

REVIEW ARTICLE



Failed spinal anaesthesia: mechanisms, management, and prevention

P. D. W. Fettes^{1*}, J.-R. Jansson² and J. A. W. Wildsmith¹

¹University Department of Anaesthesia, Ninewells Hospital & Medical School, Dundee DD1 9SY, UK.

²AstraZeneca R&D SE-151 85, Sodertalje, Sweden

*Corresponding author. E-mail: paulfettes@nhs.net

Although spinal (subarachnoid or intrathecal) anaesthesia is generally regarded as one of the most reliable types of regional block methods, the possibility of failure has long been recognized. Dealing with a spinal anaesthetic which is in some way inadequate can be very difficult; so, the technique must be performed in a way which minimizes the risk of regional block. Thus, practitioners must be aware of all the possible mechanisms of failure so that, where possible, these mechanisms can be avoided. This review has considered the mechanisms in a sequential way: problems with lumbar puncture; errors in the preparation and injection of solutions; inadequate spreading of drugs through cerebrospinal fluid; failure of drug action on nervous tissue; and difficulties more related to patient management than the actual block. Techniques for minimizing the possibility of failure are discussed, all of them requiring, in essence, close attention to detail. Options for managing an inadequate block include repeating the injection, manipulation of the patient's posture to encourage wider spread of the injected solution, supplementation with local anaesthetic infiltration by the surgeon, use of systemic sedation or analgesic drugs, and recourse to general anaesthesia. Follow-up procedures must include full documentation of what happened, the provision of an explanation to the patient and, if indicated by events, detailed investigation.

Br J Anaesth 2009; **102**: 739–48

Keywords: anaesthetic techniques, regional; anaesthetic techniques, spinal; complications

Two conditions are, therefore, absolutely necessary to produce spinal anaesthesia: puncture of the dura mater and subarachnoid injection of an anaesthetic agent.

Gaston Labat, 1922

Spinal (intrathecal) anaesthesia is generally regarded as one of the most reliable of regional block methods: the needle insertion technique is relatively straightforward, with cerebrospinal fluid (CSF) providing both a clear indication of successful needle placement and a medium through which local anaesthetic solution usually spreads readily. However, the possibility of failure has long been recognized, the above quote being taken from the work of Gaston Labat,²⁴ the 'father' of modern regional anaesthesia. His two conditions for success, although perhaps a little simplistic when related to current knowledge, still indicate the essence of the method and provide a starting point for the consideration of failure, although it may be helpful to define exactly what this means first. Literally, the word failure implies that a spinal anaesthetic was attempted, but that no block resulted; this happens, but perhaps a

commoner outcome is that a block results, but is inadequate for the proposed surgery. Such inadequacy may relate to three components of the block: the extent, quality, or duration of local anaesthetic action, often with more than one of these being inadequate. This review has considered all three eventualities within the definition of 'failure'.

Most experienced practitioners would consider the incidence of failure with spinal anaesthesia to be extremely low, perhaps less than 1%. However, a figure as high as 17% has been quoted from an American teaching hospital, yet most of the failures were judged to be 'avoidable'.²⁸ A survey at another such institution considered that this high rate was 'unacceptable', and recorded the much lower, but still significant, figure of 4%, with 'errors of judgement' as the major factor.³² The clear implication is that careful attention to detail is vital, and it has been shown that a failure rate of <1% is attainable in everyday practice.¹⁷ Minimizing the incidence of failure is obviously a pre-requisite for gaining the benefits of spinal anaesthesia, and prevention must start with full recognition of the potential pitfalls so that clinical practice can be tailored to their avoidance.

In general terms, block failure is usually ascribed to one of three aspects: clinical technique, inexperience (of the unsupervised trainee especially), and failure to appreciate the need for a meticulous approach.¹⁰ However, such broad categories reveal little about the many detailed ways in which an intrathecal injection can go astray within each of the five phases of an individual spinal anaesthetic, these being, in sequence, lumbar puncture, solution injection, spreading of drug through CSF, drug action on the spinal nerve roots and cord, and subsequent patient management. All of the problems involved are well described in the literature, but usually long ago, and many practitioners seem unaware of the issues involved. For instance, the neuroscience division of AstraZeneca received 562 'Product Defect Notification' reports in the 6 yr to December 31, 2007, all ascribing failed spinal anaesthetics to ineffective bupivacaine solution (Fig. 1). Nearly one-third of reports (179) were from the UK, but virtually every country where the drug is marketed was represented. However, analysis showed that the returned material was within the product's specification in every case so a formal review, based on a literature search, was thought to be worthwhile.

Search strategy

For this review 'PubMed' and 'Google' databases were searched using the terms 'failed regional anaesthesia', 'failed regional anesthesia', 'failed spinal anaesthesia', and 'failed spinal anesthesia'. Relevant articles were retrieved as were any possibly relevant papers in their reference lists. Supporting searches were performed on subjects that may not have been otherwise identified, specific examples being CSF volume, dural ectasia, and the chemical compatibility of local anaesthetics with adjuncts.

In addition, searches were made using 'Planet' (an AstraZeneca internal database), 'Biosis', 'Current Contents', 'Embase', 'PsycINFO', 'Medline', and 'Medline Daily update', using the terms 'Failed Spinal Anaesthesia' and 'Failed Spinal Anesthesia' as sole search terms and 'spinal anesthesia' or 'spinal anaesthesia' or 'spinal anesthetic' or 'spinal cord anesthesia' or 'spinal cord anaesthesia' or 'anesthesia, spinal' or 'anaesthesia, spinal' and 'treatment failure' or 'therapy failure', and 'Intrathecal'. All papers identified as relevant are included in this review.

Mechanisms and their prevention

Failed lumbar puncture

Inability to obtain CSF, sometimes referred to as a 'dry tap', is the only cause of failure which is immediately obvious. A needle with a lumen blocked at the outset is a theoretical possibility, but is most unlikely with modern equipment. However, both needle and stylet must be checked for correctness of fit before use, and the needle should not be advanced without the stylet in place because

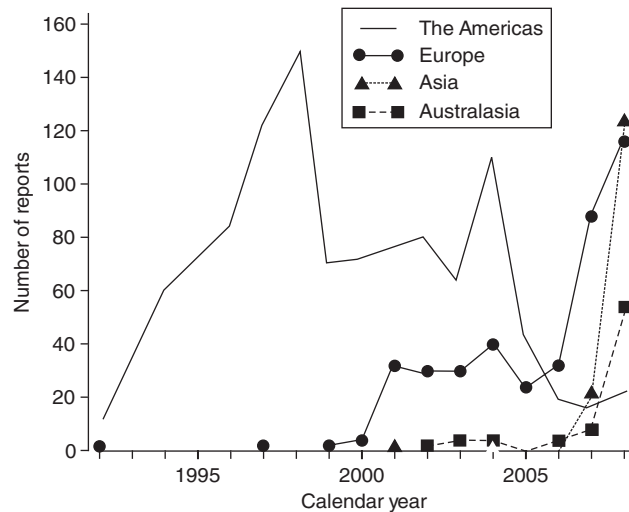


Fig 1 Annual numbers of reports of failed spinal anaesthesia with bupivacaine received by AstraZeneca between January 1, 1993 and December 31, 2008 plotted according to region of the world.

tissue or blood clot can easily obstruct the fine bore needles used now. Otherwise, a failed lumbar puncture is virtually always because of either poor positioning of the patient or incorrect needle insertion, both factors being within the control of the anaesthetist. Abnormalities of the spine (kyphosis, scoliosis, calcification of ligaments, consequences of osteoporosis), obesity, and patient anxiety make both positioning the patient and needle insertion more difficult, especially in the elderly. Texts of regional anaesthesia give more extensive instruction than can be provided here, and good clinical training is the key to success, but most difficulties are attributable to lack of adherence to the basic rules.

Positioning

The patient is placed on a firm surface; the lumbar laminae and spines are 'separated' maximally by flexing the whole spine (including the neck), the hips, and knees; rotation and lateral curvature of the spine are avoided; these points apply to lumbar puncture in both sitting and lateral horizontal positions; the former is usually an easier option in 'difficult' patients, but sometimes the reverse is true. The role of the assistant in achieving and maintaining the patient in the correct position cannot be underestimated.³⁵

Needle insertion

Although its accurate identification can be difficult using clinical land-marks, what is judged to be the third lumbar inter-space is used usually, but examination may indicate that another is preferable. However, care should be taken not to venture too cephalad and risk damage to the spinal cord.³³ With the midline approach, insertion should start precisely in the mid-line, mid-way between the posterior spines, with the needle shaft at right angles to the back in both planes. Small, incremental changes in needle angle

should be made only if there is resistance to advancement; if resistance is met, cephalad angulation should be tried first, and such angulation may be appropriate from the start if the patient is unable to flex fully (e.g. the obstetric patient at term). A degree of caudad angulation is sometimes needed, with a slight lateral direction being required very rarely. All authorities recommend that the anaesthetist should have a good knowledge of spinal anatomy and relate these to changes in tissue resistance as the needle is advanced so that a mental 'picture' of where the needle tip lies is appreciated.

The above points apply specifically to the midline approach; lateral or paramedian approaches are preferred by some,²⁷ especially if the mid-line ligaments are heavily calcified, but they are inherently more complex techniques. However, in the face of difficulty, the same basic rules apply: make sure that the patient is in the correct position and that the correct angles and insertion technique are used.

Adjuncts

A calm, relaxed patient is more likely to assume and maintain the correct position, so explanation (before and during the procedure) and gentle, unhurried patient handling are vital; light anxiolytic premedication contributes much to relaxing the patient; local anaesthetic infiltration at the puncture site must be effective without obscuring the landmarks, but must include both *intra*dermal and s.c. injection. Achieving the correct position is a particular challenge in the patient in pain (e.g. from a fractured hip) and systemic analgesia (i.v. or inhalation) helps considerably. The aim of such adjuncts is to optimize the patient's position and to prevent any movement. As will be discussed later, it takes only slight movement to displace the needle from its target.

Advances in ultrasound technology are reaching the stage where it can be used to overcome difficulties with lumbar puncture, but clinicians will still need to be aware of the problems and how they should be overcome.

Pseudo-successful lumbar puncture

The appearance of clear fluid at the needle hub is usually the final confirmation that the subarachnoid space has been entered. Rarely, however, the clear fluid is not CSF, but local anaesthetic injected as a 'top-up' for an epidural which then proved inadequate for a Caesarean section, or even spreading there from the lumbar plexus.²⁶ Unfortunately, a positive test for glucose in the fluid does not confirm that this fluid is definitely CSF because extracellular fluid constituents diffuse rapidly into fluids injected into the epidural space. Another, even rarer, suggested cause of clear fluid appearing at the needle hub, but not confirming successful lumbar puncture, is a congenital arachnoid cyst.³⁹

Solution injection errors

The appearance of CSF in the needle hub is an essential pre-requisite for spinal anaesthesia, but it does not guarantee success, which also requires that a fully effective dose is both chosen and actually deposited in the CSF.

Dose selection

Studies of many factors influencing intrathecal drug spread have shown that the dose injected, within the range normally used, has only a small effect on the extent of a spinal anaesthetic, but is far more important in determining the quality and duration of block.²⁰ Overall, the actual dose chosen will depend on the specific local anaesthetic used, the baricity of that solution, the patient's subsequent posture, the type of block intended, and the anticipated duration of surgery. Thus, knowledge of the factors influencing intrathecal drug spread and clinical experience with any particular local anaesthetic preparation are important guides to choosing an effective dose.

However, the need to guarantee an adequate effect means that the doses of drugs injected in standard 'single shot' techniques are larger than is strictly necessary, experience with dose titration during continuous spinal anaesthesia showing clearly that lower doses are often effective.²¹ In attempts to either minimize hypotension, for example by attempting to produce a unilateral block, or speed postoperative mobilization, by decreasing duration, some practitioners use lower doses than is traditional³ (e.g. 5–10 rather than 15 mg of hyperbaric bupivacaine). Used correctly, and in appropriate situations, such doses can be reliable, but they do mean that the margin for error is reduced and that the consequences of other problems (e.g. Loss of injectate—see below) will be exaggerated and so risk an inadequate block. It becomes even more important to ensure that the whole of that lower dose reaches the CSF and then spreads properly, remembering that the 'dead space' of the needle will contain a significant proportion of what is a small volume to start with.

Loss of injectate

The Luer connection between syringe and needle provides a ready opportunity for leakage of solution. A particular variant of this problem being a leak through a defect at the junction of needle hub and shaft.⁶ Given the small volumes involved, the loss of even a few drops may cause a significant decrease in the mass of drug reaching the CSF, and thus in its effectiveness. To avoid this, it has long been conventional teaching that the syringe containing the injectate must be inserted very firmly into the hub of the needle, and that a subsequent check is made that no leakage occurs.

Misplaced injection

Needle and syringe must be connected firmly, but great care should be taken to avoid either anterior or posterior

displacement of the needle tip from subarachnoid to epidural space, where deposition of a spinal dose of local anaesthetic will have little or no effect. Fluid aspiration, after attachment of the syringe, should confirm free flow of CSF and, thus, that the needle tip is still in the correct space, but such aspiration may displace the tip unless performed carefully, as may the force of the injection of the syringe contents. To prevent displacement at any stage, it has been advocated that the dorsum of one hand should be anchored firmly against the patient's back and the fingers used to immobilize the needle, while the other hand is used to manipulate the syringe.⁴⁰ Most practitioners would recommend aspiration for CSF after the injection to confirm that correct placement is maintained, and some advocate that this is done half way through as well although neither of these practices has been shown to influence the outcome of the block.^{32,40}

Tip displacement must be guarded against with any type of spinal needle, but it is a particular issue with the 'pencil point' needles now used widely to minimize the incidence of post-dural puncture headache. The opening at the end of these needles is proximal to the tip, so only a minor degree of 'backward' movement during syringe attachment may result in epidural injection as was recognized at an early stage in the widespread use of such needles.¹² The distances involved are of the order of a millimetre or two, but (as with leakage) misplacement of only a small amount of solution can have significant effects. An additional issue with pencil-point needles is that the opening, being much longer than the bevel of a Quincke needle, may 'straddle' the dura so that some solution reaches the CSF, and some the epidural space (Fig. 2).⁴¹ This may be exaggerated by the dura acting as a 'flap' valve across the needle opening. Initially, CSF pressure pushes the dura outwards so that aspiration is

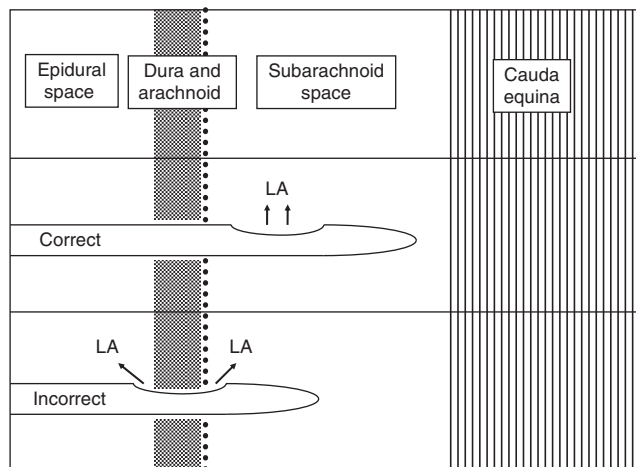


Fig 2 Possible positions of the tip of a pencil-point needle. If it is correctly placed (upper picture) all of the local anaesthetic solution will reach the subarachnoid space, but if the opening 'straddles' the dura (lower picture) some solution will be deposited in the epidural space.

successful (Fig. 3A), but subsequent injection pushes the dura forward and the solution is misplaced (Fig. 3B).

A variant is that the needle tip penetrates the dura, but it is the arachnoid mater that acts as the flap valve so that a subdural injection results (Fig. 3C). This misplacement is usually thought of as leading to excessive spread during epidural block, but the equivalent phenomenon has been described after intended subarachnoid injection,³⁷ and is a recognized complication of myelography.²² Subdural injection has also been identified as the cause of a failed block when either epidural¹¹ or subarachnoid¹⁵ injection was intended.

These eventualities, being subtle abnormalities of placement, are impossible to identify at the actual time, but rotation of the needle through 360° after the initial appearance of CSF, and before check aspiration, has been advocated as a way of minimizing the possibility of them occurring, the theory being that the rotation reduces the risk of the membrane edges catching on the opening.

Inadequate intrathecal spread

The intrathecal spread of a local anaesthetic solution, even when correctly placed, has truly been described as capricious.⁷ The factors that affect it are many, but the focus here will be on those that may result in inadequate spread.

Anatomical abnormality

Intrathecal spread is governed by interplay between solution physical characteristics, gravity, and the configuration of the vertebral canal. Anatomical abnormalities that lead to problems with spread can be both overt and covert. The curves of the vertebral column are integral to solution

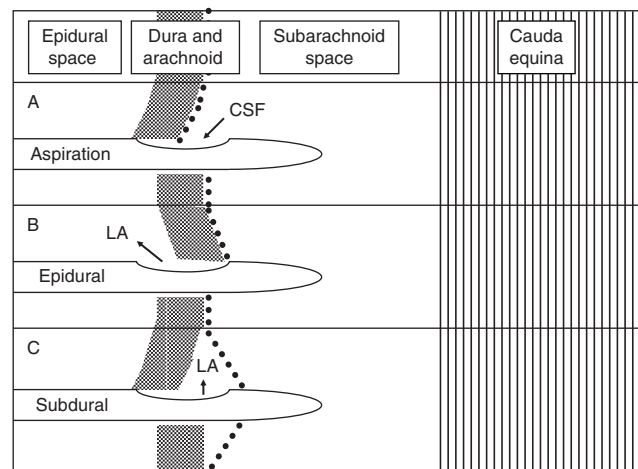


Fig 3 To show how the dura or arachnoid mater may act as a 'flap' valve across the opening of a pencil point needle. During aspiration (A) the dura/arachnoid are pulled back allowing CSF to enter the needle. During injection the dura (B) or arachnoid (C) is pushed forward and the local anaesthetic enters the epidural or subdural space.

spread and any obvious abnormality, kyphosis, or scoliosis, may interfere with the process. Examination of the patient should reveal whether this might occur, but it is not possible to predict whether the effect will be excessive spread or failure.

A very rare possibility, which is not apparent on examination, is that the ligaments that support the spinal cord within the theca form complete septae and act as longitudinal or transverse barriers to local anaesthetic spread. This can result in a block that is entirely unilateral² or of insufficient cephalad spread. Spinal stenosis or other pathological lesions might also limit spread, effectiveness, or both, one such case being attributed to the consequences of previous intrathecal chemotherapy.^{1 42} Similarly, previous surgery within the vertebral canal may result in adhesions that interfere with spread.

An interesting 'abnormality' considered to have caused restricted spread in a single patient was a larger than usual volume of CSF in the lumbar theca.¹⁸ Subsequent systematic study has shown that lumbar CSF volume is the most important factor influencing the variability seen between individuals in the spread of an intrathecal injection.⁹ A negative correlation was found between lumbar CSF volume and the peak sensory level achieved with hyperbaric bupivacaine when the injection was performed in both supine and sitting positions. A variation of this factor is dural ectasia, which is a pathological enlargement of the dura seen in the majority of patients with Marfan's syndrome and in some other connective tissue disorders.²⁵

Solution density

Consistently effective spinal anaesthesia requires that the practitioner has a good understanding of the factors that affect intrathecal spread, particularly, but not only, solution density. A solution with a density within the normal range of that of CSF ('isobaric') will virtually guarantee block of the lower limbs with little risk of thoracic nerve block and thus hypotension.⁴³ However, plain solutions of bupivacaine, although often referred to as isobaric, are actually of sufficiently lower density to be hypobaric, especially at body temperature. As a result their range of spread is much less predictable than that of a truly isobaric preparation, and occasionally the block may be no higher than the first, or even second, lumbar dermatome when administered to the non-pregnant supine patient.²⁹ Although the impact of variations in CSF volume has yet to be studied with these solutions, it seems likely that this factor may well be a factor in their variability.

Solutions with a density greater than that of CSF (hyperbaric) move very definitively under the combined influence of gravity and the curves of the vertebral canal. Over a hundred years ago, Barker, one of the early pioneers of spinal anaesthesia in the UK, observed that the addition of glucose to the solution made for a more reliable effect.⁴ In the standard scenario, that of a patient placed supine after the injection of a hyperbaric

preparation at the mid-lumbar level, the solution will spread 'down' the slope under the effect of gravity to pool at the 'lowest' point of the thoracic curve, so exposing all nerve roots up to that level to an effective concentration of local anaesthetic. However, if lumbar puncture is performed at the fourth lumbar or the lumbo-sacral interspace the local anaesthetic may be 'trapped' below the lumbar curve, especially if the patient is in the sitting position during injection and maintained in that position for a period thereafter.

This results in a block that is restricted to the sacral segments, just as has been described with a spinal catheter that passes caudally.³¹ Prevention relies on avoiding too low an injection level unless, of course, a deliberate 'saddle' block is intended.

Ineffective drug action

The last possible explanation for a failed spinal is that the solution actually injected reaches the target nerves, but is inactive or ineffective, with a variety of explanations being possible.

Identification errors

Spinal anaesthetics are supplied in aqueous solution ready for injection and there is no opportunity for confusion in the preparation of the solution itself. However, other optically clear solutions, such as a separate local anaesthetic for skin infiltration or analgesic adjuvants, are often used from the same sterile preparation area and the possibility that confusing them may lead to an ineffective block must be considered. Recognition of the possibility of such injection errors has led to the widespread use of syringe labelling in anaesthesia, but this is not as easy within a sterile field as it is on an anaesthetic work station. Attention to detail is essential, but minimizing the number of ampoules on the block tray (such as using the same local anaesthetic for both skin infiltration and spinal) and consistent use of different sizes of syringe for each component of the procedure help considerably.

Chemical incompatibility

The mixing of two different pharmaceutical preparations also raises the possibility of ineffectiveness as a result of interaction between local anaesthetic and adjuvant. Local anaesthetics seem to be compatible with most of the common opioids, but there has been little formal study of the effects of mixing them, and the situation is even less definitive with other adjuvants such as clonidine, midazolam, and other more extreme substances. Certainly, there are no studies of the stability of three or more substances when mixed together for intrathecal use, a not unknown practice today. Chemical reaction might generate an obvious precipitate, but another possibility is that the pH of the local anaesthetic solution becomes even lower than it was to start with. This would decrease the concentration

of the un-ionized fraction that is what diffuses into nerve tissue and, unless the solution mixes well with CSF, a decreased effect could result. There is at least one report indicating that the incidence of failure is greater after the addition of a vasoconstrictor solution and this could represent an example of this effect.³⁰

Inactive local anaesthetic solution

The older, ester-type local anaesthetics are chemically labile so that heat sterilization and prolonged storage, particularly in aqueous solution, can make them ineffective because of hydrolysis and hence they need very careful handling. Although the more modern amide-linked drugs (e.g. lidocaine, bupivacaine, etc.) are much more stable and can be heat sterilized in solution and then stored for several years without loss of potency, there have been a number of reports attributing failure of spinal anaesthetics to inactive drug.^{8 16 38 44}

Local anaesthetic resistance

Very rarely a failed spinal anaesthetic has been attributed to physiological 'resistance' to the actions of local anaesthetic drugs, although the reports tend to the anecdotal.^{5 23 36 45} A history of repeated failure of dental or other local anaesthetic techniques is accompanied by speculation that the problem is because of a sodium-channel mutation that renders the drugs ineffective. However, no such mutation has ever been described, and the clinical reports are incomplete, specifically failing to consider not only the recognized causes of failure, but also the behaviour of an anxious patient preferring general anaesthesia as an explanation for the 'resistance'. Very detailed investigation would be required for 'resistance' to be accepted as an explanation. As an aside, any patient giving a history of repeated failures with local anaesthesia should be managed by an experienced clinician.

Failure of subsequent management

Not all of a patient's claims of discomfort, or even pain, during a spinal anaesthetic are the result of an inadequate injection. A properly performed spinal anaesthetic will produce complete somatic, and a major degree of autonomic, nerve block in the lower half of the body unless a specifically restricted method is used. However, ensuring that this block occurs is only part of the process because the unaffected components of the nervous system require consideration and management. Specifically, this relates to conscious awareness of the clinical setting and of 'sensations' transmitted through unblocked nerves, with both factors possibly making the patient claim that the block has failed. This may not actually be the case, but patient management certainly has failed if such a claim is made when the block is actually as good as it could be.

Lying supine and wide awake while undergoing surgery is not a pleasant experience, even for the most sanguine of

individuals, and anxiety alone can cause much difficulty. Further, operating tables are designed for surgical access, not patient comfort; and intra-abdominal stimuli may result in afferent impulses in unblocked parasympathetic and phrenic nerve fibres. The more anxious the patient, the greater will be the impact of these factors and the more likely will it be that the patient will fail to cope with the situation and claim that the anaesthetic has not worked properly. Expectation plays a part, and good preoperative patient counselling followed by a supportive approach from the anaesthetist during the operation is important in avoiding such problems, but so is the judicious, and pro-active use of *systemic* sedative and analgesic drugs. Sufficient sedation to produce drowsiness, or even sleep (with appropriate monitoring), is rarely contra-indicated other than in the obstetric situation, and even there small doses may occasionally be useful.

Testing the block

In recent years, it has become almost mandatory, certainly in the obstetric setting, to test the level of block formally before surgery commences. This apparently sensible precaution may be difficult or impossible to undertake in some patients (for example the demented patient with a fractured neck of femur). Excessive focus on testing can also have a negative impact. Most patients will have some anxiety about the effectiveness of the injection, and this will be increased if testing is started too soon. Conventional practice is to check motor block by testing the ability to lift the legs, followed by testing of sensory block to stimuli such as soft touch, cold, or pin prick, all of which have their proponents. It is advisable to start testing in the lower segments, where onset will be fastest, and work upwards. Proving early on that there is some effect encourages patient confidence; testing too soon does the opposite.

Even if there is no formal assessment of the level of block, the clinician must be confident that an adequate block has been produced. Establishing that the *level* of block is appropriate for the projected surgery is often taken to demonstrate that the *quality* of block is adequate also, but this is not always the case if cold or pin-prick stimuli are used. The observation that the upper block level is a few dermatomes above which innervate the surgical field (not forgetting the deeper structures) is a good start, but it does not *guarantee* that the quality of block is sufficient. A covert pinch of the site of the proposed surgical incision may be a better indicator of skin analgesia, and can be reassuring if the block has been slow in onset. Indeed, there is much to be said, particularly when the patient is conscious, for asking the surgeon to do the same with a toothed surgical forceps before incising the skin,¹⁰ but surreptitiously and *without* asking a loaded question such as 'Does that hurt?!' The patient is distracted by conversation and an exchange of glances between surgeon and anaesthetist is all that is needed for surgery to begin.

Catheter and combined techniques

The great majority of spinal anaesthetics involve a single, through needle injection and, as has been noted, this requires some certainty about its effectiveness for surgery. To take advantage of the rapid onset and profound block of spinal anaesthesia, both continuous and combined spinal–epidural techniques have been introduced to increase flexibility. If the catheters are correctly placed, problems of inadequate spread, quality, and duration of effect can be dealt with although many of the potential technical problems outlined above can still apply. However, both methods require a greater level of skill and experience to use, the insertion of an intrathecal catheter can be surprisingly difficult to achieve in some patients and, as has been mentioned already, can result in the misdirection of the local anaesthetic solution, with the risk of neurotoxicity.³⁴ It is vital to leave no more than 2–3 cm of catheter within the dura to avoid this. In the combined technique, it is common to inject a relatively small volume for the spinal component, so the problems that can result in a proportion not reaching the subarachnoid space are very relevant, but at least the epidural catheter can be used in attempts to rescue the situation.

Management of failure

Failure of a spinal anaesthetic is an event of significant concern for both patient and anaesthetist even when it is immediately apparent, but it can have serious consequences (clinical and medico-legal) if the problem only becomes evident once surgery has started. If there is any doubt about the nature or duration of the proposed surgery, a method other than a standard spinal anaesthetic should be used. The trainee anaesthetist should avoid over-selling the technique, especially in the early days of unsupervised practice. Promising that all will be achieved by one injection leaves no room for manoeuvre, but offering one injection to reduce pain and a second to ensure unconsciousness does. If a spinal anaesthetic does fail in some way, the management options are limited; so, the first rule is to expend every effort in prevention.

Prevention is better than cure

Having made the decision to use a spinal anaesthetic, the block should be performed with meticulous attention to detail as has been indicated above. It is impossible to over-emphasize this point.

The failed block

The precise management of the failed block will depend on the nature of the inadequacy and the time at which it becomes apparent. Thus, some monitoring of the onset of the block and correct interpretation of the observations are both vital. The slower the onset of either motor or sensory

block, the more likely is the block to be inadequate, so the more detailed this assessment should be. While the onset of spinal anaesthesia is rapid in most patients, it can be slow in some; so, ‘tincture of time’ should always be allowed.¹⁰ However, if most of the expected block has not developed within 15 min, some additional manoeuvre is almost certainly going to be needed. The possibilities, their explanations, and suggested immediate responses are as follows:

- (1) *No block*: the wrong solution has been injected, it has been deposited in the wrong place, or it is ineffective. Repeating the procedure or conversion to general anaesthesia are the only option. If, after operation, the patient has significant pruritus, it is likely that only an opioid was injected.
- (2) *Good block of inadequate cephalad spread*: the level of injection was too low, anatomical abnormality has restricted spread, or some injectate has been misplaced. If a hyperbaric solution was used, flex the patient’s hips and knees and tilt the table head down. This straightens out the lumbar curve, but maintains a cephalad ‘slope’ and allows any solution ‘trapped’ in the sacrum to spread further. A variation with the same aim, but perhaps better suited to the obstetric situation, is to turn the patient to the full lateral position with a head down tilt, reversing the side after 2–3 min. If a plain (and usually slightly hypobaric) solution has been used, it may help to sit the patient up, but beware of peripheral pooling of blood.

If a spinal catheter injection results in inadequate spread, the response should not be to inject more of the same solution because dose has minimal effect on intrathecal spread.²⁰ Either posture should be manipulated as above, or a different baricity of solution should be tried, or the catheter should be withdrawn before the injection is repeated.³¹
- (3) *Good, but unilateral block*: this is most likely because of positioning, but it is possible that longitudinal ligaments supporting the cord have blocked spread. If the operation is to be on the anaesthetized limb, then the surgeon should know that the other leg has sensation, and the patient should be reassured and closely monitored. Otherwise, turning the patient onto the unblocked side if a hyperbaric solution was used (or the reverse for plain solutions) may facilitate spread.
- (4) *Patchy block* (This term is used to describe a block that appears adequate in extent, but the sensory and motor effects are incomplete.): causes of inadequate block are numerous and include all those discussed above, but the most likely explanation is that the local anaesthetic was at least partially misplaced, or that the dose given was inadequate. If this becomes apparent before surgery starts, the options are to repeat the spinal injection or to use a greater degree of systemic supplementation than was planned, the latter being the

only option after skin incision. It may not be necessary to recourse to general anaesthesia, sedation, or analgesic drugs often being sufficient especially when patient anxiety is a major factor. Infiltration of the wound and other tissues with local anaesthetic by the surgeon may also be useful in such situations.

- (5) *Inadequate duration*: the most likely explanation is that for one of several reasons an inadequate dose of local anaesthetic was delivered to the CSF. Alternatively, lidocaine (intended for skin infiltration) was confused for bupivacaine, or the operation has taken longer than expected. Systemic supplementation or infiltration of local anaesthetic may tide matters over, but often the only option is to convert to general anaesthesia.

Repeating the block

Where no effect at all has followed the injection it seems reasonable to repeat the procedure, paying close attention to avoiding the potential pitfalls. In all other situations besides total failure, there must be some local anaesthetic in the CSF already, and anxieties relating to several issues have to be taken into account:

- (1) A restricted block may be because of some factor, probably anatomical, impeding the physical spread of the solution, and it may have exactly the same impact on a second injection, resulting in a high concentration of local anaesthetic at or close to the site of injection. Cauda equina lesions were described after continuous spinal anaesthesia when very restricted spread prompted repeat injections rather than the manipulation of other factors,³⁴ and a similar problem has been described after repeated needle injection.^{14 19}
- (2) Repeat injection, especially in response to a poor quality block, may lead to excessive spread,¹³ so it may be argued that a lower dose should be used to reduce the risk of this possibility.
- (3) A good quality, but unilateral block, might lead to an attempt to place a second injection into the 'other' side of the theca, but the risk of placing the second dose in the same side must be significant.
- (4) Barriers to spread within the subarachnoid space may also affect epidural spread (and vice versa), so an attempt at epidural block may not succeed either.
- (5) A block of inadequate cephalad spread might be overcome by repeating the injection at a higher level, but should perhaps only be attempted when the indication for a regional technique is considerable.
- (6) The final concern, particularly applicable to the last mentioned, but relevant to nearly all situations where a repeat block might be considered, is that the adjacent nerve tissue is already affected by local anaesthetic action so that the risk of direct needle trauma is increased.

Only some of these problems have actually been described, most being in the category of theoretical possibilities, but such concerns do reinforce the view that every effort must be made to ensure that the first injection is fully effective.

Recourse to general anaesthesia

There are many ways in which an inadequate block might be 'rescued', but there is a limit to how much discomfort or distress an individual patient can tolerate, so general anaesthesia must be considered if one or two simple measures have not rectified matters. Common sense and clinical experience are usually the best indicators of exactly when to convert to general anaesthesia, so the unsupervised trainee can be at a disadvantage. However, it is far better to make the decision sooner rather than later and have to deal with a seriously distressed patient. Of course, explaining later why the anticipated technique had not been provided can be difficult. It is another reason why prevention (getting the block right to start with) is the best approach, but it is also a reason for not 'over-selling' the regional approach before operation.

If general anaesthesia is induced to supplement a partially effective spinal anaesthetic, any degree of sympathetic nerve block will make hypotension more likely.

Follow-up initiatives

Clinical follow-up

As with any anaesthetic complication, the details should be documented fully in the notes, and the patient provided with an apology and a full explanation after operation. Giving the patient a written summary of events for presentation to a future anaesthetist can be very helpful, although care should be taken to prevent medico-legal recourse. Rarely, inadequate spread has been the first indication of pathology within the vertebral canal. Therefore, it may be appropriate to look for symptoms and signs of neurological disease, and involve a neurologist if there is any suspicion of these being present.

It is during the follow-up of a patient in whom no block was obtained, the possibility of local anaesthetic 'resistance' may seem an attractive explanation. As has already been noted, much wider consideration of the possibilities, supported by very detailed investigation, is needed than has been the case in previous reports.

Investigating local anaesthetic effectiveness

Spinal anaesthesia is usually a simple and effective technique, but 'failure' can occur at any time and in the hands of any clinician, no matter how experienced. However, if the procedure has, apparently, been routine and straightforward concerns can arise that the current supply of local anaesthetic is defective, especially if two or more such failures occur in the same hospital within a short period of time. The preparations which have been most implicated

are those of hyperbaric bupivacaine (probably because it is the drug used most commonly at present), with drug from both major suppliers, Abbott³⁸ and AstraZeneca,^{8 16 44} being involved. In fact, the chemical stability of the amide drugs and modern standards of pharmaceutical manufacture mean that drug inactivity is a most unlikely cause of a failed spinal anaesthetic, but it remains a possibility which at least has to be eliminated.

As has been suggested, performing skin infiltration with some of the solution intended for the spinal injection should demonstrate that it is effective. If the concern continues the operating theatre, pharmacy and anaesthetic department records should be cross-checked to see whether other practitioners in the hospital have experienced any problems. Similarly, distributors should be able to check whether other hospitals which have been supplied with material from the same batch have reported difficulty. If such enquiries reveal that others are using the same material to good effect, the clinician should consider the advice of those two great authorities, Lee and Atkinson, on 'The spinal that does not take':

All experienced workers have encountered this occasionally even though accepted procedure has apparently been followed. Reflection, however, usually discloses some flaw in technique. In 1907 Alfred E. Barker wrote that for successful spinal analgesia it is necessary 'to enter the lumbar dural sac effectually with the point of the needle, and to discharge through this, all the contemplated dose of the drug, directly and freely into the cerebrospinal fluid, below the termination of the cord' (Barker, 1907). Failure to follow the details of this advice is the commonest cause of a poor result.²⁷

References

- Adler R, Lenz G. Neurological complaints after unsuccessful spinal anaesthesia as a manifestation of incipient syringomyelia. *Eur J Anaesthesiol* 1998; **15**: 103–5
- Armstrong PJ. Unilateral subarachnoid anaesthesia. *Anaesthesia* 1989; **44**: 918–9
- Atallah MM, Shorrab AA, Abdel Mageed YM, Demian AD. Low-dose bupivacaine spinal anaesthesia for percutaneous nephrolithotomy: the suitability and impact of adding intrathecal fentanyl. *Acta Anaesthesiol Scand* 2006; **50**: 798–803
- Barker AE. A report on clinical experiences with spinal analgesia in 100 cases. *Br Med J* 1907; **i**: 665–74
- Batas D, et al. Resistance to local anaesthetics: a case report. http://bj.a.oxfordjournals.org/cgi/qa-display/short/brjana_el;1576
- Ben-David B, Levin H, Tarhi D. An unusual explanation for a failed spinal. *Can J Anaesth* 1995; **45**: 448–9
- Bier A. Versuche ueber Cocainisierung des Rueckenmarkes. *Dtsche Z Chir* 1899; **51**: 361–9
- Calthorpe N. Inadequate spinal anaesthesia with 0.5% Marcaine Heavy (batch DK 2016). *Int J Obstet Anaesth* 2004; **13**: 131
- Carpenter RL, Hogan QH, Liu SS, Crane B, Moore J. Lumbosacral cerebrospinal fluid volume is the primary determinant of sensory block extent and duration during spinal anaesthesia. *Anesthesiology* 1998; **89**: 24–9
- Charlton JE. Managing the block. In: Wildsmith JAW, Armitage EN, McClure JH, eds. *Principles and Practice of Regional Anaesthesia*, 3rd Edn. Edinburgh: Churchill Livingstone, 2003
- Collier CB. Accidental subdural injection during attempted lumbar epidural block may present as a failed or inadequate block: radiological evidence. *Reg Anesth Pain Med* 2004; **29**: 45–51
- Crone W. Failed spinal anaesthesia with the Sprotte needle. *Anesthesiology* 1991; **75**: 717–8
- Deshpande S, Idriz R. Repeat dose after an inadequate spinal block. *Anaesthesia* 1996; **51**: 892
- Drasner K, Rigler ML. Repeat injection after a 'failed spinal': at times, a potentially unsafe practice. *Anesthesiology* 1991; **75**: 713–4
- Gershon RY. Local anaesthesia for cesarian section with a subdural catheter. *Can J Anaesth* 1996; **43**: 1068–71
- Harris RW, McDonald P. Inadequate spinal anaesthesia with 0.5% Marcaine Heavy (batch DK-1961). *Int J Obstet Anaesth* 2004; **13**: 130–1
- Harten JM, Boyne I, Hannah P, Varveris D, Brown A. Effects of height and weight adjusted dose of local anaesthetic for spinal anaesthesia for elective Caesarean section. *Anaesthesia* 2005; **60**: 348–53
- Hirabayashi Y, Fukuda H, Saitoh K, Inoue S, Mitsuhashi H, Shimizu R. Failed spinal anaesthesia: cause identified by MRI. *Can J Anaesth* 1996; **43**: 1072–5
- Hirabayashi Y, Konishi R, Shimizu R. Neurologic symptom associated with a repeated injection after failed spinal anaesthesia. *Anesthesiology* 1998; **89**: 1294–5
- Hocking G, Wildsmith JAW. Intrathecal drug spread. *Br J Anaesth* 2004; **93**: 568–78
- Hurley RJ, Lambert DH. Continuous spinal anaesthesia with a microcatheter technique: preliminary experience. *Anesth Analg* 1990; **70**: 97–102
- Jones MD, Newton TH. Inadvertent extra-arachnoid injection in myelography. *Radiology* 1963; **80**: 818–22
- Kavlock R, Ting PH. Local anesthetic resistance in a pregnant patient with lumbosacral plexopathy. <http://www.biomedcentral.com/1471-2253/4/1>
- Labat G. *Regional Anesthesia: Its Technic and Clinical Application*. Philadelphia, PA: WB Saunders Company, 1922
- Lacassie HJ, Millar S, Leithe LG, et al. Dural ectasia: a likely cause of inadequate spinal anaesthesia in two parturients with Marfan's syndrome. *Br J Anaesth* 2005; **94**: 500–4
- Lang SA, Prusinkiewicz C, Tsui BCH. Failed spinal anaesthesia after a psoas compartment block. *Can J Anaesth* 2005; **52**: 74–8
- Lee JA, Atkinson RS. *Sir Robert Macintosh's Lumbar Puncture and Spinal Analgesia*. Edinburgh: Churchill Livingstone, 1978
- Levy JH, Islas JA, Ghia JN, Turnbull C. A retrospective study of the incidence and causes of failed spinal anaesthetics in a university hospital. *Anesth Analg* 1985; **64**: 705–10
- Logan ML, McClure JH, Wildsmith JAW. Plain bupivacaine—an unpredictable spinal anaesthetic agent. *Br J Anaesth* 1986; **58**: 292–6
- Manchikanti L, Hadley C, Markwell SJ, Colliver JA. A retrospective analysis of failed spinal anaesthetic attempts in a community hospital. *Anesth Analg* 1987; **66**: 363–6
- Morrison LMM, McClure JH, Wildsmith JAW. Clinical evaluation of a spinal catheter technique in femoro-popliteal graft surgery. *Anaesthesia* 1991; **46**: 576–8
- Munhall RJ, Sukhani R, Winnie AP. Incidence and etiology of failed spinal anaesthetics in a university hospital. *Anesth Analg* 1988; **67**: 843–8

- 33** Reynolds F. Case report: damage to the conus medullaris following spinal anaesthesia. *Anaesthesia*. 2001; **56**: 235–47
- 34** Rigler ML, Drasner K, Krejce TC, Yelich SJ, Scholnick FT, DeFontes JA. Cauda equina syndrome after continuous spinal anaesthesia. *Anesth Analg* 1991; **72**: 275–81
- 35** Rubin AP. Spinal anaesthesia. In: Wildsmith JAW, Armitage EN, McClure JH, eds. *Principles and Practice of Regional Anaesthesia*, 3rd Edn. Edinburgh: Churchill Livingstone, 2003
- 36** Schmidt SI, Moorthy SS, Dierdorf SF, Anagnostou JM. A series of truly failed spinal anesthetics. *J Clin Anesth* 1990; **2**: 336–8
- 37** Singh B, Sharma P. Subdural block complicating spinal anaesthesia. *Anesth Analg* 2002; **94**: 1007–9
- 38** Smiley RM, Redai I. More failed spinal anesthetics with hyperbaric bupivacaine. *Int J Obstet Anaesth* 2004; **13**: 131–4
- 39** Stace JD, Gaylard DG. Failed spinal anaesthesia. *Anaesthesia* 1996; **51**: 892–3
- 40** Tarkkila PJ. Incidence and causes of failed spinal anesthetics in a university hospital: a prospective study. *Reg Anesth* 1991; **16**: 48–51
- 41** Thomson GE, McMahon D. Spinal needle manufacture, design and use. *Bailliere's Clin Anaesthesiol* 1993; **7**: 817–30
- 42** Westphal M, Gotz T, Booke M. Failed spinal anaesthesia after intrathecal chemotherapy. *Eur J Anaesthesiol* 2005; **22**: 235–6
- 43** Wildsmith JAW, McClure JH, Brown DT, Scott DB. Effects of posture on the spread of isobaric and hyperbaric amethocaine. *Br J Anaesth* 1981; **53**: 273–8
- 44** Wood M, Ismail F. Inadequate spinal anaesthesia with 0.5% Marcaine Heavy (batch 1961). *Int J Obstet Anaesth* 2003; **12**: 310–1
- 45** Woolard A. Causes of local resistance. <https://www.biomedcentral.com/1471-2253/4/1/comments/comments>