Why obstetric epidurals fail: a study of epidurograms

C. B. Collier
Department of Anaesthetics, Royal Hospital for Women, Paddington, New South Wales, Australia

SUMMARY. In a study of the factors involved in the occasional failure of continuous obstetric epidural blockade, contrast injections through epidural catheters and radiographic screening were undertaken in 35 post-partum patients. The two major causes of inadequate block were found to be transforaminal escape of the catheter tip, and persistent unilateral block associated with an obstructive barrier in the epidural space. Recommendations for overcoming these problems are discussed.

There is a well-recognized failure rate in the establishment of satisfactory continuous epidural blockade. Most reports suggest that this rate is low in general surgical cases, but considerably higher in obstetric patients, even in expert hands, although no direct comparison can be made. The factors involved in the majority of these failures have never been adequately explained, despite previous radiographic investigation, nor have efficient measures been introduced to overcome them. The following work is an attempt to remedy the situation, with the aid of contrast injections and X-ray studies.

PATIENTS AND MATERIALS

This study was undertaken at the Royal Hospital for Women over a 3-year period involving 35 patients in labour or undergoing caesarean section. The project was approved by the Hospital Ethics Committee, and informed written consent obtained from all agreeable patients. At the commencement of the study, 10 patients who had undergone satisfactory epidural blockade were enrolled, so that a collection of 'normal' epidurograms could be obtained. Thereafter, women with atypical blocks were recruited, as soon as possible after delivery, and their epidural catheters left in situ.

The majority of the catheters had three lateral eyes in standard or closer configurations, although one catheter with a single terminal eye was included. All were Portex catheters inserted through disposable 16 gauge Tuohy needles (length 105 mm) in the midline using a loss of resistance to air technique. The X-rays were performed in the Radiology Department at the earliest convenient time post-partum, using a bucky table with image intensification, usually within 1 h of delivery, although in four cases there was a delay overnight, with a maximum interval of 18 h. Fluoroscopic screening was undertaken with the patient initially supine, and then in the left lateral position, with radiographic plates being exposed in both planes.

The radiopaque contrast used was the triiodinated non-ionic water soluble medium lohexol (Omnipaque), in 300 mg/ml concentration. A dose of 10–13 ml of contrast, depending on the patient's height and the observed pattern of filling, was given over 2–3 min through the epidural catheter without a filter. Any adverse effects on the patient were noted and the catheter was then removed from the labour ward cases and inspected. The post-operative catheters were left in place for continuous infusions.

RESULTS

A total of 35 epidurograms were completed, including the 10 control patients. Of the 25 atypical cases investigated, 18 represented unsatisfactory blocks, and the other seven were complicated blocks including a continuous subdural, and cases of subarachnoid and high epidural block.

The 18 cases of unsatisfactory block were divided...
into three groups based on the history and X-ray findings, and represented catheter escape (four cases), unilateral (11 cases) or incomplete blocks (three cases). Incomplete block has been defined as persistent failure to block sufficient either caudal or cephalad segments, or occasionally both. These figures do not represent the relative incidence of the various complications, as many cases of escape were obvious clinically and not investigated. Furthermore, several patients declined to participate in the study, whilst others could not be included because of time constraints, or because the offending catheter had been removed.

No major side-effects resulted from the contrast injections in this study. One patient complained of a transient mild burning sensation in her back during epidural injection, but symptoms subsided completely within two minutes, without sequelae.

The normal epidurogram

The 10 studies following clinically satisfactory block allowed the compilation of a normal epidurogram profile, which will be briefly described.

In the AP view (Fig. 1), the contrast was seen to spread over approximately six vertebral levels, typically four or five segments above the injection site and one or two below. The characteristic appearance was of a central contrast column much denser in its lateral aspects than medially, with contrast continuing along
the spinal nerves through the intervertebral foramina for a variable distance. Typically, some root spill appeared at most of the vertebral levels outlined with contrast, producing the classical ‘Christmas-tree’ appearance.

In the lateral view, the marked anterior and posterior layers of contrast were usually obvious. The anterior layer was not uniform in its width, as behind an intervertebral disc it tended to be narrow, with enlargement behind the centre of the vertebral body. The posterior contrast band tended to be wider than the anterior, with a light mid-zone between the two, containing the foramina with their nerve roots usually outlined by contrast.

1. TRANSFORAMINAL ESCAPE (OR ‘TOO MUCH CATHETER’)

Patients in this group, in whom the catheter escaped from the epidural space through an intervertebral foramen, developed the poorest nerve-block in the whole study. Because the problem is readily preventable and often easy to correct it assumes increased importance. Four such patients were studied. The usual clinical story was of a straightforward epidural puncture and catheter insertion in the labour ward, but the first one or two doses of local anaesthetic produced either no nerve block at all, or only a limited unilateral block confined to one or two of the adjacent L 1.2.3. dermatomes, with only minimal localized pain relief, occasionally accompanied by unilateral lumbar sympathetic block or moderate quadriceps weakness. Often, particularly in early labour, the block of the L1 dermatome alone was sufficient to produce unilateral analgesia for a short period of time. On many such occasions it was evident that the extent of the block had not been accurately assessed, and the situation falsely labelled as a ‘unilateral block’ or a ‘missed segment’, as the patient’s pain was predominantly one-sided and confined to a small area on the totally unblocked side. A true ‘missed segment’ is extremely rare in our practice. Two characteristic cases are described below.

Case 1

In this patient the epidural catheter had been inserted at L2-3 erroneously leaving the 18 cm mark at the skin (the depth of the epidural space was not recorded), and only analgesia in the right lower abdomen (L1) had resulted, following three doses of bupivacaine 0.375% over 2 h (total 35 ml). The AP epidurogram (Fig. 2) showed the catheter emerging through the right L3 intervertebral foramen, and a ‘psoasgram’, with the contrast clearly outlining the psoas muscle. The lateral view revealed most of the contrast to be anterior to the psoas, with none in the epidural space. The very limited analgesia that developed resulted from local anaesthetic diffusing through to the lumbar plexus within the posterior part of the psoas muscle, in front of the transverse processes of the lumbar vertebrae. The catheter was withdrawn by 9 cm and another 5 ml dose of contrast was injected, but this failed to deliver any contrast into the epidural space.

Case 2

This case was unusual in view of the extremely shallow depth of the epidural space, and bilateral escape. The patient was of slight stature (height 150 cm, weight 51 kg), the L3-4 epidural space was located at a depth of only 2.5 cm and the catheter inserted to leave 3.5 cm in the space. A dose of 10 ml bupivacaine 0.375% produced only a left thigh block (L2-3), which could not be improved by withdrawing the catheter by 1 cm and administering a further dose.

The catheter was removed and another inserted 2.5 cm into the epidural space at L2-3 (depth of the epidural space now 2.75 cm). A dose of 8 ml bupivacaine 0.375% produced good pain relief for labour with a T9 sensory level, but a heavy right leg and only a reasonable block for forceps delivery 90 min later.
The epidurogram (Fig. 3) revealed the catheter to be emerging through the right L2 intervertebral foramen with the characteristic psoas shadow, together with limited and patchy epidural filling.

In none of the four cases of escape did the operator report the presence of unusual or excessive paraesthesia on catheter insertion.

2. UNILATERAL OR MISSED SEGMENT BLOCK

Unilateral and missed segment block are considered together here, for clinically they are frequently mistaken for one another, often as a result of poor assessment of the area of nerve-block. A missed or unblocked segment has been defined by Ducrow as an area in which analgesia is absent, whilst present above and below. In this series there was only one case classified as a missed segment block; that being a failed caesarean section involving a catheter with blocked eyes (described later). However, what we were most commonly asked to review was a labouring patient with unsatisfactory analgesia labelled as 'a missed segment or patchy block', only to discover an individual with a totally unilateral block who had developed pain in a small area of the unblocked side, usually involving one or two of the T10, T11 or T12 dermatomes, depending on the progression of the labour. In these situations a brief check on the temperature of the patient's feet usually revealed the cold vasoconstricted extremity of an unblocked side, before formal sensory testing was undertaken. This virtually always excluded the diagnosis of a 'missed segment'. Although most of these 'patchy blocks' were the result of a purely unilateral block initially, some degree of bilateral spread of analgesia was usually obtained after one or two further doses of local anaesthetic, often combined with partial catheter withdrawal.

The epidurogram findings on the 11 patients with inadequate blocks in this group, were further divided into three categories, as being attributable to (a) a midline anatomical barrier (five cases), (b) spinal deformity (two cases) and (c) catheter malfunction (four cases).

(a) The midline barrier and its connections

Our five cases of unilateral block would tend to support the view that the flow of local anaesthetic and contrast media is restricted to one side by the existence of an obstructive barrier in the epidural space. Whether this barrier represents 'the dorsomedian connective tissue band' (Blomberg), the dorsal midline septum ('plica mediana dorsalis', Savolaine et al), a distended midline pedicle (Hogan et al) or simply the epidural fat, is a contentious issue.
Why obstetric epidurals fail

Case 3

This patient scheduled for elective caesarean section, underwent uncomplicated epidural puncture at L3-4, but following a total of 25 ml lignocaine 2% with adrenaline, the block remained left-sided (to T4). The catheter was reinserted at L2-3 and following a further 14 ml of local anaesthetic, a patchy right-sided block developed. Despite the imperfect block, the patient was keen to remain awake for surgery, and was comfortable except during uterine manipulation when moderate, but shortlived, central abdominal pain was experienced.

Epidurogram the following day revealed the tip of the catheter to be at L3, in the midline (Fig. 4). The AP view showed the totally left-sided spread of contrast, from L1-L5, with a virtual straight line separating the unblocked right side. This was the only case with a suspected septum where the contrast remained entirely unilateral. In the lateral view the contrast was seen to lie mostly posteriorly, with a fairly empty anterior space, with a very attenuated band of contrast.

Case 4

The second case in this group involved a patient in her second labour. She reported that her previous epidural had remained largely right-sided, with only limited pain relief on the left. A similar situation developed on this occasion following puncture at L2-3, with 6 cm of catheter in the epidural space. The right side was blocked to T10, but the left side only below L4, following 16 ml of bupivacaine 0.5% with fentanyl 50 mcg. Withdrawal of the catheter by 3 cm and a further 5 ml did not improve the block. It was not until an additional 10 ml had been given and 20 min elapsed that satisfactory bilateral block developed. This provided adequate analgesia for caesarean section.

Screening of the AP epidurogram revealed the catheter tip at L3, and the first 9 ml of contrast to be entirely on the right side. The following 4 ml spread to the left, from above downwards. The film showed the predominantly unilateral spread from T12 to S1, with the suggestion of a straight midline border from L3 to S1 (Fig. 5). In the lateral aspect the middle zone was almost completely free of contrast above L5, with marked anterior and posterior columns. This appearance was suggestive of a dorsal midline barrier between T12 and L4, with a broad dorsolateral extension producing the central filling defect. The exact position of the catheter tip could not be determined.

Case 5

The third case from this group was managed differently, as described by Nunn and MacKinnon. A catheter ('lower') had been inserted in this patient in early labour at L3-4, with 3 cm entering the epidural space. Despite 20 ml bupivacaine 0.375% and the usual adjustments, the block remained unilateral on the left. A second catheter was then inserted at L2-3 ('upper'), to a similar depth, and increments of bupivacaine injected. It was not until a further 15 ml had been given over 20 min, that satisfactory bilateral block developed.

The epidurogram (Fig. 6) revealed that the first 10 ml of contrast given through the lower catheter produced only a left-sided peripheral spread (with some extravasation of contrast along the catheter to the skin). The first 4 ml through the upper catheter was also left-sided, with a further 2 ml finally appearing on the right as recorded. The lateral view revealed the spread of contrast to be fairly uniform across the epidural space, suggesting a midline barrier without lateral extensions.
Fig. 6 AP radiographs. Left: unilateral spread with marked root-spill after contrast (10ml) through lower catheter. Right: after 6 ml through upper catheter, limited spread to the right occurs. (Extravasation to skin is arrowed)

(b) Spinal Deformity; Scoliosis

Two patients developing unilateral block were noted from their X-rays to suffer from scoliosis of a fairly minor degree (asymptomatic). No spinal abnormalities were noted by the operators prior to block being initiated. One case is described below.

Case 6

This patient developed a persistent right-sided block in labour, following a straightforward epidural puncture at L2-3 and the injection of 5 ml bupivacaine 0.375% through the Tuohy needle, followed by another 15 ml through the catheter, which was inserted to a depth of 3 cm in the epidural space. Good analgesia up to T9 developed on the right after 10 min without motor block, but the left side was totally unblocked, even after a further bolus of 6 ml was injected in the left lateral position. Repeat puncture at L3-4, with the addition of 16 ml lignocaine 2%, produced no improvement and intramuscular analgesia was required.

The AP epidurogram, following delivery, showed a thoracolumbar scoliosis, with a primary curve to the left (Fig. 7). Rotation of the lower thoracic spinous processes was clearly visible. The epidural catheter could be seen at L4, with its tip well to the right of the midline, and contrast confined to the right side of the spinal column, with good right-sided root filling between T10 and the sacrum. The lateral view was unremarkable.

(c) Catheter Malfunction

A further four cases of unilateral or missed segment block were studied, and in the apparent absence of any of the predisposing factors mentioned above, were grouped together under the general heading of 'catheter malfunction'; these included blocked eyes (two cases), the use of a terminal eye catheter (one case) and lateral catheter insertion (one case).

Blocked catheter eyes

Two catheters had to be replaced during this study when blood-clot occluded all three eyes. Another case with a predominantly unilateral spread of analgesia (and contrast) was found to have a catheter with only one eye patent to saline flush, the other two being occluded by clot. One unusual cause of blockage was seen.
Why obstetric epidurals fail 25

Case 7
The catheter was removed from this patient following a failed awake caesarean section with a missed segment at T12 bilaterally. Testing with a saline flush revealed only the proximal of the three lateral eyes to be patent. Microscopic examination revealed the presence of some debris blocking the lumen of the catheter, between the proximal and middle eyes. Aspiration of saline through the catheter caused the debris to move more proximally, where it was photographed (Fig. 8) and then excised. The nature of this hard white material could not be ascertained but it was presumed to be a fragment of nylon 'swarf' remaining after eye drilling in manufacture, and the resulting obstruction may have accounted for the unsatisfactory block, as almost certainly only one small catheter eye was patent during labour and surgery.

Terminal Eye Catheter
Case 8
Use of a terminal eye catheter was associated with a predominantly left-sided block and persistent right abdominal pain throughout labour. X-ray screening revealed the catheter tip to be in the midline with an extensive narrow left-sided lateral column of dye from T2-L4 (Fig. 9), although there were no symptoms of a high block. A smaller volume of contrast was present on the right, but only from T10-L3 with free spread across the midline. The lateral view was unremarkable apart from the high, mostly posterior spread of the column of contrast. In the absence of any evidence of skeletal abnormality, anatomical barrier or catheter misplacement, the cause of this predominantly unilateral block was suggested as being maldistribution of the local anaesthetic through the single terminal eye of the catheter. This particular type of catheter had given us considerable trouble with unsatisfactory blocks in labour and for Caesarean section in a previous study,11 with as many as 8% having to be resited.

Lateral Catheter Placement
Case 9
Another predominantly unilateral block seemed to result from a misdirected catheter in labour. Even after repeated boluses, analgesia on the right side was poor and patchy, and never above T12. An epiduro-
gram showed the catheter tip to be laterally placed to the left at the L3 level, whilst the spread of contrast and root filling although bilateral, was far more marked on the left.

3. INCOMPLETE BLOCK

Three cases appeared to fall into this category, in which there was persistent failure to block sufficient caudal or cephalad segments or both. The term 'incomplete block', was derived from the work of Michael et al. although no explanation as to its causation has been proposed. In the first two cases an anatomical obstruction to the spread of epidural contrast was detected.

Incomplete Block with Abnormal Epidurogram

Case 10

The first case involved a patient in her second labour who reported a successful epidural two years previously. On this occasion however, block at L3–4 produced good analgesia from T9–L5 bilaterally, but no sacral spread, leaving the patient distressed with marked perineal pain, despite three top-ups (28 ml) of 0.375% bupivacaine with fentanyl, two in the sitting position. The catheter was removed and replaced in the L2–3 space, and following a further 12 ml the block now extended on the right side to T4, but there was only patchy sacral block, and a dull pain persisted throughout labour.

Screening of the AP epidurogram showed the catheter tip at L3 in the midline and contrast present from T8–L5 bilaterally, with a highly unusual appearance in that there was minimal nerve-root filling, whilst the central column of dye was fairly amorphous with scalloped edges and contained many air-bubbles (Fig. 10). The lateral view revealed that most of the contrast had flowed posteriorly, with a mass of air-bubbles anteriorly. The combined radiographs suggested that the contrast was largely confined to the posterior epidural space bilaterally.

Case 11

The second patient received an epidural puncture at L4–5 in labour, and developed a very limited bilateral block between T11 and L4. Upper abdominal pain persisted throughout early labour, and perineal discomfort was a problem later, with no sacral block developing, despite five top-up doses of 2% lignocaine with adrenaline (total 60 ml) being given over 6 h. The operator reported that the catheter could not be threaded upwards and that the Tuohy needle had been rotated through 180° and the catheter inserted caudally (not a recommended manoeuvre). The epidurogram was almost identical to the previous case.

Incomplete Block with Normal Epidurogram

Case 12

The third patient was a heroin addict, receiving regular methadone, who only developed incomplete and patchy analgesia after two epidural punctures and a total of 55 ml lignocaine 2% for caesarean section. Following a normal epidurogram, her post-operative infusion of bupivacaine and pethidine failed. The aetiology of this unsatisfactory analgesia was unknown, although the development of a competitive block at the spinal cord receptor level was postulated.

DISCUSSION

A recently published study of over 17 000 continuous epidural blocks in general surgical patients revealed a failure to attain adequate analgesia at the first attempt in 4.1%. This figure was reduced to 0.3% following repeat punctures. The incidence of initially unsatisfactory blocks in obstetric patients has usually been reported to be far greater, ranging from Ducrow with 8% to Michael et al with 23%, with a small but significant number of failures persisting, even follow-
ing various ‘adjustments’ such as partial catheter withdrawal, additional doses of local anaesthetic, change of posture and finally repeat puncture.

Our own figures, based on almost 2000 blocks annually, are similar to those of Ducrow, with a 7–8% initial failure rate, falling to a 2% incidence of persistent failure. On the basis of the 18 cases of unsatisfactory obstetric block investigated here, three clinical entities appear to exist.

1. TRANSFORAMINAL ESCAPE

This scenario, described above, is so typical that we did not feel justified in investigating radiographically more than four patients presenting in this manner. The relevant history and physical signs should be easily elicited and corrective measures taken, for this situation has been recognized since the paper by Iklé in 1952. Indeed, his communication, supported by others, suggested that no more than 3 or 4 cm of catheter should be inserted into the epidural space, a prudent recommendation that seems to be frequently overlooked these days.

Sanchez et al reported a 7% incidence of transforaminal escape on X-ray when 12.5 cm of catheter were inserted, and noted that longer lengths of catheter tended to curl up near their point of insertion, rather than running straight in their direction of insertion. Another radiological study, by Bridenbaugh et al, reported a 4.5% incidence of escape when 5 or 10 cm of catheter was inserted into the epidural space. Moir and Willocks however, produced quite different findings, being only able to detect a 1% escape rate in their study based solely upon clinical findings.

A figure of approximately 6% would represent a current assessment of our own ‘escape rate’, based on the data derived from our labour ward statistics (involving all grades of anaesthetists) prior to the start of this study, when epidural catheters were usually being inserted to leave between 2 and 6 cm in the space. It was estimated that only about half of our cases of escape were successfully treated during the course of the block, by catheter withdrawal to a more suitable length and further local anaesthetic injection; the mechanism presumably being that although the catheter tips were now correctly positioned, the subsequent dose of local anaesthetic (or contrast) followed the path opened by the errant catheter and previous dose, out of the epidural space.

Whilst the majority of our cases of escape developed some degree of lumbar plexus block, it is interesting that in only one was sympathetic block detected, although the lumbar sympathetic trunk is situated adjacent to the medial margin of the psoas and seemingly accessible to escaping local anaesthetic. Case 2 was fairly unique in displaying bilateral foraminal escape, and serves to stress two points. Firstly, that the depth of the epidural space may be less than previously reported, and secondly that even 2.5 cm of catheter in the epidural space of an adult may be too great a length. We recommend that no more than 2–4 cm of catheter be inserted into the epidural space in any adult patient. The depth of the epidural space and the length of catheter inserted should always be determined, either by direct observation or derived by Doughty’s method, and the figures recorded in the notes.

If the block remains unsatisfactory after catheter withdrawal and a further dose of local anaesthetic with the unblocked side dependent, then the epidural should probably be resited in an adjacent interspace, inserting a shorter length of catheter, perhaps with a change of technique, as the paramedian approach has been shown to encourage the catheter to pursue a straight course in the epidural space. Indeed, some authorities recommend the use of the paramedian approach for all obstetric epidural blocks.

Although the original placement of the catheter is usually at fault in cases of escape, it remains possible that catheters may migrate inwards, as demonstrated by Bishton et al, who recorded an inward catheter migration of 1 cm or more in 14% of their obstetric patients. They could however, only attribute one case of unilateral block to inward migration in 153 patients, and postulated that the other inwardly migrating catheters simply coil up in the subcutaneous tissues. Secure strapping appears essential.

We were unable to confirm the finding of Hehre et al who recorded a high incidence (43%) of nerve-root paraesthesia during the insertion of ‘escaping catheters’, and we do not consider the occurrence of paraesthesia to be a diagnostic criterion. Transforaminal escape has only been detected by us in obstetric patients. With experience of several thousand epidural blocks for general surgery, we have not encountered this complication clinically, nor recognized it radiographically, outside the obstetric arena. The distortion of the epidural venous system in pregnancy may be a causative factor.

2. UNILATERAL OR MISSED SEGMENT BLOCK

Our labour ward statistics suggest that this group accounted for only about half as many initially inadequate blocks (3% of all patients) in our hands, as transforaminal escape (6%). However, in both groups almost 50% of the blocks remained inadequate
throughout labour and delivery, despite corrective measures.

The problem of unilateral block has been widely reported, whilst missed segments have attracted less attention, although Ducrow\(^2\) detected a high (6.7\%) incidence of unblocked segments in labouring patients, which was persistent in 1.5\%, when 0.25\% bupivacaine were being used. Usually only one segment was involved in each patient, but in 15\% two segments were unblocked. Occasionally there were bilateral unblocked segments. Ducrow also reported a 1.5\% incidence of unilateral block, but suggested no theories to account for these inadequate blocks.

Our findings suggest that a true missed segment is very rare in labour, whilst unilateral blocks are far more frequent. The occurrence of a missed segment is sometimes reported during cesarean section when breakthrough pain develops in a single dermatome, but assessment is difficult in the surgical patient, who has presumably demonstrated satisfactory analgesia to pinprick in that segment preoperatively. This discussion will therefore focus on unilateral block.

Hehre et al\(^3\) produced an early radiographic study of epidural failure in 1960, but they only filled their epidural catheters and not the surrounding area with contrast. Most of their failures resulted from technical errors with the majority of catheters not being in the epidural space. In 1970, with improved techniques, Usubiaga et al\(^22\) undertook a similar study to ours involving contrast injection and considered that ‘congenital or acquired midline adhesions between the dura mater and the lamina may act as diffusion barriers’, and also that a catheter tip positioned in the anterior epidural space was more likely to lead to a unilateral block ‘because of anterior midline trabeculations’. Our findings would support their first statement, while the second remains unproved.

(a) The midline barrier and its connections

Our five cases of unilateral block appeared to result from maldistribution of local anaesthetic by a barrier of an unconfirmed nature. It is interesting to note that several of our patients have reported identical unilateral block in successive pregnancies, including two in this series.

It seems odd that Hogan and his co-workers\(^9\) could argue against the existence of such obstructive barriers, when Blomberg\(^7\) has directly visualized ‘the dor-

somedian connective tissue band’ through an epiduroscope. Hatten\(^23\) has produced evidence, similar to ours, of isolation of injectate to a single half of the posterior epidural space, and Savolaine et al\(^8\) having studied 40 patients with CT scanning after contrast injection, have concluded that ‘all 40 patients showed the posterior epidural space to be divided by the dor-
sal midline septum and an additional transverse connective tissue plane’. Furthermore, Savolaine et al\(^8\) used cadaver dissection to demonstrate that these planes or septae were true membranous tissue planes extending laterally from the midline septum and not artefacts produced by the contrast or CT technique. The transverse or dorsolateral septa divide the poste-
rior epidural space into anterior and posterior com-
partments, where epidural catheters could go astray.

On the other hand those workers who claim not to have distorted the local anatomy with contrast, resins or telescopes have produced different results. Hogan\(^24\) and Hogan et al\(^9\) undertook cryomicrotome and rapid fixation techniques in cadavers, believing the freezing process allowed detailed examination of epidural anatomy without disruption. Their findings were, ‘that the posterior epidural fat appears notably free of any septation or internal structure’. Many artefacts undoubtedly occur, for although most epidurograms performed by radiologists utilizing the sacral approach demonstrate the septum clearly,\(^25\) those performed by anaesthetists using the lumbar approach rarely outline such a structure.

Hogan\(^24\) and Hogan et al\(^9\) suggest that instead of a septum we are seeing ‘a distended midline pedicle’ which carries the blood supply to the dorsal fat pad, and that a Tuohy needle will frequently pass through the pedicle into the posterior epidural space if the midline approach is used. This may account for the occasional absence of loss of resistance and difficulty in threading a catheter when the epidural space has been penetrated. These workers dismiss Blomberg’s findings during cadaver epiduroscopy\(^7\) as representing deformation of the posterior fat pad. The findings of Savolaine et al\(^8\) are rejected as being artefactual, because of the high injection pressures generated in the epidural space, and their fresh cadaver findings are similarly dealt with as being disruptive of the balance of forces within the semifluid epidural fat.

Adding to the confusion, Savolaine,\(^26\) and Gaynor\(^27\) reported that using MRI, they could not detect the plica, but this is not surprising if it is considered that fibrous bands ‘would need to be 2–3 mm thick to be apparent’\(^27\) and the whole epidural space is only of the order of 5 mm in depth.

Hogan\(^24\) concludes that the midline fat and its pedicle with lateral attenuations function as an inconstant partition. Although the argument may continue for many years, it does appear that most workers accept that a barrier to free flow in the dorsal epidural space does exist in some patients, as we have demonstrated. The summary by Blomberg\(^7\) following epiduroscopy would appear to encompass the whole spectrum of findings: ‘in every case, there was a dorsal connective
tissue band in the midline of the epidural space. The appearance of the band varied from strands of connective tissue to a complete membrane (in 2% of cadavers). The membranes were found to extend vertically over at least two lumbar segments, which was as far as could be visualized with the epiduroscope.

The septal barriers we have demonstrated have been incomplete in all five patients, in that increased volumes of either local anaesthetic or contrast have eventually reached the unblocked side, so that the judicious use of fractionated doses of local anaesthetic will often prove successful if time allows. The radiographic studies have confirmed that as the volume of injectate increases, and two or three vertebral spaces become filled, the contrast usually spreads slowly around either the cephalad or caudal end of the septum to the other side.

The management of a unilateral block may be difficult and time-consuming, but partial withdrawal of the epidural catheter and a further dose or two of local anaesthetic (up to 30 ml) often of increased concentration, combined with an opioid and perhaps a change of posture is usually recommended first. If this fails, the catheter may be withdrawn and the block resited. If however, any analgesia has developed on the contralateral side then it is probably worth persevering with the initial block by the addition of small incremental doses, to cross the barrier.

Should the epidural puncture need to be repeated, it may be worthwhile to leave the original catheter in place, as this has been shown to be helpful in overcoming unblocked segments in patients with disc disease. It is possible that the second catheter might be inserted on the other side of the septum. A different approach to the epidural space, whether paramedian or midline, for the second catheter, might prove advantageous in the presence of a septum.

(b) Spinal Deformity; Scoliosis

Our two cases of unilateral block in the presence of fairly minor degrees of scoliosis were unexpected, although it is well known that more severe deformity may be associated with failed or patchy blocks.

Epidural spread was directed away from the primary scoliosis in both cases, with presumably both bony and soft tissue abnormalities accounting for the unusual distribution of epidural solutions in these cases. In one case the catheter itself was deflected away from the midline, in the other only the epidural solution was displaced.

Although scoliosis is only a fairly rare cause of epidural inadequacy, it may be impossible to overcome, as in Case 6, the only patient in the entire series in whom it was impossible to obtain any degree of bilateral nerve-block, with the contrast material also being confined to one side. Similarly, difficult and inadequate blocks are seen following surgical correction of scoliosis and other spinal deformities where scar tissue and bone grafts may disrupt the spread of local anaesthetic.

(c) Catheter malfunction

Blocked catheter eyes

The type of epidural catheter used, and particularly the number, configuration and patency of its eyes, as well as differential eye flow has attracted little attention in relation to inadequate block, except where the terminal eye catheter has been used in obstetrics. The possible role played by blockage of catheter eyes by blood clot and fibrin is now being investigated.

Terminal eye catheter

In a previous study comparing lateral eye with terminal eye catheters in obstetric use it was found that the incidence of unsatisfactory blocks with the terminal eye was unacceptably high (32%), when compared to lateral eyes (12%), with unilateral and missed segment blocks comprising the majority of the failures. This was attributed to the poor lateral spread of injected solutions, as they tend to form a single unidirectional stream away from the tip, as opposed to the three streams separated by arcs of 120° from the lateral eye catheters. Our limited results and other studies suggest that with terminal eyes there tends to be increased longitudinal spread of epidural solutions at the expense of lateral spread, reflecting the inadequate analgesia often obtained, particularly in obstetric patients. We no longer use terminal eye catheters in parturients.

Lateral catheter placement

It appears that catheters heading laterally towards the intervertebral foramina, but of insufficient length to escape, may end up with their tips in a lateral pocket of the epidural space, which is not conducive to effective bilateral spread. Directing the Tuohy needle laterally for catheter insertion is not recommended.

3. INCOMPLETE BLOCK

Incomplete block with abnormal epidurogram

The common feature in both of our cases of incomplete block was the most unusual X-ray picture. An identical radiograph has only been seen by us once before, and that was in the case described by Boezaart and Levendig, whose labouring patient developed a
persistently missed segment in the right groin, which they attributed to a large air bubble seen overlaying the right T12-L1 region on the epidurogram. Whilst it is thought that the presence of excessive volumes of air bubbles in the epidural space can possibly impede the actions of local anaesthetic agents, it seems an unlikely explanation in our two cases, even though the sacral roots can be notoriously difficult to block, and the loss of resistance to air test had been used with relatively large volumes of air. It was more likely that the posterior epidural distribution of the contrast was the significant factor, for if this reproduced the spread of local anaesthetic/opioid mixture, then little would have flowed anteriorly to reach the nerve roots at the intervertebral foramina, especially in the lower lumbar and sacral areas, where the anterior spread of contrast was at its least.

It seems reasonable to surmise that the tips of the epidural catheters in these two cases were positioned in a posterior compartment of the epidural space, behind a dorsolateral extension of a partial midline barrier. Flow across the midline was seen to be unimpeded. The factors that direct the catheter tip towards the posterior epidural space can only be surmised, but low catheter insertion may contribute, and it is suggested that the L4-5 space not be used in obstetrics and catheters be only directed cephalad.

Incomplete block with normal epidurogram

It is difficult to determine the precise pattern of events in this poorly-blocked patient, who was taking heroin and methadone in pregnancy. Whilst tolerance to epidural opioids would be expected in this case, it is interesting to surmise whether there might be a change in susceptibility to local anaesthetic blockade in the addicted patient, perhaps at the receptor level. Aviles et al. have proposed that following opiate withdrawal, hyperalgesia results from activation of a specific descending modulatory system, mediated partly by spinal cord kappa and alpha-2 adrenergic receptors, and attenuated by clonidine. In addition, Golomb et al. have shown that whilst rabbits developed tachyphylaxis to repeated epidural bupivacaine, no tolerance was seen after repeated intrathecal application. They attributed this to a decrease in drug availability at the epidural receptor sites. We may have been observing clinically a combination of both these effects.

As with many previous workers, we have been unable to establish a precise correlation between the spread of epidural contrast and the extent of nerve-block, although a loose relationship appeared to exist in the majority of cases, even allowing for the different volumes of local anaesthetic and contrast used in most of the patients and the viscous nature of the contrast medium. Also, allowance must be made for possible catheter movement in the time between block insertion and investigation. Even so, the epidurogram results have provided interesting data and the appearance of some marked anomalies has enabled us to differentiate some of the factors involved in inadequate blockade, of which transforaminal catheter escape and the presence of obstructive barriers in the posterior epidural space appear to be the most important.

ACKNOWLEDGEMENTS

The author would like to thank Portex (UK) Ltd for their support and supply of epidural catheters; Dr Finn Tohver, Neuroradiologist at Prince Henry/Prince of Wales Hospitals for his expert advice, and Annette Collet and the Department of Medical Imaging at The Royal Hospital for Women for their assistance.

This work was derived from a study submitted as an MD thesis to the University of New South Wales, and presented in part to the 1994 AGM of the Australian Society of Anaesthetists.

REFERENCES