal surgery incl. forceps delivery, hip surgery
L1 (Groin) S2 (Perineum)	Lower limb surgery Perineal and rectal surgery

For certain blocks, less local anaesthetic is needed when hyperbaric rather than plain solutions are used. Special considerations apply to obstetric patients and so the following chart does not apply to them (see later section).

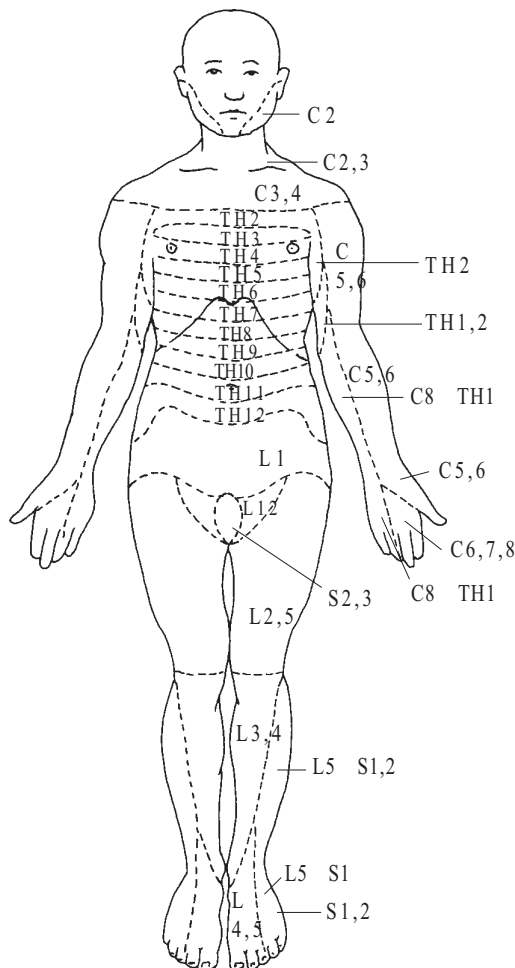


Figure 5. Diagram of dermatomes

Table 2.

Type of block	Hyperbaric Bupivacaine	Plain Bupivacaine	Hyperbaric Lignocaine
Saddle block, eg operations on genitalia, perineum	2ml		3ml 1ml
Lumbar block, eg operations on legs	3-3.5ml		3-3.5ml 2ml
Mid-thoracic block, eg hernia, hysterectomy	3-4ml		3-4ml 2ml

The volumes of local anaesthetic shown in Table 2 should be considered only as a guideline. The lower volumes suggested should generally be injected in particularly small people. More may have to be given if the resultant block is not high enough for the proposed operation. Hyperbaric agents are more reliable when trying for a mid-thoracic block.

Preparation for Lumbar Puncture

Assemble the necessary equipment on a sterile surface. It will include:

A spinal needle. The ideal would be 24-25 gauge with a pencil point tip to minimise the risk of the patient developing a post-spinal headache.

An introducer, if using a fine gauge needle as they are thin and flexible, and therefore difficult to direct accurately. A standard 19 gauge (white) disposable needle is suitable for use as an introducer.

A 5ml syringe for the spinal anaesthetic solution.

A 2 ml syringe for local anaesthetic to be used for skin infiltration.

A selection of needles for drawing up the local anaesthetic solutions and for infiltrating the skin.

A gallipot with a suitable antiseptic for cleaning the skin, eg chlorhexidine, iodine, or methyl alcohol.

Sterile gauze swabs for skin cleansing.

A sticking plaster to cover the puncture site.

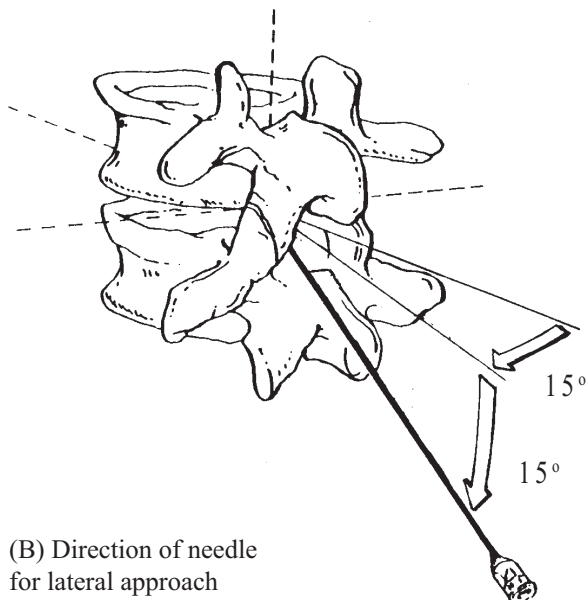
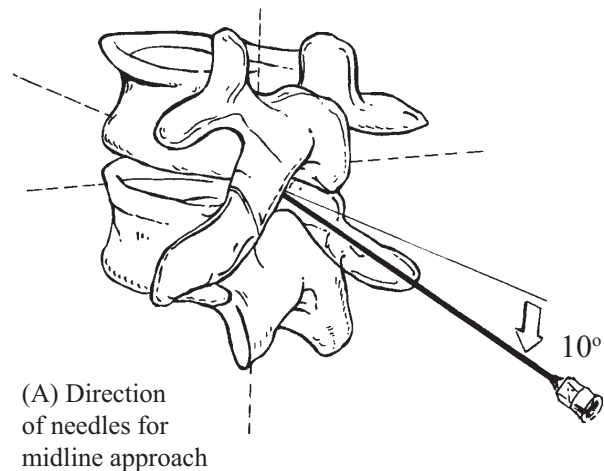
The local anaesthetic to be injected intrathecally should be in a single use ampoule. **Never use local anaesthetic from a multi-dose vial for intrathecal injection.** Spare equipment and drugs should be readily available if needed.

Performing the Spinal Injection

It is assumed that the patient has been adequately prepared, has had the procedure fully explained, has reliable intravenous access, is in a comfortable position and that resuscitation equipment is immediately available.

1. Scrub and glove up carefully.
2. Check the equipment on the sterile trolley.
3. Draw up the local anaesthetic to be injected intrathecally into the 5ml syringe, from the ampoule opened by your assistant. **Read the label.** Draw up the exact amount you intend to use, ensuring that your needle does not touch the outside of the ampoule (which is unsterile).
- 4 Draw up the local anaesthetic to be used for skin infiltration into the 2ml syringe. **Read the label.**
5. Clean the patient's back with the swabs and antiseptic ensuring that unsterile skin is not touched by your gloves. Swab radially outwards from the proposed injection site. Discard the swab and repeat several times making sure that a sufficiently large area is cleaned. Allow the solution to dry on the skin.
6. Locate a suitable interspinous space. You may have to press hard to feel the spinous processes in an obese patient.
7. Raise an intradermal wheal of local anaesthetic with a disposable 25 gauge needle at the proposed puncture site.
8. Insert the introducer if using a 24-25 gauge needle. Ideally it should be advanced into the interspinous ligament but care should be exercised in thin patients that an inadvertent dural puncture does not occur.
9. Insert the spinal needle (through the introducer, if applicable). Ensure that the stylet is in place so that the tip of the needle does not become blocked by a tiny particle of tissue or clot. It is imperative

that the needle is inserted **and stays** in the midline and that the bevel is directed laterally. It is angled slightly cephalad (towards the head) and slowly advanced. An increased resistance will be felt as the needle enters the ligamentum flavum, followed by a loss of resistance as the epidural space is entered. Another loss of resistance may be felt as the dura is pierced and CSF should flow from the needle when the stylet is removed. If bone is touched, the needle should be withdrawn a centimetre or so and then re-advanced in a slightly more cephalad direction again ensuring that it stays in the midline.



10. If a 25 gauge spinal needle is being used, be prepared to wait 20-30 seconds for CSF to appear after the stylet has been withdrawn. If no CSF appears, replace the stylet and advance the needle a little further and try again.

11. When CSF appears, take care not to alter the position of the spinal needle as the syringe of local anaesthetic is being attached. The needle is best immobilised by resting the back of the non-dominant hand firmly against the patient and by using the thumb and index finger to hold the hub of the needle. Be sure to attach the syringe firmly to the hub of the needle; hyperbaric solutions are viscous and resistance to injection will be high, especially through fine gauge needles. It is, therefore, easy to spill some of the local anaesthetic unless care is taken.

12. Aspirate gently to check the needle tip is still intrathecal and then slowly inject the local anaesthetic. When the injection is complete, withdraw the spinal needle, introducer and syringe as one and apply a sticking plaster to the puncture site.

Practical Problems

The spinal needle feels as if it is in the right position but no CSF flows. Wait at least 30 seconds, then try rotating the needle 90 degrees and wait again. If there is still no CSF, attach an empty 2ml syringe and inject 0.5-1ml of air to ensure the needle is not blocked then use the syringe to aspirate whilst slowly withdrawing the spinal needle. Stop as soon as CSF appears in the syringe.

Blood flows from the spinal needle. Wait a short time. If the blood becomes pinkish and finally clear, all is well. If blood only continues to drip, then it is likely that the needle tip is in an epidural vein and it should be advanced a little further or angled more medially to pierce the dura.

The patient complains of sharp, stabbing leg pain. The needle has hit a nerve root because it has deviated laterally. Withdraw the needle and redirect it more medially away from the affected side.

Wherever the needle is directed, it seems to strike bone. Make sure the patient is still properly positioned with as much lumbar flexion as possible and that the needle is still in the mid-line. If you think that you are not in the midline check with the patient which side they feel the needle. Alternatively, if the patient is elderly and cannot bend very much or has heavily calcified interspinous ligaments, it might be better to attempt a lateral approach to the dura.

This is performed by inserting the spinal needle about 1cm lateral to the mid line at the level of the upper border of a spinous process, then directing it both cephalad and medially. If bone is contacted it is likely to be the vertebral lamina. It should then be possible to "walk" the needle off the bone and into the epidural space, then advance through it to pierce the dura (fig. 6).

Assessing the Block

Some patients are very poor at describing what they do or do not feel, therefore, objective signs are valuable. If, for example, the patient is unable to lift his legs from the bed, the block is at least up to the mid-lumbar region.

It is unnecessary to test sensation with a sharp needle and leave the patient with a series of bleeding puncture wounds. It is better to test for a loss of temperature sensation using a swab soaked in either ether or alcohol. Do this by first touching the patient with the damp swab on the chest or arm (where sensation is normal), so that they appreciate that the swab feels cold. Then work up from the legs and lower abdomen until the patient again appreciates that the swab feels cold.

If the replies are inconsistent or equivocal, the patient can be **gently** pinched with artery forceps or fingers on blocked and unblocked segments and asked if they feel pain. Using this method, there is rarely any difficulty in ascertaining the extent of the block.

Surgeons should be dissuaded from prodding the patient and asking "can you feel this?". Surgeons and patients should be reminded that when a block is successful, a patient may still be aware of touch but will not feel pain.

Problems with the Block

No apparent block at all. If after 10 minutes the patient still has full power in the legs and normal sensation, then the block has failed probably because the injection was not intrathecal. Try again.

The block is one-sided or is not high enough on one side.

a). When using a hyperbaric solution, lie the patient on the side that is inadequately blocked for a few minutes and adjust the table so that the patient is slightly "head down".

b). When using an isobaric solution, lie the patient on the side that is blocked. (Moving a patient around in any way at all in the first 10-20 minutes following injection will tend to increase the height of the block).

Block not high enough.

a). When using a hyperbaric solution, tilt the patient head down whilst they are supine (lying on the back), so that the solution can run up the lumbar curvature. Flatten the lumbar curvature by raising the patients knees.

b). When using a plain solution turn the patient a complete circle from supine to prone (lying on the front) and back to supine again.

Block too high. The patient may complain of difficulty in breathing or tingling in the arms or hands. **Do not tilt the table "head up"**. (See later under 'Treatment of a total spinal.')

Nausea or vomiting. This may occur with high spinal blocks which may be associated with hypotension. Check the blood pressure and treat accordingly. (See later)

Shivering. This occurs occasionally. Reassure the patient and give oxygen by mask.

Monitoring

It is essential to monitor the respiration, pulse and blood pressure closely. The blood pressure can fall precipitously following induction of spinal anaesthesia, particularly in the elderly and those who have not been adequately preloaded with fluid. Warning signs of falling blood pressure include pallor, sweating or complaining of nausea or feeling generally unwell.

A moderate fall in systolic blood pressure to, say, 80mmHg in a young fit patient or 100mmHg in an older patient is acceptable, provided the patient looks and feels well and is adequately oxygenated.

Bradycardia is quite common during spinal anaesthesia particularly if the surgeon is manipulating the bowel or uterus. If the patient feels well, and the blood pressure is maintained, then it is not necessary to give atropine. If, however, the heart rate drops below 50 beats per minute or there is hypotension, then atropine 300-600mcg should be given intravenously.

It is generally considered good practice for all patients undergoing surgery under spinal anaesthesia to be given supplemental oxygen by face mask at a rate of 2-4 litres/minute, especially if sedation has also been given.

Treatment of Hypotension

Hypotension is due to vasodilation and a functional decrease in the effective circulating volume. The treatment is, therefore, to reverse the vasodilatation with vasoconstrictor drugs and increase the circulating volume by giving fluids. All hypotensive patients should be given OXYGEN by mask until the blood pressure is restored.

A simple and effective way of rapidly increasing the patient's circulating volume is by raising their legs thus increasing the return of venous blood to the heart. This can either be done manually by an assistant or by tilting the lower half of the operating table. Tilting the whole operating table head down will also achieve the same effect, but is unwise if a hyperbaric spinal anaesthetic has been injected in the preceding 15 minutes as it will result in the block spreading higher and the hypotension becoming more severe. If an isobaric spinal solution has been used, tilting the table at any time will have very little effect on the height of the block.

Increase the speed of the intravenous infusion to maximum until the blood pressure is restored to acceptable levels and, if the pulse is slow, give atropine intravenously. Vasoconstrictors should be given immediately if the hypotension is severe, and to patients not responding to fluid therapy.

Vasopressors

Ephedrine is probably the vasopressor of choice. It causes peripheral blood vessels to constrict and raises the cardiac output by increasing the heart rate and the force of myocardial contraction. It is safe for use in pregnancy as it does not reduce placental blood flow.

Ephedrine is generally available in 25 or 30 mg ampoules. It is best diluted to 10mls with water for injections and then given in increments of 1-2ml (2.5-6mg) titrated against the blood pressure. Its effect generally lasts about 10 minutes and it may need repeating. Alternatively, the ampoule may be added to a bag of intravenous fluid and the rate of infusion altered to maintain the desired blood pressure.

It can also be given intramuscularly but its onset time is delayed although its duration is prolonged. Larger doses are necessary when it is given intramuscularly.

Other Vasopressors

Metaraminol (Aramine). It is supplied in 10mg ampoules and should be diluted and used incrementally (1-5mg) as with ephedrine. It has a slower onset time (at least 2 minutes after intravenous injection) but lasts longer (20-60 minutes)

Methoxamine (Vasoxine). It is available in 20mg ampoules and is best diluted before injection. Suitable adult doses are 2.5-5mg. It is a pure peripheral vasoconstrictor and reflex bradycardia, needing treatment with atropine can occur.

Phenylephrine. A pure peripheral vasoconstrictor which is available in 10mg ampoules. Dilute before use. Suitable adult doses for intravenous use are 100-200mcg which last about 15 minutes. A reflex bradycardia may occur.

Noradrenaline (Levophed). A powerful vasoconstrictor available in 2mg ampoules which must be diluted in 1000ml of intravenous fluid before use. It is then given at an initial rate of 2-3ml/minute and thereafter titrated against the blood pressure. Control the infusion with the utmost care.

Adrenaline/Epinephrine. Available as 1mg/ml (1:1,000) and 1mg/10ml (1:10,000) ampoules. Dilute 1ml of 1:1,000 adrenaline to at least 10ml with saline and give increments of 50mcg (0.5ml of 1:10,000) repeating as necessary. Monitor the effect of adrenaline closely - it is a very powerful drug but only lasts a few minutes.

Treatment of Total Spinal

Although rare, total spinals can occur with frightening rapidity and result in the death of the patient if not quickly recognised and treated. They are more likely to occur when a planned epidural injection is, inadvertently, given intrathecally. The warning signs that a total spinal block is developing are:

Hypotension - treat as detailed above. Remember that nausea may be the first sign of hypotension.

Bradycardia - give atropine

Increasing anxiety - reassure.

Numbness or weakness of the arms and hands, indicating that the block has reached the cervico-thoracic junction.

Difficulty breathing - as the intercostal nerves are blocked the patient may state that they can't take a deep breath. As the phrenic nerves (C 3,4,5) which supply the diaphragm become blocked, the patient will initially be unable to talk louder than a whisper and will then stop breathing.

Loss of consciousness.

Action:

Ask for help - several pairs of hands may be useful!

Intubate and ventilate the patient with 100% oxygen.

Treat hypotension and bradycardia with intravenous fluids, atropine and vasopressors as described earlier. If treatment is not started quickly the combination of hypoxia, bradycardia and hypotension may result in a cardiac arrest.

Ventilation will need to be continued until the spinal block recedes and the patient is able to breathe again unaided. The time this will take will depend on which local anaesthetic has been injected.

Once the airway has been controlled and the circulation restored, consider sedating the patient with a benzodiazepine as consciousness may return before muscle power.

General Postoperative Care

The patient should be admitted to the recovery room as with any other anaesthetised patient. In the event of hypotension in the recovery room, the nurses should know to elevate the legs, increase the rate at which intravenous fluids are being administered, give oxygen and summon the anaesthetist. Further doses of vasoconstrictors or fluids may be required, particularly if surgical bleeding continues.

Patients should be advised as to how long their spinal block will last and be told to remain in bed until full sensation and muscle power has returned.

Complications of Spinal Anaesthesia

Headache: a characteristic headache may occur following spinal anaesthesia. It begins within 12-24 hours and may last a week or more. It is postural, being made worse by raising the head and relieved by lying down. It is often occipital and may be associated with a stiff neck. It is frequently accompanied by nausea, vomiting, dizziness and photophobia.

It is more common in the young, in females and especially in obstetric patients. It is thought to be caused by the continuing loss of CSF through the hole made in the dura by the spinal needle. This results in descent of the brain and traction on its supporting structures.

The incidence of headache is related directly to the size of the needle used. A 16 gauge needle will cause headache in about 75% of patients, a 20 gauge needle in about 15% and a 25 gauge needle about 3%. It is, therefore, sensible to use the smallest needle available especially in high risk obstetric patients.

As the fibres of the dura run parallel to the long axis of the spine, if the bevel of the needle is parallel to them, it will part rather than cut them and therefore, leave a smaller hole. Make a mental note of which way the bevel lies in relation to the notch on the hub and then align it appropriately. It is widely considered that pencil-point needles (Whiteacre or Sprotte) make a smaller hole in the dura and are associated with a lower incidence of headache than conventional cutting-edged needles (Quincke).

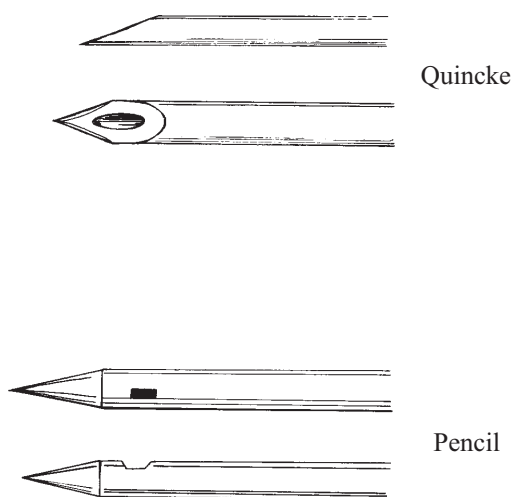


Figure 7. Patterns of spinal needle tips.

As the sacral autonomic fibres are among the last to recover following a spinal anaesthetic, urinary retention may occur. If fluid pre-loading has been excessive, a painful distended bladder may result and the patient may need to be catheterised.

Permanent neurological complications are extremely rare. Many of those that have been reported were due to the injection of inappropriate drugs or chemicals into the CSF producing meningitis, arachnoiditis, transverse myelitis or the cauda equina syndrome with varying patterns of neurological impairment and sphincter disturbances.

If inadequate sterile precautions are taken, bacterial meningitis or an epidural abscess may result although it is thought that most such abscesses are caused by the spread of infection in the blood.

Finally, permanent paralysis can occur due to the "anterior spinal artery syndrome". This is most likely to affect elderly patients who are subjected to prolonged periods of hypotension and may result in permanent paralysis of the lower limbs.

It used to be thought that bedrest for 24 hours following a spinal anaesthetic would help reduce the incidence of headache, but this is now no longer believed to be the case. Patients may get up once normal sensation has returned, if surgical considerations so allow.

Treatment of spinal headache : Patients with spinal headaches prefer to remain lying flat in bed as this relieves the pain. They should be encouraged to drink freely or, if necessary, be given intravenous fluids to maintain adequate hydration. Simple analgesics such as paracetamol, aspirin or codeine may be helpful as may measures to increase intra-abdominal and hence epidural pressure such as lying prone. Caffeine containing drinks such as tea, coffee or Coca-Cola are often helpful. Prolonged or severe headaches may be treated with epidural blood patch performed by aseptically injecting 15-20ml of the patient's own blood into the epidural space. This then clots and seals the hole and prevents further leakage of CSF.

Other Complications

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Spinal Anaesthesia in Obstetrics

There are several reasons for preferring spinal anaesthesia to general anaesthesia for caesarean sections. Babies born to mothers having spinal (or epidural) anaesthesia may be more alert and less sedated as they have not received any general anaesthetic agents through the placental circulation. As the mother's airway is not compromised, there is a reduced risk of aspiration of gastric contents causing chemical pneumonitis (Mendelson's syndrome).

Many mothers also welcome the opportunity of being awake during the delivery and being able to feed their child as soon as the operation is complete.

There are, however, also disadvantages. It may be difficult to perform the spinal injection as lumbar flexion may be impeded by the pregnant uterus and, if labour has started, the mother may be unable to remain still when having contractions. Unless small gauge needles (25 gauge) are used, the incidence of post-spinal headache may be unacceptably high. Spinal anaesthetics for caesarean section should not be performed until the anaesthetist has accumulated sufficient experience in their performance with non-pregnant patients.

In the absence of hypovolaemia due to bleeding, spinal anaesthesia is a simple and safe alternative to general anaesthesia for manual removal of a retained placenta. It does not produce uterine relaxation and if this is required, a general anaesthetic with a volatile agent may be preferred.

Technique

Spinal anaesthesia is performed and managed in pregnant patients in the same way as in non-pregnant patients but with a number of special considerations.

It is generally recommended that obstetric patients should be pre-loaded with not less than 1500 mls of a crystalloid solution before the dural puncture is performed.

Although spinal anaesthesia is not contra-indicated in the presence of mild pre-eclampsia, remember that such patients may have altered clotting function and are relatively hypovolaemic. There is always a chance that a pre-eclamptic patient may suddenly fit and anticonvulsant drugs (diazepam or thiopentone) must be immediately available. The advantages and disadvantages of spinal versus general anaesthesia will have to be carefully considered for each patient.

Pregnant women need smaller volumes of spinal anaesthetic solution than non-pregnant women in order to obtain a given height of block. For a caesarean section, anaesthesia should extend to T6 (about the bottom of the sternum) to be completely successful. This can usually be achieved with the following regimes, although the hyperbaric agents are more predictable:

2.0-2.5 ml of a hyperbaric solution of 0.5% bupivacaine or

2.0-2.5 ml of an isobaric solution of 0.5% bupivacaine or

1.4-1.6 ml of a hyperbaric solution of 5% lignocaine or

2.0-2.5 ml of an isobaric solution of 2% lignocaine with added adrenaline (0.2 ml of 1:1000)

If anaesthesia is required for a forceps delivery, 1.0ml of a hyperbaric solution injected with the mother in the sitting position is usually adequate.

Anaesthesia to T10 is needed for removal of a retained placenta. This can be obtained by injecting 1.5mls of a hyperbaric solution with the patient sitting and then lying her down.

Positioning of the Pregnant Patient

Pregnant patients should never lie supine as the gravid uterus will compress the vena cava and, to a lesser extent the aorta (aorto-caval compression) resulting in hypotension. They should, instead, always lie with a lateral tilt. This can be achieved either by tilting the whole table or by inserting a wedge under the patients right hip. The uterus is displaced slightly to the left and the vena cava is not compressed (see Update No. 2).

As with all patients undergoing surgery under spinal anaesthesia, oxygen should be given during the operation. As hypotension commonly occurs despite fluid preloading, many anaesthetists routinely give a dose of vasoconstrictor intravenously. Ephedrine is the favoured vasoconstrictor as it does not cause constriction of the uterine blood vessels. If it is not available, one of the other vasoconstrictors discussed previously should be used as untreated hypotension can seriously damage the unborn infant.

After delivery of the baby, syntocinon is the oxytocic of choice as it is less likely to produce maternal nausea and vomiting than ergometrine.

CONTROL OF HEART RATE

Dr I Kestin, Consultant Anaesthetist, Derriford Hospital, Plymouth.

The heart will beat independently of any nervous or hormonal influences. This spontaneous rhythm of the heart (called intrinsic automaticity) can be altered by nervous impulses or by circulatory substances, like adrenaline. The muscle fibres of the heart are excitable cells like other muscle or nerve cells, but have a unique property. Each cell in the heart will spontaneously contract at a regular rate because the electrical properties of the cell membrane spontaneously alter with time and regularly "depolarise". This means the reversal of the electrical gradient across the cell membrane that causes muscle contraction or passage of a nervous impulse. Muscle fibres from different parts of the heart have different rates of spontaneous depolarisation; the cells from the ventricle are the slowest, and those from the atria are faster.

The coordinated contraction of the heart is produced because the cells with the fastest rate of depolarisation "capture" the rest of the heart muscle cells. These cells with the fastest rate of depolarisation are in the sinoatrial node (SA node), the "pacemaker" of the heart, found in the right atrium. As the SA node depolarises, a wave of electrical activity spreads out across the atria to produce atrial contraction. Electrical activity then passes through the atrioventricular node (AV node) and through into the ventricles via the Purkinje fibres in the Bundle of His to produce a ventricular

contraction. If there is any disease of the conducting system of the heart, then this process may be interfered with and the heart rate altered. If, for example, there is disease of the AV node, then there is an electrical block between the atria and the ventricles. The ventricles will beat with their own inherent rhythm, which is much slower, usually 30-50 beats per minute.

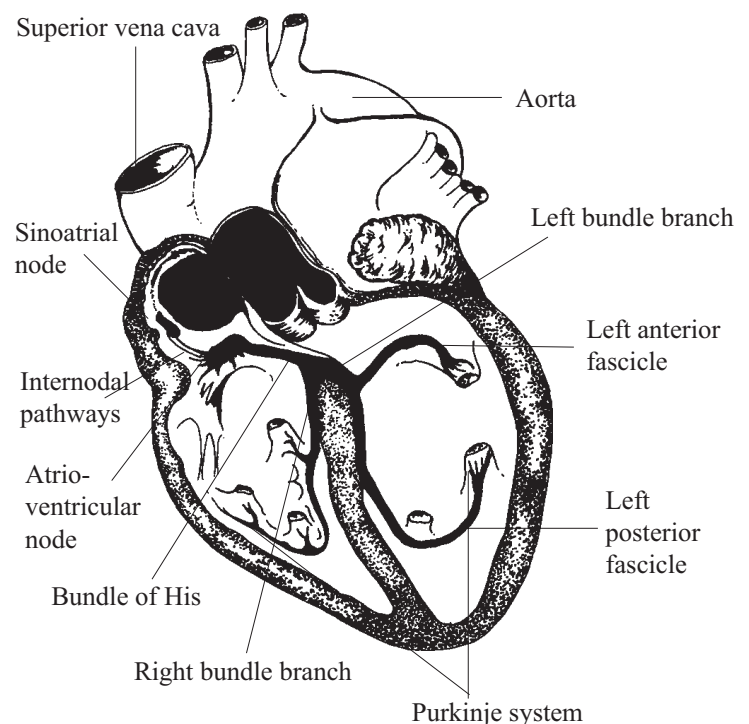


Figure 1. Conducting system of the heart.

Anaesthetic drugs, like halothane, may depress the rate of depolarisation of the SA node, and the AV node may become the pacemaker of the heart. When this occurs it is frequently termed nodal or junctional rhythm.

This automatic rhythm of the heart can be altered by the autonomic nervous system. The sympathetic nervous system supply to the heart leaves the spinal cord at the first four thoracic vertebra, and supplies most of the muscle of the heart. Stimulation via the cardiac beta-1 receptors causes the heart rate to increase and beat more forcefully. The vagus nerve also supplies the atria, and stimulation causes the heart rate to decrease (bradycardia). Surgical procedures can cause vagal stimulation and produce severe bradycardia. Examples include pulling on the mesentery of the bowel, anal dilatation or pulling on the external muscles of the eye. Under normal conditions the vagus nerve is the more important influence on the heart. This is especially noticeable in athletes who have slow heart rates.

There are nervous reflexes that effect heart rate. The afferents are nerves in the wall of the atria or aorta that respond to stretch. The aorta contains high pressure receptors. When the blood pressure is high these cause reflex slowing of the heart to reduce the cardiac output and the blood pressure. Similarly, when the blood pressure is low, the heart rate increases, as in shock. Similar pressure receptors

are found in the atria. When the atria distend, as in heart failure or overtransfusion, there is a reflex increase in the heart rate to pump the extra blood returning to the heart. When there is a sudden reduction in the pressure in the atria the heart slows. This is called the Bainbridge Reflex and is the cause for the marked bradycardia sometimes seen during spinal anaesthesia. It is best treated by raising the legs to increase the venous return.

Circulatory substances can also affect the heart rate. Catecholamines, like adrenaline, are released during stress, and will cause an increase in heart rate. Drugs are another common cause of change in the heart rate and most anaesthetic drugs can do this. Halothane affects the SA node and will also depress the force of contraction of the heart. Isoflurane, by contrast has little direct affect on the heart, but causes peripheral vasodilation of the blood vessels. This will then decrease the blood pressure, and hence produce a reflex tachycardia as explained above. Ketamine causes stimulation of the sympathetic nervous system, and therefore produces a tachycardia. Other circulating substances may also affect the heart rate, acting indirectly through the autonomic nervous system. For example increased blood concentrations of carbon dioxide will cause stimulation of the sympathetic nervous system and tachycardia, and is an important sign of respiratory failure.

DRAW-OVER ANAESTHESIA Part 2 - Practical Application

Dr M B Dobson, Consultant Anaesthetist,
John Radcliffe Hospital, Oxford OX3 9DU

In the first article on draw-over, Georg Kamm described the apparatus used in draw-over anaesthesia. In this issue, I want to describe the ways in which draw-over apparatus can be used to provide safe, high quality anaesthesia. We must first recognise that safe anaesthesia is not produced by apparatus alone!

The essentials for safe anaesthesia in any situation include adequate pre-operative assessment, preparation and resuscitation of patients, reliable intravenous access, a pleasant and safe induction, a secure airway, adequate tissue oxygenation, appropriate monitoring, and rapid recovery. None of these depends on high cost or high technology equipment, but all require properly trained and reliable people, on whom primary safety depends. If you are responsible for anaesthesia in a district hospital, and do not have extensive specialist training, you are well advised to use a small number of safe, widely applicable clinical techniques. This will allow you to become thoroughly familiar and confident with them through regular practice. No-one can be safe or confident when they use an unfamiliar technique. Restricting yourself to a small number of techniques also means that you use a limited number of drugs, and it is easier to make sure that adequate stocks are held in the hospital which do not run out.

A draw-over system is most suitable for the needs of district hospitals. It is simple to understand, robust, independent of compressed gases, and can be repaired on site if necessary. In a draw-over system the carrier gas (air, with or without oxygen enrichment) passes through a low resistance vaporiser, through a self-inflating bag or bellows and reaches the patient via a universal breathing valve which ensures that expired gases are directed into the atmosphere and do not re-enter the anaesthetic system.

Ether as an Anaesthetic Agent

Ether has largely disappeared from anaesthetic practice in Western countries, because of a number of apparent disadvantages: it has a pungent smell, and this combined with its high blood solubility

prolongs the induction of anaesthesia with ether alone. It has also been associated with post-operative vomiting, and people are concerned about possible dangers of fires and explosions. Nevertheless, ether has many important advantages - it increases cardiac output and is a respiratory stimulant - and is therefore the only volatile agent which can safely be used for spontaneously breathing patients if oxygen is not available. It is certainly the safest volatile anaesthetic in the hands of the inexperienced or occasional anaesthetist, and the experienced anaesthetist can easily use ether as part of a more sophisticated technique which avoids the problems of slow induction, vomiting, and delayed recovery.

Most of the disadvantages of ether are seen when it is used alone for induction of anaesthesia. They include a slow onset, an unpleasant smell for the patient, with coughing, breath-holding and laryngeal irritability, salivation, swallowing and sometimes vomiting. In the vast majority of patients, these problems can be easily and safely avoided by intravenous induction of anaesthesia with drugs such as thiopentone or ketamine. Insertion of an endotracheal tube secures the airway, and allows the concentration of ether to be increased rapidly to maintenance levels with no risk of laryngospasm. If a muscle relaxant is used, inhaled ether concentrations of 3-4% are enough to ensure unconsciousness, and wake up reasonably rapidly at the end of surgery. Ether also provides a considerably longer period of post-operative analgesia than other volatile anaesthetics. Thus, the clinical disadvantages of ether can be overcome, allowing us to make use of its advantages in safety, availability and economy. (A summary of a suitable technique for ether anaesthesia is shown in Table 1, Page 20). The only problem remaining is the question of its flammability.

Ether is flammable (will burn, but not explode) when mixed with air. In this respect you can compare it with alcohol, but not with petrol, which will explode when ignited in air. The addition of oxygen (or nitrous oxide) to ether does produce an explosive mixture, in which ignition could be caused by a source such as surgical diathermy, a sparking electric socket, or (especially in a dry climate) static electricity. Flammable or explosive mixtures must therefore be separated from possible ignition sources - there are two ways of doing this:-

Separation in time. Healthy patients are most likely to need added oxygen at the beginning of anaesthesia (before and just after intubation) and at its end (before extubation). At these times surgical diathermy is not in use. During the operation use ether/air without added oxygen unless the patient is very sick, old, very young or anaemic, or there are other indications such as pregnancy, cardio-respiratory disease or high altitude.

Separation in space. During the use of flammable/explosive mixtures no source of ignition is permitted in a "zone of risk" which extends 30 cm from all points of the breathing system where gas might escape - thus no diathermy in the thoracic cavity, head and neck, or mouth is permitted, but diathermy in the bladder or abdominal cavity is considered safe. A simple scavenging system - a length of tubing to direct the expired gases away from the site of surgery, is helpful. In dry climates (including air conditioning) anti-static precautions should also be used.

It is worth remembering that Western operating theatres are still mostly built with antistatic precautions, since even without ether there is a risk of fires and explosions with other substances mixed with oxygen (enflurane, trichloroethylene, alcohol etc.).

Using Other Volatile Anaesthetic Agents

Halothane is widely available, and has a number of advantages. It is non-flammable, has a pleasant, non-irritant smell, and induces unconsciousness more quickly than ether. Its disadvantages are that it depresses the cardiovascular and respiratory systems, resulting in hypotension and hypoxia. It is more potent than ether, and must never be given by "open drop" techniques. Halothane should never be put in an EMO vaporiser, as it attacks the metal from which these vaporisers are made, and the vaporiser will be wrecked! The most suitable draw-over vaporiser for halothane is the Oxford Miniature Vaporiser, which can also be used for other volatile anaesthetics if these are available (e.g. trichloroethylene, enflurane etc.).

Halothane can be used alone for anaesthesia; its main disadvantages in this situation is the respiratory depression which it causes, and supplementary oxygen should always be used throughout the procedure. If oxygen is not available, ventilation

should be assisted or controlled to prevent hypoxia. Halothane sensitises the heart to adrenaline, and you should warn the surgeon not to infiltrate the wound with adrenaline-containing solutions when halothane is in use. (Some anaesthetists allow infiltration of up to 20 ml of 1:200,000 adrenaline provided the pulse is closely monitored).

Halothane may be very useful in combination with other volatile anaesthetics. If you plan an inhalational induction, begin with halothane, then change to ether once the patient becomes unconscious - this is much quicker and more pleasant for the patient - and you will see the contrast between the respiratory depression of halothane and the stimulation of ether!

Halothane has also been used successfully for military anaesthesia in combination with trichloroethylene, using two Oxford Miniature Vaporisers in the "Tri-service" apparatus. The agents complement each other, since halothane is a good hypnotic but a poor analgesic, while the reverse is true of trichloroethylene. Use 0.5% trichloroethylene as a "baseline" and vary the concentration of halothane to obtain the required depth of anaesthesia. Turn the trichloroethylene off a few minutes before the end of the operation as it takes a while to wear off. Once again, added oxygen is necessary.

Draw-over Without Volatile Anaesthetics

Whichever kind of general anaesthetic you use, the patient must have a secure airway and adequate breathing. There is no reason why you should not use the draw over system to provide these in conjunction with a total intravenous anaesthetic. The invention of electronically controlled infusion pumps leads some to suggest that these may one day replace vaporisers for most anaesthetics - but in many situations a carefully regulated and monitored intravenous infusion of a drug such as ketamine can be given using an ordinary intravenous drip and a watch with a second hand.

Prepare a solution of intravenous anaesthetic to a standard concentration (e.g. ketamine 1000mg in a 500 ml bottle or bag of normal saline, equal to ketamine 2mg/ml). You will need to know the number of drops/ml of your giving set. Prepare your apparatus, give oxygen by facemask, and induce anaesthesia with a fast running infusion

(you will need about 120mg of ketamine - 60ml of the above dilution). When the patient has lost consciousness give a muscle relaxant and intubate the trachea. Reduce the infusion of ketamine to about 2mg/min of the above dilution according to clinical signs for maintenance, and give further doses of relaxant as necessary. You must monitor your infusion continuously - if it stops or becomes "tissued" the patient may become aware. At the end of anaesthesia reverse the relaxant, stop the ketamine, make sure the patient is breathing well and put them in the recovery position. Benzodiazepine premedication or postmedication will prevent dreaming and emergence reactions. The addition of atropine will reduce excessive secretions.

You can use a similar technique with other intravenous agents, but be warned that recovery after the use of barbiturate infusions may be very prolonged.

Oxygen Supplies

We have already noted some of the problems of oxygen supplies: in developing countries hospitals may have to purchase their own cylinders, and many of these go missing when sent for re-filling. With the draw-over system, missing cylinders do not cause the anaesthetic service to collapse, but oxygen is still very desirable, especially if your patient is very young, old, anaemic or ill.

The use of a T-piece (see Fig 1) to enrich a draw-over system is very economical and allows you to make the most of your supplies. A flow of 1 litre/min provides an inspired concentration of 30-40% oxygen; 4 litres/min provides 60-80%. To make the best use of oxygen post-operatively, or in cases of breathing difficulty due to respiratory infections

etc, use a nasopharyngeal catheter (eg a 8-10FG rubber or plastic catheter) inserted into the nasopharynx with a flow of 1 litre/min for a child or 2 litres/min for an adult, giving an inspired concentration of about 40% oxygen. It is desirable to humidify the flow of oxygen and vital to check that the catheter is not inserted too far (e.g. into the oesophagus) or gastric dilatation could result. As well as its economy, this method is preferred by many patients as it allows them to talk, cough, expectorate and eat - all difficult to do with a conventional facemask!

Other sources of oxygen are worth considering. Industrial (welding) oxygen is normally made by the same process as "Medical oxygen" - and indeed industrial oxygen is often made to a higher degree of purity! You must check your own local specification!

Oxygen concentrators (see Update No.1) can also provide a supply for draw-over or ward use. Concentrators compress room air to a pressure of 4 bar, then pass it through a zeolite column which absorbs the nitrogen, leaving up to 96% oxygen (the rest is argon). If excessive flows are demanded the concentration delivered falls off. Small concentrators, which meet the World Health Organisation's (WHO) standards can deliver 4 litres/min of oxygen (>90%) with a power consumption of around 350 watts (mains electricity or AC generator required). Concentrators are usually the cheapest way of getting oxygen - often 30-50% of the cost of cylinders. They require simple servicing every 5000 hours and an overhaul every 20,000 (equivalent in running time to about half a million miles for a car!). For details of WHO approved concentrators write to the author.

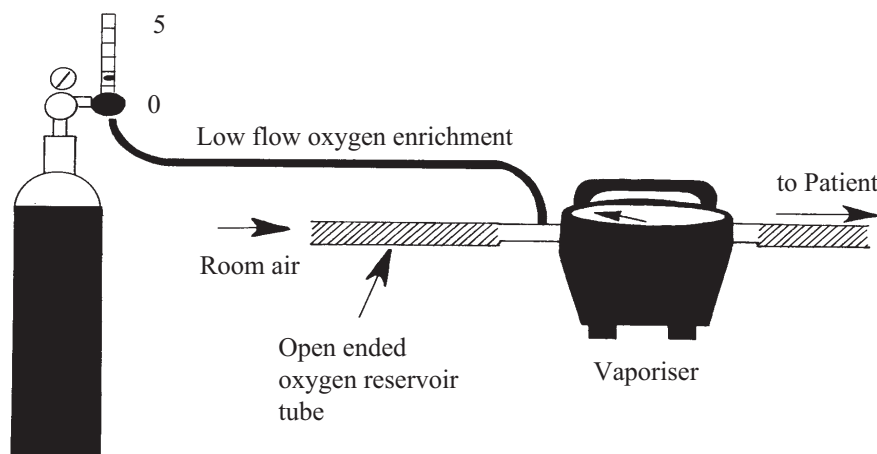


Figure 1. Adding oxygen to a drawover circuit

Table 1. Suggested plan for General Anaesthesia

Is General anaesthesia required for this case? \Rightarrow **NO** \Rightarrow Use regional technique



YES



Is the anaesthetist trained in endotracheal intubation? \Rightarrow **NO** \Rightarrow Use ketamine or spinal



YES



Has the patient a difficult airway? \Rightarrow **YES** \Rightarrow Use regional or seek expert help



NO



Proceed as follows:-

- .. Check your apparatus and drugs
- .. Obtain intravenous access and preoxygenate the patient
- .. Give a sleep dose of thiopentone or ketamine
- .. Give 1mg/kg suxamethonium i.v.
- .. Intubate the trachea
- .. Ventilate the lungs manually with 3% ether in air. Increase this during the first 5 minutes to 6-10% to settle the patient. (Halothane 1-1.5% can be used instead of ether).
- .. When breathing returns (usually after 3-5 minutes) allow the patient to breathe 6-8% ether in air or 1-1.5% halothane in oxygen-enriched air **or** if available give a long term relaxant (eg alcuronium or gallamine) and continue to ventilate the lungs manually, at an appropriate concentration of volatile agent (This technique allows rapid recovery).
- .. At the end of surgery reverse long acting muscle relaxants (if given) with neostigmine and atropine, continuing to ventilate the lungs until breathing resumes; turn the patient on his side, and remove the tube when the patient is awake.

This "universal" technique can be used for almost all types of surgery, and for both elective and emergency cases.

Dr M B Dobson, Consultant Anaesthetist,
Oxford, UK

If you work in a district hospital it is unlikely that you will have the help of a skilled technician to look after your apparatus, and the responsibility is therefore yours. No apparatus will work reliably unless it is properly and regularly inspected and cared for. Draw-over apparatus is not difficult to understand, and many simple procedures will prevent or correct breakdown. The first rule is not to interfere with apparatus which is working well! If you do have to make a repair, obtain a copy of the service manual, and make sure you have all the necessary spare parts and any special tools before you start.

Routine Care

Like all machines, your draw-over system requires regular attention to keep it in good, reliable working order. One of the main advantages of draw-over apparatus is that it is relatively simple to carry out these regular checks and simple repairs yourself - but remember that vaporisers and valves are precision instruments, and need to be handled carefully. Never use excessive force.

Make sure your apparatus is stored in a clean, dry place, away from dusty environments. Wipe it over regularly with a soft, moist cloth and a little detergent. Close off open ends with corks or plastic caps to prevent dust and insects getting inside.

Black (anti-static) anaesthetic breathing hoses are liable to perish in humid atmospheres; after use they will be wet inside from the water vapour in the patient's breath. After use hang them vertically in a cupboard to allow them to dry. Inspect them regularly looking especially for cracks in between the corrugations - this is where they most often develop leaks. If you do not use ether, you do not need anti-static hoses, and white polythene corrugated hoses are both cheaper and more resistant to humidity. Check your inflating bellows or Ambu bag for cracks or perishing in the rubber. These items are almost impossible to repair, so it is wise to have a spare in the supply cupboard.

Regularly inspect your Ambu (or other universal breathing) valves, and clean them when necessary. The inlet and exhaust ports can be unscrewed by hand, and the valve rubbers removed by gentle

pulling. Wash the inside and outside of the valve with warm soapy water, and allow the parts to dry thoroughly before carefully re-assembling the valve. Most Ambu valves can be sterilised, either with antiseptics or by autoclaving, but sterilisation is only necessary if the valve has been contaminated by use on an infected patient - for example one with tuberculosis.

When using the Oxford inflating bellows with an AMBU (or other universal breathing valve) ensure that you disable the flap valve nearest the patient using the magnet provided. This will prevent the valves from jamming during intermittent positive pressure ventilation.

If your anaesthetic facemasks have an inflatable margin check the state of the rubber, as it is likely to perish in time. If the small bung used to retain the air is missing it should be replaced with a suitable substitute - do not inflate the mask and tie a knot in the inflating tube!

Check your stock of endotracheal tubes regularly. Red rubber tubes are liable to deteriorate in hot and humid conditions. The inflatable cuff is especially vulnerable and should be tested before use.

Special Attention for Vaporisers

Drain and discard the contents of your vaporisers once a week, to avoid the build-up of deposits inside.

Vaporisers are precision instruments and must be treated with care. When complicated repairs are needed, the machine must be sent to a competent medical engineer or service centre, but there are a number of simple problems which you can deal with yourself. First of all, write to the manufacturers to obtain a service manual and any replacement parts you will need. When these have arrived, set aside a time when the vaporiser will not be needed for clinical use, and you have time to work on it. Below are brief descriptions of some of the operations you should be able to manage on Penlon vaporisers (EMO & OMV - the address is Penlon Ltd, Radley Road, Abingdon OX14 3PH. Telephone 44 235 554222 Fax 44 235 555252). Other brands of draw-over vaporisers generally need the attention of a service engineer.

The EMO Vaporiser - Common Faults

1. The pointer sticks and is difficult or impossible to move

Cause: build up of sticky deposits around the internal rotor drum.

Remedy: remove the drum and clean it; re-assemble the vaporiser.

You will need: Maintenance manual, screwdrivers, artery forceps, penetrating oil, ether, brass polish, vaseline and possibly a new main gasket.

2. The thermocompensator breaks - only the metal disc is visible in the window on top of the vaporiser.

Cause: metal fatigue after 5-10 years use.

Remedy order a replacement unit from the manufacturer. This is very simple to exchange for the broken unit - only a screwdriver needed to loosen 3 screws.

You will need: Screwdriver, replacement part.

3. Broken window of the filler gauge. Warning: you must not use an EMO with a broken filler gauge - it will give a dangerously high concentration of ether

Cause: accidental breakage.

Remedy: order and fit a replacement from the manufacturer. Fitting is simple - loosen 3 screws, remove the old unit and slot in the replacement.

You will need: screwdriver, replacement part.

Problems with the Oxford Miniature Vaporiser

OMV's used with halothane gradually become stiff to operate, due to the build-up of thymol (used as a preservative in halothane) in the mechanism. To clean this off properly you will have to take the top off the vaporiser. First obtain the service manual; you will almost certainly need to fit new rubber seals, so order these at the same time. A temporary "repair" can be achieved by pouring ether into the inlet and outlet ports, and gently working the concentration control from side to side. Do not use excessive force or you will bend it. The thymol will be dissolved by the ether. Afterwards, tip all the ether out, and ventilate with the bellows to dry out the vaporiser before re-filling it with the correct agent.

If you order a new OMV, remember that there are

many different models - be sure to specify which you want. The air inlet can be on the right (usually for draw-over) or left (for a compressed gas machine) and the tapers can be either 22mm ISO (draw-over) or 23mm cagemount (compressed gas machine). Make sure you know what you want before you order!

A video tape of the servicing of EMO and OMV vaporisers can be obtained from Dr Roger Eltringham, Department of Anaesthetics, Gloucestershire Royal Hospital, Gloucester, UK.

Technical Queries

Dr Ray Towey from Tanzania writes to ask:-

Q: "Is it possible to connect the outlet of the Puritan Bennett oxygen concentrator to an Oxford Miniature Vaporiser (OMV) to provide a continuous gas flow for an Ayres T-piece paediatric breathing system? My concern is that the outlet pressure of gas from the concentrator is too low to permit IPPV from an Ayre's T-piece".

Short answer: No problem, but the flow from the concentrator of 4 litres/minute means that with a fresh gas requirement of 150ml/kg/min you will be limited to using this system on patients under about 20kg - if you exceed this, rebreathing will be a problem.

Long answer: There are actually 2 questions to answer:

Q1: Does the OMV work efficiently with a continuous gas flow of 4 litres/min or less?

Answer: The OMV works **best** in the intermittent flow of a draw-over system, but with continuous flows its performance at 4 litres/min is satisfactory. If the flow is reduced to 2 litres/min it will give significantly less than indicated. I therefore recommend that you keep the flow at 4 l/min for all sizes of patients up to 20kg.

Q2: Does the back pressure generated by IPPV with a T-piece reduce the flow from the concentrator significantly?

Answer: No. Small concentrators like the Puritan Bennett and other WHO-approved models (Healthdyne & DeVilbiss) produce oxygen at a pressure of up to 5 p.s.i. (=0.35 bar, 260 mmHg, 340cm. water). The back pressure generated by IPPV is unlikely to exceed 30 cm. water, which is

only a tenth of that available. I have checked this in the laboratory using a P-B concentrator, and measuring the flow delivered through a high precision flowmeter while producing back pressure by applying a gate clamp to the oxygen tubing (see figure 1) with the concentrator flow control set to deliver 4 l/min.

Conclusions:

1. Flow from the concentrator is well maintained
 2. Even with significant back pressure, the flow indicated on the concentrator's flowmeter is a reliable guide to the flow actually being delivered.
- until back pressure reaches 60-100 mmHg (75-130 cm. Water). Results are shown in Table 1 below.

The results obtained were as follows

Table 1.

Flow from Concentrator	Back pressure applied	Actual flow delivered
4	0	4.25
4	15 mmHg	4.25
4	30 mmHg	4.1
4	45 mmHg	3.8
4	60 mmHg	3.8
3.5	100 mmHg	3.4
2	200 mmHg	1.75
1	300 mmHg	1.25
0	500 mmHg	0

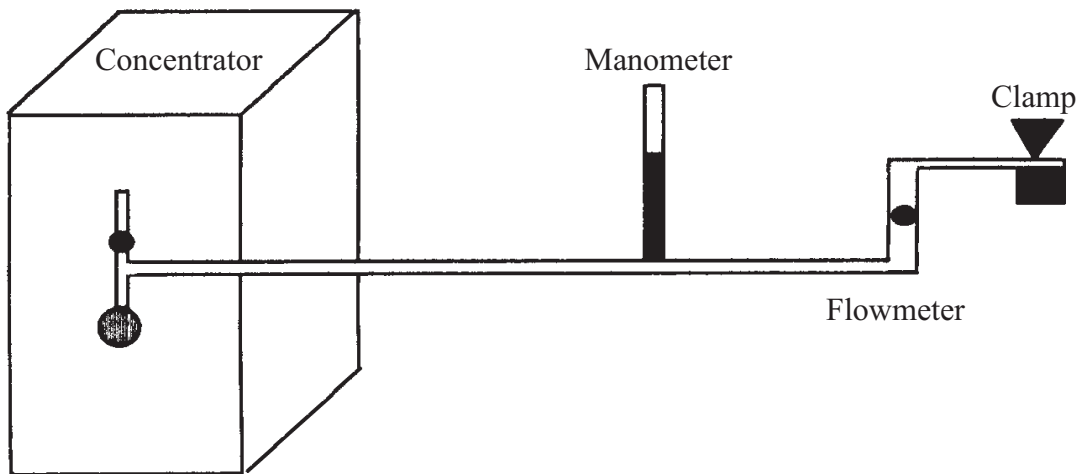


Figure 1.

MORPHINE

Dr I Kestin, Consultant Anaesthetist, Derriford Hospital, Plymouth.

Structure.

Morphine is obtained from opium, the juice secreted by the seeds of the poppy. It works on several types of receptors, widely found in nervous tissue. "Opioids" is a term used for all drugs that act on these receptors. These other opioids may be natural occurring substances, such as morphine, or made in the laboratory such as pethidine.

Morphine works on receptors in the cell membranes. These are protein-lipid molecules that alter their shape when stimulated to effect molecular changes within cells. There are thought to be three types of receptors that respond to opioids, mu, kappa and lambda. Morphine acts mainly on mu receptors to cause a wide variety of effects. The most important of these are relief of pain and respiratory depression. In anaesthesia morphine is used to relieve pain. This is an effect of its action on the spinal cord to decrease the transmission of painful stimuli from body to brain, and its action within the brain itself.

Side Effects.

Morphine has many side effects. The most dangerous is respiratory depression. Minor degrees of respiratory depression may be detected following standard doses of morphine, but this is not clinically important. With higher doses or in frail patients, the respiratory rate decreases, the patient becomes increasingly sedated, and the pupils very small. Common side effects are nausea and vomiting due to a central action of morphine stimulating one of the centres in the brain concerned with vomiting called the chemotactic trigger zone. Other central nervous system side effects of morphine are cough suppression, sedation, and dependence leading to addiction. Addiction is not a problem when morphine is used to treat acute pain after surgery; sufficient morphine should always be given to relieve the pain.

Morphine also has an effect on the muscle of the bowel and urinary tract, causing the sphincter to contract and reduce the peristalsis (the wavelike movements of the bowel muscle that propel its contents forwards). This results in a delayed

emptying of the stomach, constipation, and may also lead to urinary retention.

Morphine can also cause histamine release, which causes itching of the skin and nose and a mild flushing of the skin. Morphine has little direct effect on the heart or blood pressure. However the blood pressure may fall slightly following the pain relief produced by morphine and also with the sedation which may be produced. Significant hypotension following morphine is usually due to other causes such as hypovolaemia. Occasionally patients with severe asthma may become wheezy. An unimportant, but early noticeable effect is that the pupils become small. This helps to differentiate respiratory depression caused by morphine from other causes.

Precautions.

All patients who have been given morphine must be carefully observed for evidence of respiratory depression. This can be detected as a slow respiratory rate and a very sleepy patient with pin point pupils. Oxygen should be given by face mask, and positive pressure ventilation of the lungs started if necessary. Naloxone, 100-400 micrograms may be given intravenously if available.

Dose and Uses

Morphine can be given orally, rectally, by intramuscular or intravenous injection, subcutaneously, sublingually, or injection into the epidural or subarachnoid space. The dose for analgesia by IM injection is 100-150mcg/kg, repeated 2 hourly as required. The dose used intravenously during anaesthesia depends on the nature and duration of the surgery. The usual dose given at the start of surgery when intermittent positive pressure ventilation is used is 100-200mcg/kg, followed by required additional doses of 1-2mg intravenously when required. After the patient has woken up further doses of 1-2mg may be given until the patient is free of pain. Much higher doses are sometimes used during specialist surgery such as cardiac or neurosurgery.

Morphine can be given to relieve chronic pain especially from cancer. Much higher doses are needed orally than by injection. The oral dose is very variable for individual patients; sufficient should be given to relieve the pain.

Morphine can be given into the epidural or subarachnoid space. This is to deliver the morphine close to one of its sites of action, the spinal cord. It is thought that pain relief of long duration can be obtained with very low doses of morphine. A single dose of epidural morphine may relieve pain for 12-24 hours. The usual adult dose for epidural morphine is 3-7 milligrams, and of subarachnoid morphine between 250mcg and 1mg. The main risk of this technique is that severe respiratory depression may occur up to 18 hours after the initial injection

because of the slow circulation of cerebral spinal fluid which carries the morphine up to the brain to act on the respiratory centre. It is vital that all those caring for a patient who has had this technique are aware of the potential side effects and watch out for them. This technique can only be used in specialist hospitals with intensive care facilities. In all other aspects the side effects of epidural and subarachnoid morphine are similar to morphine given by any other route.

CLINICAL DILEMMA

A 26 year old man was admitted to your hospital after a road traffic accident. He had abdominal pain and was found to be breathless and cyanosed on examination. His chest X ray is seen in figure 1.

1. What is the abnormality seen?
2. What complications may occur with it?
3. What is the treatment?

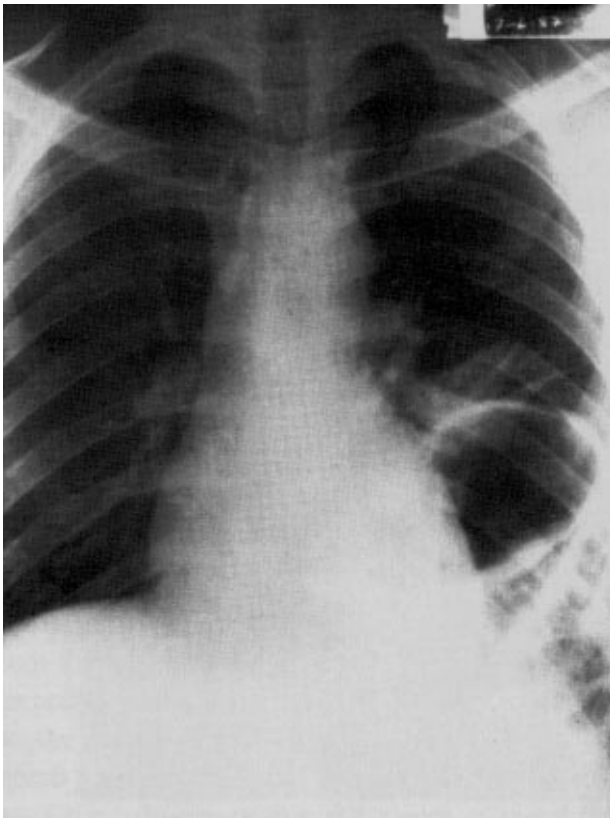


Figure 1.

Answers

1. The X ray shows a traumatic rupture of the left diaphragm with bowel in the chest.
2. The bowel may herniate through the tear as seen in the X ray. If gastric dilation develops severe respiratory distress may result. If treatment of the herniation is delayed ischaemia may develop in the affected bowel leading to gangrene.
3. Many cases of ruptured diaphragm are associated with other intra-abdominal injuries and it is usually repaired at the same laparotomy.

Treatment should include oxygenation, resuscitation and in the presence of a lot of gastric air the passage of a nasogastric tube. During anaesthesia ventilation should be controlled due to the inefficient ventilation resulting from this injury.

Comment.

Traumatic diaphragmatic hernias are more often described on the left than the right. They are usually the result of severe blunt trauma which causes a tear in the dome of the diaphragm resulting in herniation. Since the intra-abdominal pressure is higher than the pleural pressure bowel will tend to move into the thoracic cavity.

There is often a delay in diagnosis until breathlessness results from gastric dilation. Clinically the patient may have reduced air entry on the effected side, and bowel sounds may be audible in the left chest. A chest X ray may reveal the characteristic changes seen in the example, or may be misdiagnosed as Penetrating trauma may also cause lacerations of the diaphragm which are usually small. Herniation is less common at the time of injury, but the patient may present years later when a hernia develops.

showing other changes at the left base such as pleural fluid or basal consolidation. If the stomach is dilated the X ray may suggest a pneumothorax, which if drained would reveal gastric contents. If a nasogastric tube has been passed it may be seen in the chest on X ray. The condition is also sometimes diagnosed at laparotomy performed for other abdominal injuries. In cases of doubt a chest

X ray taken after ingestion of contrast material will confirm the diagnosis. After diagnosis, treatment should not be delayed due to the potential complications discussed earlier. The left diaphragm is usually repaired at laparotomy, right sided injuries (which are uncommon and may be difficult to diagnose) via a thoracotomy.

THE MAINTENANCE OF AN ANEROID SPHYGMOMANOMETER

Mr Mike Yeats, Derriford Hospital, Plymouth

The first article in this series described the maintenance of a mercury sphygmomanometer, this article describes the maintenance of an aneroid blood pressure apparatus. Aneroid means, in Greek, operating without liquid or containing no fluid. Aneroid blood pressure gauges are generally smaller than mercury ones but they are easily damaged and can go out of calibration without detection.

A common type of aneroid apparatus is shown in figure 1. It consists of a dial which normally rises to 300mmHg and a thin brass corrugated bellows inside. There is a shaft which connects two pins at right angles to each other; one of these rests on the bellows, the other is inside a concave sided triangle which meshes with a pinion connected to the dial pointer. A thin coiled spring (known as a hair spring) is also connected to the pinion and returns the pointer to zero when the pressure is released.

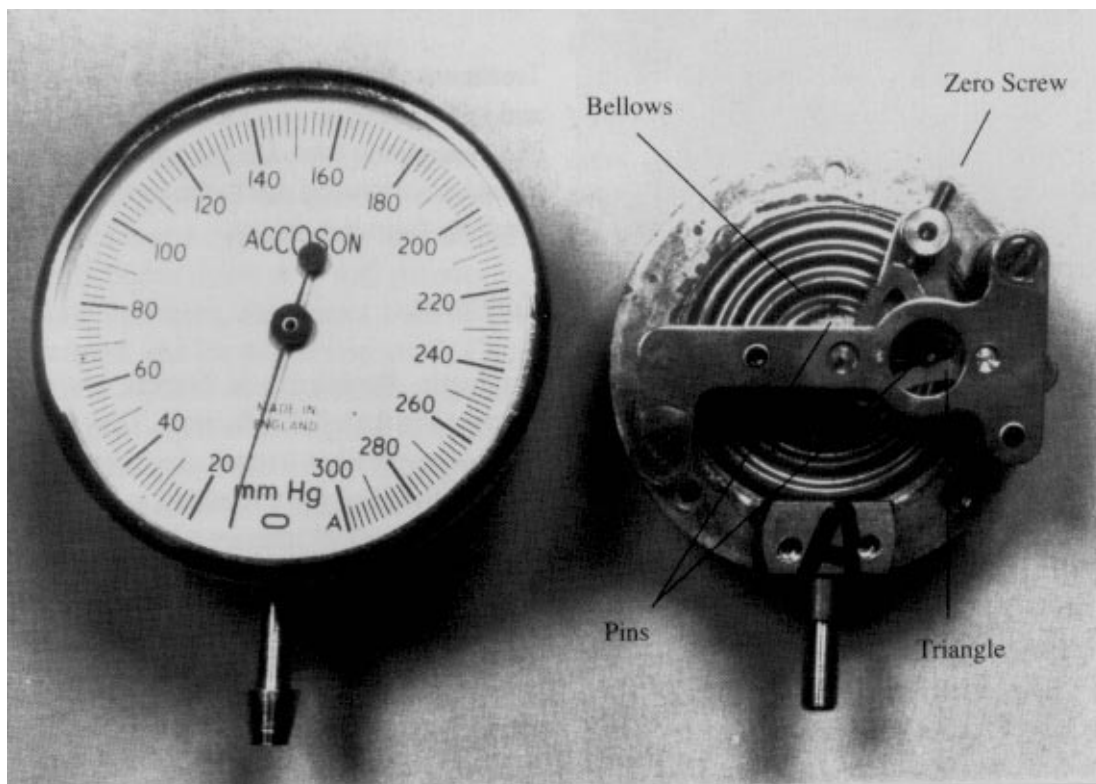


Figure 1. An Aneroid Sphygmomanometer

When in use the gauge is connected to a blood pressure cuff around the patient's arm. As the pressure in the cuff rises, the pin resting on the expanding bellows is lifted. This movement is

transmitted by the other pin which moves the triangle and therefore the pinion and pointer. This can be seen in figure 2.

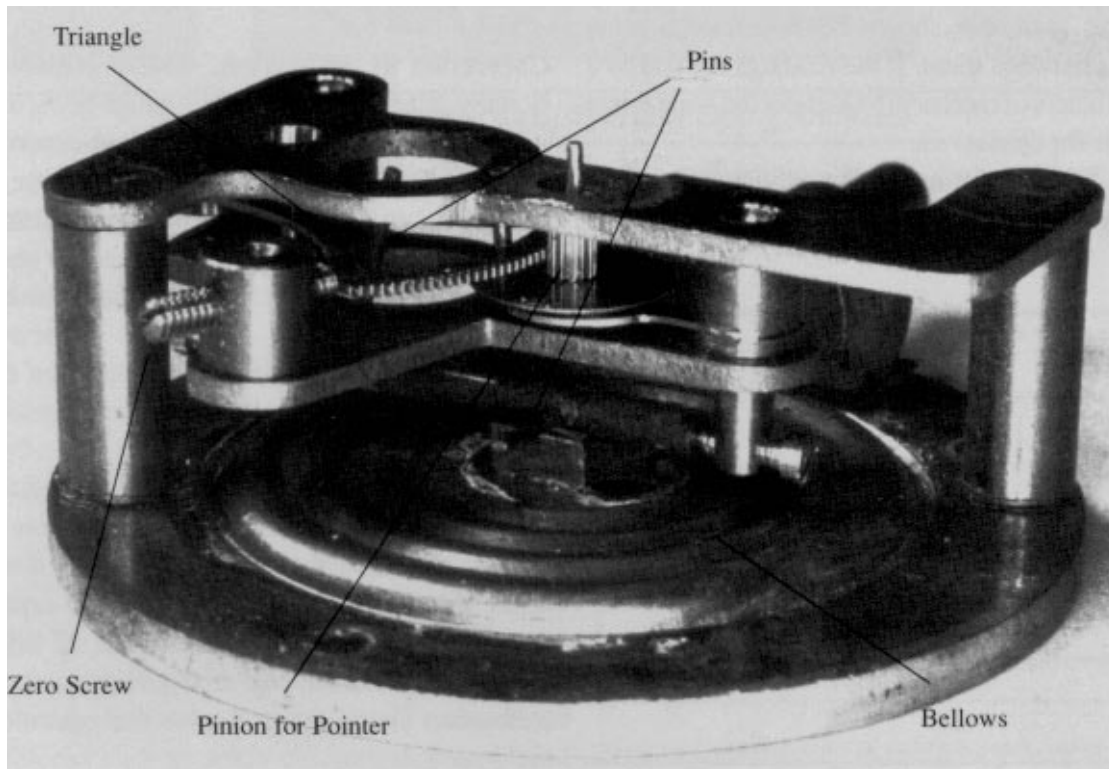


Figure 2.

The following errors may occur:

Leaks in the system. If a leak develops in the system wrap the cuff around itself and secure the end. Inflate the system to 250mmHg, watch the pointer. If it slowly drops there is a leak - it is most likely to be in the cuff or inflation bulb. It is fairly rare for a leak to occur in the gauge itself. A small pointed brush with soapy water on it will help find the smallest leak.

Incorrect zero - the gauge does not return to zero after the cuff has been deflated. On some models, such as the example photographed, there is an adjustment screw to set the zero point. However using this screw requires the instrument to be taken out of the case and the screw may be very stiff. The easiest method of adjusting the zero is by removing the glass from the front of the gauge and carefully taking off the pointer and replacing it in the correct position. The pointer can usually be taken off using your finger and thumb nails. If this is not successful find two very small screwdrivers or thin flat pieces of metal and lever the pointer upwards using one on each side.

Calibration check. Every aneroid blood pressure gauge should be compared with a well maintained mercury sphygmomanometer on a regular basis. Connect the gauges together with a plastic T-piece and connect the third arm to an inflation bulb (figure 3).

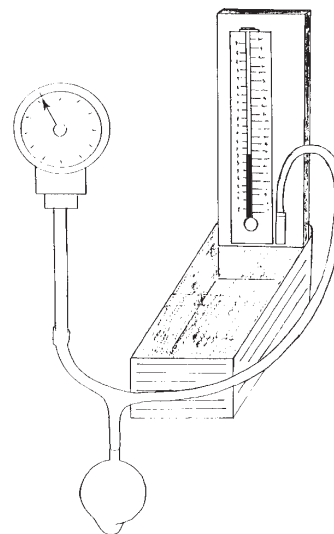


Figure 3. Method of comparing aneroid and mercury sphygmomanometers

Inflate the bulb slowly and note the readings showing on each instrument on a piece of paper at intervals of say, 20mmHg, starting at 40mmHg and going up to 200mmHg. After you have finished the test inspect the figures (example shown below) and note the difference between them. If the readings are within a few millimeters of mercury throughout the scale this is acceptable for clinical use.

In Table 1 the aneroid is reading 10mmHg higher across the scale - this is an example of a linear error.

Table 1. Example of a linear error

Mercury Sphygmomanometer (mmHg)	Aneroid Sphygmomanometer (mmHg)	Difference (mmHg)
40	50	+10
60	70	+10
80	90	+10
100	110	+10
120	130	+10

Table 2. - Example of a non-linear error

Mercury Sphygmomanometer (mmHg)	Aneroid Sphygmomanometer (mmHg)	Difference (mmHg)
40	20	-20
60	50	-10
80	80	0
100	110	+10
120	140	+20

In the example shown in Table 2, at low pressures the aneroid sphygmomanometer reads less than the mercury sphygmomanometer, becomes the same at 80mmHg, and then reads higher above 80mmHg. This is an example of a non-linear error.

Correction of calibration. This is required occasionally, usually as result of the gauge being dropped. It is best done by someone who has experience of aneroid blood pressure machines. However, it may be undertaken by carefully following the instructions below. Each adjustment should be made in very small amounts followed by a check to assess the effect.

1. Start by making sure the pointer is on the zero mark.
2. Remove the glass, then carefully remove the pointer and lift off the dial. You should now see the triangle with concave sides, on one side of which is a pin. In order **to correct a non-linear error** bend this pin very slightly away or towards the side of the triangle, replace the dial and pointer and run the calibration check again. Repeat this operation until the error has gone.
3. When **correcting a linear error** bend this pin very slightly along the line of the triangle side. Run the calibration check again and keep adjusting until the error is gone.
4. **Broken cover glass.** Visit the local watch repairer or make a glass from a thin plastic sheet. After making the adjustments apply a little watch oil to the bearing points.

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Correspondence to: Dr I H Wilson, Anaesthetics Dept., Royal Devon & Exeter Hospital, Exeter, EX2 5DW, UK