SPINAL ANAESTHESIA - A PRACTICAL GUIDE

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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 skilfully, 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 if too much sedation is given.

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 they experience 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 because of a fall in blood pressure and heart rate and improved venous drainage with a resultant decrease in oozing.

Splanchnic blood flow. Because it increases blood flow to the gut, spinal anaesthesia may reduce the incidence of anastomotic dehiscence.

Visceral tone. The bowel is contracted during spinal anaesthesia and sphincters are 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

Sometimes it can be difficult to find the dural space and occasionally, it may be impossible to obtain CSF and the technique has to be abandoned. Rarely, despite an apparently faultless technique, anaesthesia is not obtained.

Hypotension may occur with higher blocks and the anaesthetist must know how to manage this situation with the necessary resuscitation drugs and equipment immediately to hand. As with general anaesthesia, continuous, close monitoring of the patient is mandatory.

Some patients are not psychologically suited to be awake, even if sedated, during an operation. They should be identified during the preoperative assessment. Likewise, some surgeons find it very stressful to operate on conscious patients.

Even if a long-acting local anaesthetic is used, a spinal is not suitable for surgery lasting longer than approximately 2 hours. Patients find lying on an operating table for long periods uncomfortable. If an operation unexpectedly lasts longer than this, it may be necessary to convert to a general anaesthetic or supplement the anaesthetic with intravenous ketamine or with a propofol infusion if that drug is available.

When an anaesthetist is learning a new technique, it will take longer to perform than when one is more practised. When one is familiar with the technique, spinal anaesthesia can be very swiftly performed.

There is a theoretical risk of introducing infection into the sub-arachnoid space and causing meningitis. This should never happen if equipment is sterilised properly and an aseptic technique is used. 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 appropriate to combine the spinal with a light general anaesthetic.

Spinal anaesthesia is particularly suitable for older patients and those with systemic disease such as chronic respiratory disease, hepatic, renal and endocrine disorders such as diabetes. Many patients with mild cardiac disease benefit from the vasodilation that accompanies spinal anaesthesia except those with stenotic valvular disease or uncontrolled hypertension (see later). 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 resuscitation 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 the spinal needle has punctured an epidural vein, 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.

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. Likewise, mentally handicapped patients and those with psychiatric problems need careful pre-operative assessment.

Children. Although spinal anaesthesia has been successfully performed on children, this is a highly specialised technique best left to experienced paediatric anaesthetists.

Sepsis on the back near the site of lumbar puncture lest infection be introduced into the epidural or intrathecal space.

Septicaemia. If a patient is septicaemic, they are at increased risk of developing a spinal abscess. Epidural abscesses can, however, appear spontaneously in patients who have not had spinal/epidural injections especially if they are immuno-deficient: e.g., patients with AIDS, tuberculosis, and diabetes

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 post-operatively 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.

Controversies in spinal anaesthesia

Operator/anaesthetist. The same individual should not be responsible for over-seeing the anaesthetic and performing the surgery as "anaesthetic" problems can occur during the course of the operation. If such problems occur once surgery has started, the safety of the patient may be severely compromised. However, in many places doctors perform a spinal anaesthetic and then delegate intra-operative care of the patient to a suitably trained assistant while the surgery is performed.

Difficult airway. At first sight, spinal anaesthesia may appear to offer an ideal solution to the problem of a patient with a potentially difficult airway who requires lower abdominal surgery. However, the onset of a total spinal block or unforeseen surgical complications may make it imperative that the airway is secured. All the equipment necessary for intubation should, therefore, always be available before spinal anaesthesia is commenced. It is

always an extremely difficult to decide on whether to embark on a spinal anaesthetic when a patient is known to be difficult to intubate. The correct decision can only be made by the individual anaesthetist when all relevant clinical information is taken into account.

Spinal with sedation. Surgery is always stressful for the patient and most patients, even when totally pain free from a successful spinal, welcome some sedation. The optimal level of sedation can be difficult to judge as too much sedation can lead to hypoventilation, hypoxia or silent regurgitation of gastric contents. As a general rule, if should be possible to easily rouse the drowsy patient and be possible to maintain verbal contact with them.

In the event of an inadequate spinal anaesthetic it is much better to electively administer a light general anaesthetic and safeguard the airway, then to over-sedate a patient with benzodiazepines or narcotics.

Combined spinal/epidural block. There is currently much interest in combining the simplicity and speed of onset of a spinal anaesthetic with the flexibility of epidural anaesthesia by inserting an epidural catheter which allows the anaesthetic block to be extended. Furthermore, the epidural catheter can be used for post-operative analgesia. As well as combining the advantages of both techniques, the disadvantages are combined and new problems, peculiar to the technique are being described. Practitioners have to be skilled in performing and managing both spinal and epidural anaesthesia before considering the combined technique.

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. Stimulation of the motor nerves causes 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 sensory fibres are blocked before motor fibres. 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 pressure or movement and yet feel no pain when surgery starts.

Practical implications of physiological changes. 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.

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 L5. Remember the structures that the needle will pierce before reaching the CSF (figure 1).

The skin. It is wise to inject a small blob 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** that 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 the ligament 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 further short distance 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.

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 down (due to gravity) from the level of the injection, while isobaric solutions are not influenced in this way. Hypobaric solutions are rarely used. 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. 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.

Lidocaine/Lignocaine (Xylocaine). Best results are said to be obtained with 5% hyperbaric (heavy) lidocaine, which lasts 45-90 minutes. 2% lignocaine can also be used but it has a shorter duration of action. If 0.2ml of adrenaline 1:1000 is added to the lignocaine, it will usefully prolong its duration of action. Recently concerns have been raised about the safety of 5% lidocaine (it is said to be potentially neurotoxic) despite it having been used uneventfully for over forty years. Lidocaine from multi-dose vials should not be used for intrathecal injection as it contains potentially harmful preservatives.

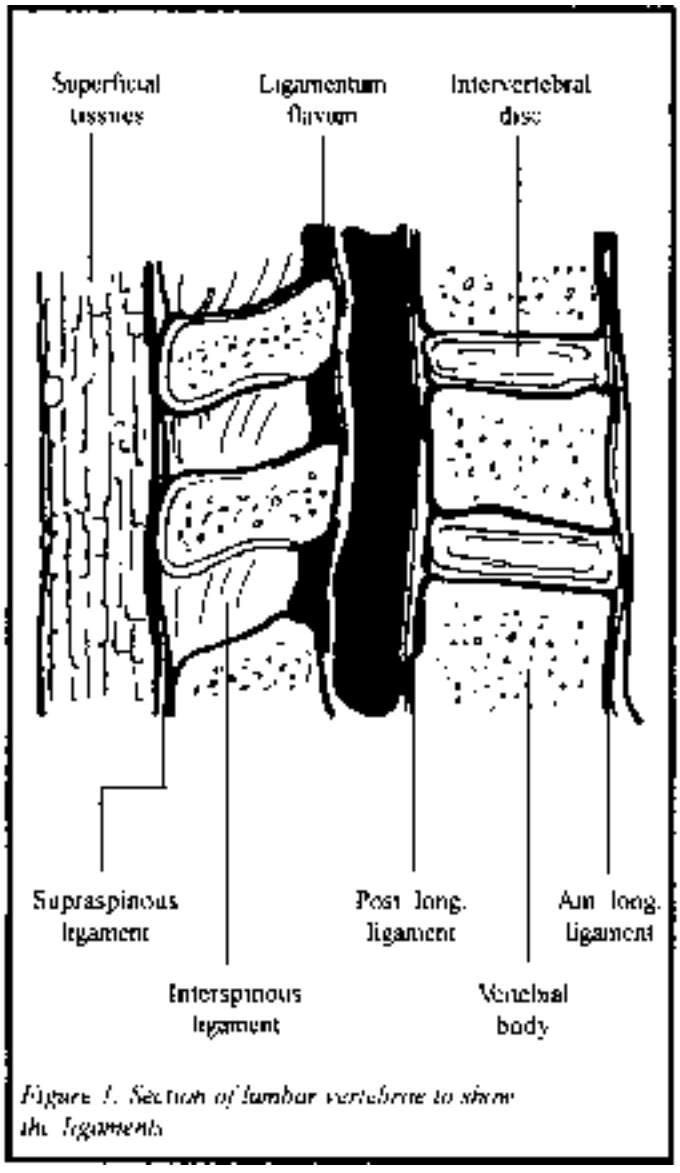

Figure 1. Section of lumbar vertebrae to show the ligaments

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

Tetracaine (Amethocaine, 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.

Pethidine/Meperidine. The 5% solution (50mg/ml) has local anaesthetic properties and is a versatile agent. The standard intravenous preparation is preservative-free and is isobaric. A dose of 0.5-1mg/kg is usually adequate for spinal anaesthesia.

Ropivacaine (Naropin) is a recently introduced long-acting local anaesthetic, similar to bupivacaine. It is not currently licensed for uses as a spinal anaesthetic.

It is generally thought that of the commonly used anaesthetic agents, lidocaine has a more rapid onset than bupivacaine, though some authors question this. Meperidine has a very rapid onset but can also wear off rapidly. It should also be remembered, especially when hyperbaric agents have been used, that patient movement, for example putting the patient "head-down" can cause the block to extend even some 20-30 minutes after it has been performed.

Spinal Anaesthesia and Common Medical Conditions

Respiratory disease. A low spinal block (below the umbilicus) 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 has a very limited respiratory reserve and is, for example, unable to lie flat.

Uncontrolled hypertension or severe valvular disease. Although moderate hypertension is not a contra-indication to spinal anaesthesia, it should be remembered that there is an almost inevitable fall in blood pressure when spinal anaesthesia is induced. This can be particularly

precipitous in patients with severe uncontrolled hypertension. Patients with aortic stenosis require a stable blood pressure (sustained after-load) to maintain their coronary perfusion. If they have a sudden fall in blood pressure, they may develop intractable cardiac arrest.

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.

Preoperative Visit

Patients should be told about their anaesthetic during the preoperative 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. 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 these sensations are perfectly normal and that if, by any chance, they feel pain they will be given a general anaesthetic.

Premedication is often unnecessary, but if a patient is apprehensive, a benzodiazepine such as 5-10mg 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 not routinely required.

Intravenous Pre-loading

All patients having spinal anaesthesia must have a large intravenous cannula inserted and be given intravenous fluids immediately before the spinal. This helps prevent hypotension following the vasodilation which is produced. 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 500mls. 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 1500mls. Crystalloids such as 0.9% Normal Saline or Hartmans are most commonly used. Dextrose 5% should be avoided as it is not effective for maintaining the blood volume

Positioning the Patient for Lumbar Puncture

Lumbar puncture is most easily performed when there is maximum flexion of the lumbar spine (figure 2). 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. Alternatively, the procedure can be performed with the patient lying on their side with their hips and knees maximally flexed.

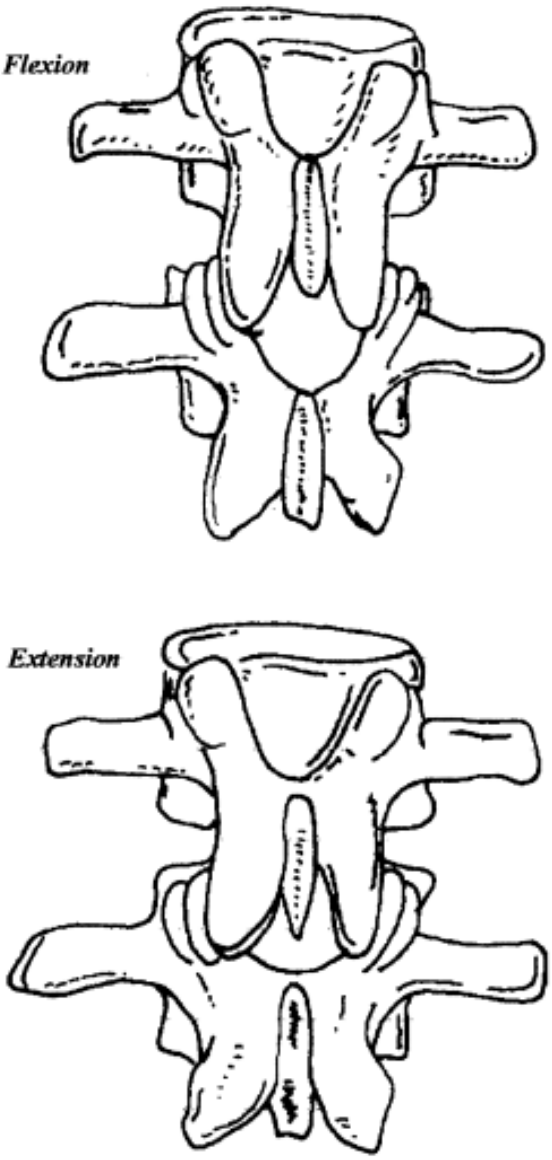

Figure 2: Effect of flexion and extension on the lumbar intervertebral space in the lumbar region

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. Consider the consequences of sudden hypotension or a vaso-vagal

attack for a sitting patient. The anaesthetist can either sit or kneel whilst performing the block.

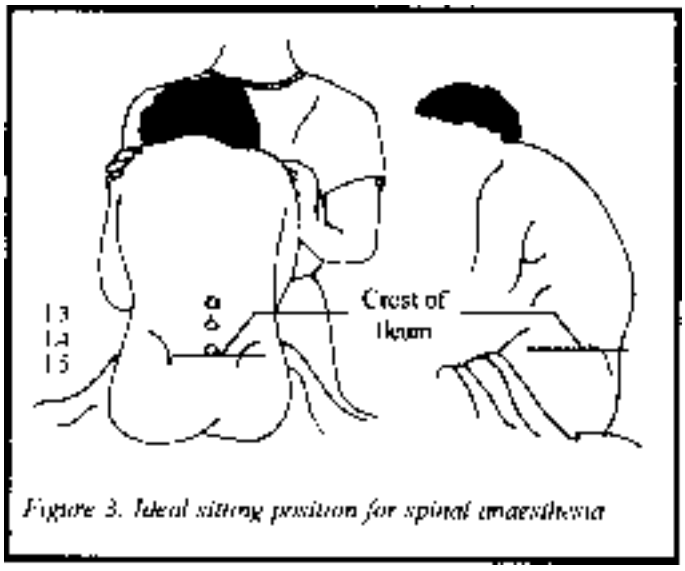

Figure 3. Ideal sitting position for spinal anaesthesia

Factors Affecting the Spread of the Local Anaesthetic Solution

A number of factors affect 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. Injecting hyperbaric solutions and then altering the patient's position probably produces the most controllable blocks.

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" affecting only the sacral nerve roots 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 of a hyperbaric agent.

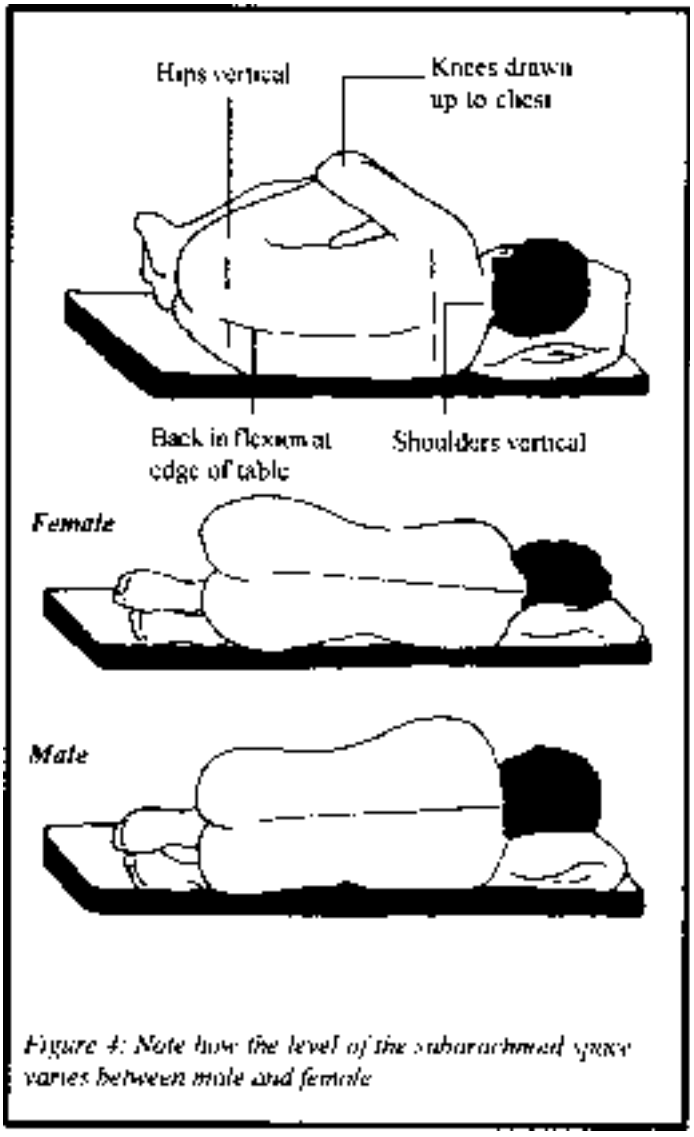

Figure 4: Note how the level of the subarachnoid space varies between male and female

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. As spinal anaesthetics are generally only injected in the lumbar region, the extent of the block is influenced more by the volume and concentration 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.

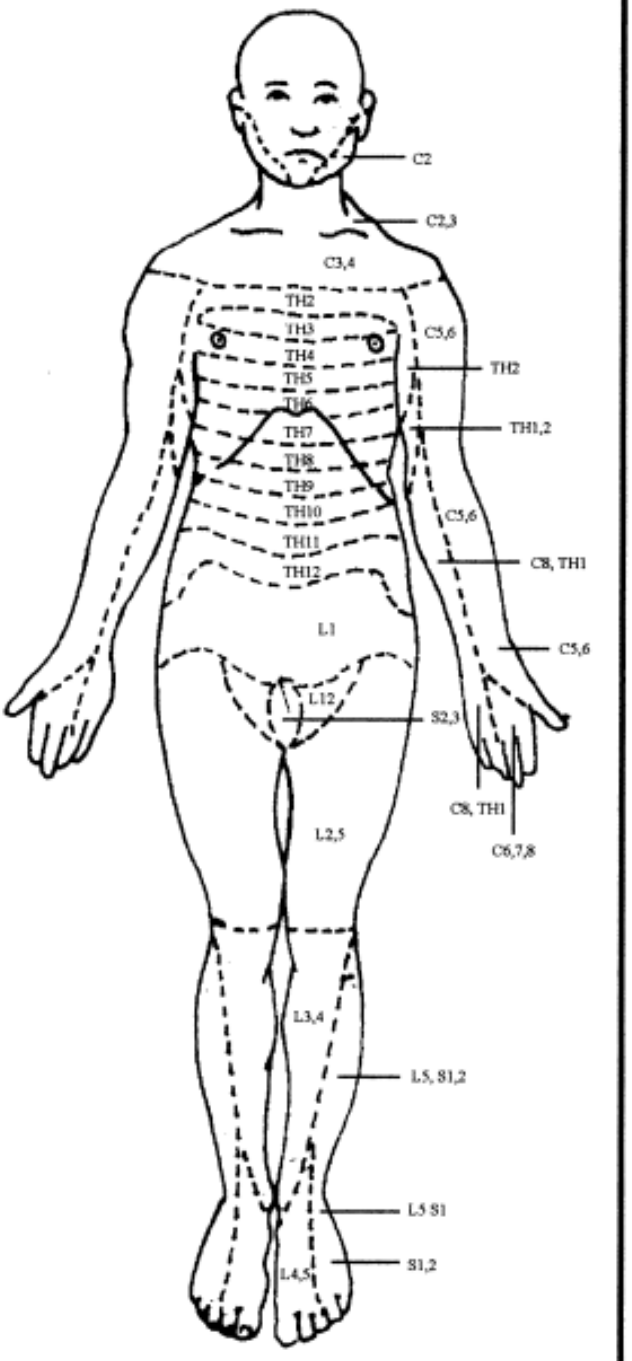

Figure 5: Diagram of Dermatones

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 (see Table 1). 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).

The volumes of local anaesthetic shown in Table 1 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 and appropriate positioning are the most reliable way of obtaining 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 2ml 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, e.g. 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 had the procedure fully explained, has reliable intravenous access, is in

Table 1.

Type of block	Hyperbaric Bupivacaine	Plain Bupivacaine	Hyperbaric Lidocaine
Saddle block e.g. operations of genitalia, perineum	2ml	2ml	1ml
Lumbar block e.g. operations on legs, groin, hernias	2-3ml	2-3ml	1.5-2ml
Mid-thoracic blocks e.g. hysterectomy	2-4ml	2-4ml	2ml

a comfortable position and that resuscitation equipment is immediately available.

- Scrub and glove up carefully.
- Check the equipment on the sterile trolley.
- 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).
- Draw up the local anaesthetic to be used for skin infiltration into the 2ml syringe. Read the label.
- Clean the patient's back with the swabs and antiseptic ensuring that your gloves do not touch unsterile skin. 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.
- Locate a suitable interspinous space. You may have to press fairly hard to feel the spinous processes in an obese patient.
- Inject a small volume of local anaesthetic under the skin with a disposable 25-gauge needle at the proposed puncture site.
- Insert the introducer if using a 24-25 gauge needle. It should be advanced into the ligamentum flavum but care should be exercised in thin patients that an inadvertent dural puncture does not occur.

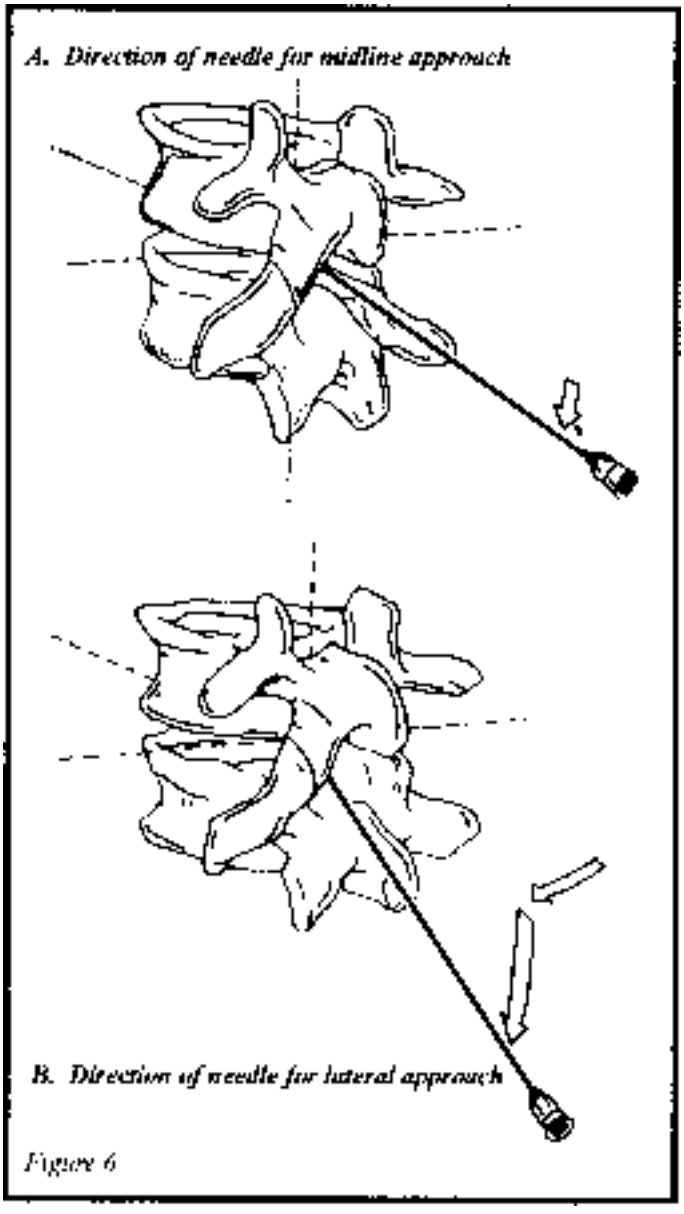

Figure 6

- 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 particles 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. 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.
- 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. 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 appears. 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 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 are not sure whether you are in the midline, ask the patient on 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 paramedian approach to the dura. This is performed by inserting the spinal needle about 0.5-1cm 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 through it to pierce the dura. When using this technique inject some local anaesthetic into the muscle before inserting the spinal needle.

The patient complains of pain during needle insertion. This suggests that the spinal needle is passing through the muscle on either side of the ligaments. Redirect your needle away from the side of the pain to get back into the midline or inject some local anaesthetic.

The patient complains of pain during injection of the spinal solution. Stop injecting and change the position of the needle.

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. 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". 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. 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 patient's knees. 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 of 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 that 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, nausea or feeling generally unwell. A moderate fall in systolic blood pressure to say 80-90mm Hg in a young, healthy 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. If the heart rate does not increase try ephedrine (see below).

It is generally considered good practice for all patients undergoing surgery under spinal anaesthesia to be given supplemental oxygen by facemask 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 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 30mg ampoules. It is best diluted to 10mls with saline 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.

Methoxamine (Vasoxine). It is available in 20mg ampoules and must be diluted before injection. A suitable adult dose is 2mg intravenously or 5-20mg by intramuscular injection. It is a pure peripheral vasoconstrictor and reflex bradycardia, needing treatment with atropine can occur. It is particularly useful to treat hypotension during spinal anaesthesia when the patient has a tachycardia.

Phenylephrine. A pure peripheral vasoconstrictor which is available in 10mg ampoules; it must be diluted before use. Suitable adult doses for intravenous use are 100-500mcg repeated after 15 minutes if necessary, or 2-5mg intramuscularly. It lasts about 15 minutes. A reflex bradycardia may occur.

Metaraminol (Aramine). It is supplied in 10mg ampoules and should be diluted and used incrementally (1-5mg) as with ephedrine. Alternatively, it can be added to 500ml of fluid and titrated against the blood pressure. It has a slower onset time (at least 2 minutes after intravenous injection) but lasts longer (20-60 minutes)

Epinephrine/Adrenaline. 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 epinephrine/adrenaline closely - it is a very powerful drug but only lasts a few minutes. It may be used during spinal anaesthesia if hypotension does not respond to first line drugs listed above or when they are not available.

Norepinephrine/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 taking particular care that to avoid extravasation.

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. Repeated doses of vasopressors and large volumes of fluid may be necessary.
- **Bradycardia** - give atropine. If this is not effective give ephedrine or adrenaline
- **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 (C3,4,5) 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.**

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

- ABC Resuscitation
- 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 small dose of a benzodiazepine as consciousness may return before muscle power and the patient will find it distressing to be unable to breathe properly.

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 elevate the patients' 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, as previously discussed. 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 a few hours and may last a week or more. It is postural, being made worse by standing or even raising the head and relieved by lying down. It is often occipital and may be associated with a stiff neck. Nausea, vomiting, dizziness and photophobia frequently accompany it. 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 traction on the meninges and pain.

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 in 1-3%. 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 (1%) than conventional cutting-edged needles (Quincke) (figure 7).

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. Sumatriptan, normally used in the treatment of migraine, is said to be effective. 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.

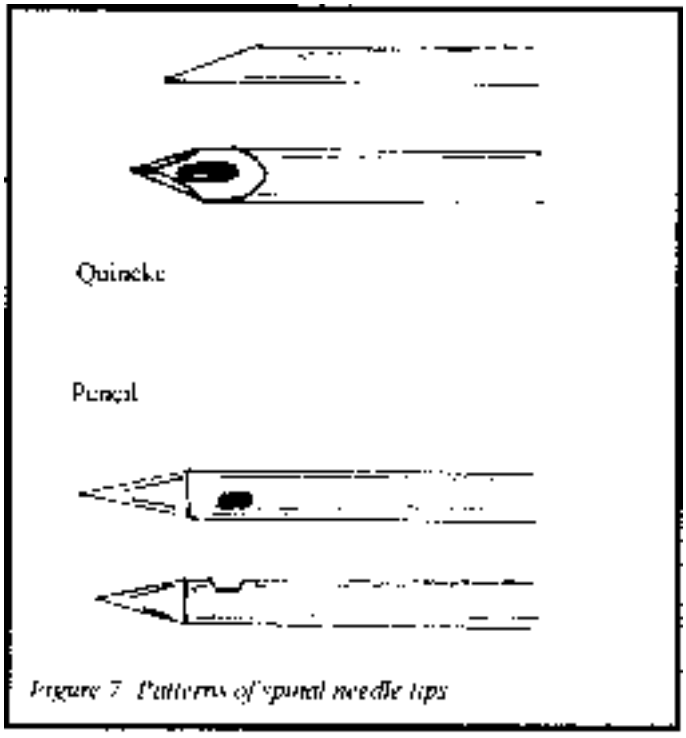

Figure 7 Patterns of spinal needle tips

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.

Urinary retention. 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. Damage to an epidural vein can lead to the formation of an epidural haematoma that compresses the spinal cord. This is most unlikely in a patient with a normal clotting profile. 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.

Spinal Anaesthesia in Obstetrics ***(See article in Update in Anaesthesia No. 9)***

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 completed. There are, however, also disadvantages. It may be difficult to perform the spinal injection as the pregnant uterus will impede lumbar flexion 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 anaesthesia for Caesarean section should not be attempted until the anaesthetist has accumulated sufficient experience in 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 1500mls 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. *(See Update in Anaesthesia No. 9).*
- 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:
  - 2.0-2.5ml of a hyperbaric solution of 0.5% bupivacaine or
  - 2.0-2.5ml of an isobaric solution of 0.5% bupivacaine or
  - 1.4-1.6ml of a hyperbaric solution of 5% lignocaine or
  - 2.0-2.5ml of an isobaric solution of 2% lignocaine with added adrenaline (0.2ml 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 in Anaesthesia No. 9).*

As with all patients undergoing surgery under spinal anaesthesia, oxygen should be given during the operation. As hypotension commonly occurs despite fluid pre-loading, many anaesthetists routinely give a dose of vasopressor intravenously. Ephedrine is the favoured vasopressor, as it does not cause constriction of the uterine blood vessels. If it is not available, one of the other vasopressors 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.

Further reading:

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