1.1 The history of epidurography

Sicard and Forestier introduced epidurography in 1926 as an X-ray diagnostic method using Lipiodol (Fig. 1.1) and they later developed myelography. Early attempts by anaesthetists to correlate the physical spread of solutions in the epidural space with the extent of the observed nerve block met with only limited success, due largely to the highly viscous nature of the contrast used. In 1940, Odom used Lipiodol mixed with procaine in the epidural space and found that his initial X-rays showed only longitudinal spread of contrast, but films at 15–30 min, coinciding with the onset of block, showed lateral flow through the intervertebral foramina. He concluded that the epidural site of action was the spinal nerves in the paravertebral space. It was not until 1954 that Bromage, using a similar technique, was able to demonstrate satisfactory nerve block in the absence of transforaminal flow.

In 1959, Nishimura et al. injected epidural lignocaine (lidocaine) mixed with radioactive iodine 131 and traced the spread with a scintillation counter, mostly in a cephalad direction. The segmental spread of analgesia approximately corresponded to the spread of radiation. In 1968, Shanks reported similar findings based on epidurograms in four patients who had developed unilateral block, and concluded that the spread of the radio-opaque dye meglumine iothalamate (Conray) did not necessarily mirror the spread of the local anaesthetic solution and the resulting nerve block. Shanks, however, employed only very small (3 mL) volumes of the dense contrast, which were insufficient to satisfactorily demonstrate epidural spread. Many recent studies on the flow of epidural dye have also used small-volume contrast injections (3–5 mL), which often do not allow for accurate extrapolation of the precise distribution of the full volume of local anaesthetic solution that would have been used clinically (i.e. approximately 10–20 mL).

In 1973, Burn et al. reported on epidurograms in 56 patients; they found that the volume of epidural solution and the site of its injection were the most relevant factors in its distribution. The rate of contrast injection and the age, height and posture of the patient had little relevance. In the same year the first generation of non-ionic water-soluble contrast media became available in the form of metrizamide (Amipaque), and correlation between epidurogram and extent of nerve-block could now be made with some confidence in individual patients. However, even today with our current contrast media the exact segmental distribution...
INTRODUCTION: WHY INVESTIGATE ATYPICAL EPIDURAL BLOCKS?

1.2 Patient selection

The data in this book have been accumulated over the past 30 years, and we have performed 178 thoracolumbar epidurograms in 173 individual patients, involving 146 obstetric, 27 gynaecological and 5 general surgical cases, aged between 17 and 81 years (Fig. 1.2). Ethics committee approval was received prior to the commencement of this study, and written informed consent obtained for the first 90 studies. After that, with the technique being well established, only verbal consent was requested. All patients happily agreed to have their case histories recorded, and a few also consented to having their clinical photographs published. Only a handful of patients declined to participate in this study, with the majority of individuals being very interested in learning why their epidural had ‘gone wrong’, and wanting some reassurance that it would not happen again. Only three patients with iodine allergy were judged unsuitable for investigation.

A total of 46 patients, including 14 obstetric patients, were recruited following satisfactory epidural block to enable us to build up a profile of the normal epidurogram using different types and gauges of epidural catheter. A group of 32 obstetric patients was studied following blocks that had developed major complications, sometimes with block failure. Another 100 obstetric patients were investigated following inadequate blocks. In almost all of these 132 cases of atypical blocks, epidurography clearly revealed the nature and extent of the underlying problem, and advanced our knowledge of the spread of epidural, subdural and intradural injections. The majority of the abnormal obstetric blocks (78) were detected in labour, with the remainder (54) arising at caesarean section, in both elective and emergency cases.

1.3 Management of failed blocks

When all adjustments, such as change of patient position and withdrawal of the epidural catheter by 1–2 cm, together with additional doses of local anaesthetic, had failed to overcome an unsatisfactory block, our usual procedure, before the start of this study, was to remove the first epidural catheter and insert a second, usually in an adjacent interspace, although a subarachnoid block was occasionally used. We then started to request that our colleagues leave the first catheter in situ for later investigation. There have been no problems associated with this practice, despite the commonly expressed fears that passage of the second epidural needle might damage the first catheter, or that two epidural catheters might become knotted together.

Although it is often found following a unilateral block that the tips of both catheters are displaced laterally to the same side by a septum, or other cause, occasionally the catheter tips are located on either side of a septum and injection through both is required for satisfactory block to develop. In this situation, two catheters are essential for adequate block rather than just for diagnostic purposes.

1.4 Indications for epidurography

There would appear to be five principal indications for epidurography following a neuraxial block:

1. Diagnosis of an atypical block
2. Verification of catheter tip position

Fig. 1.2 Classification of the patients being investigated.
1.4 Indications for epidurography

Definition of epidural adhesions

Assessment of the design and function of epidural catheters

Departmental research or audit into the efficiency of blocks

Radiologists have no use for epidurography in their routine practice, and even as far back as 1987 a major textbook stated that it was a method ‘no longer advocated for neuroradiological diagnosis’, but for those studying the spread of attempted epidural block it is an invaluable tool. However, because most contemporary radiologists have no experience of epidurograms, their reporting may be unreliable, with some of these erroneous reports even appearing in published work.

1.4.1 Diagnosis of an atypical block

Emphasizing the use of epidurograms to diagnose a complicated or failed epidural block is the main objective of this book, although other workers find different roles for epidurography. The epidural complications that may be diagnosed in this way are: (1) high epidural block, (2) accidental subarachnoid block, (3) subdural block and (4) intradural block. Intravascular injection may be very difficult to demonstrate. These complicated blocks occur either alone, involving one compartment, or in combination as a multicompartment block, and may be difficult to diagnose clinically. Table 1.1 shows the incidence of these complications that developed in 32 of our obstetric patients.

Intravascular injection may be very difficult to demonstrate. The many and varied causes of block failure that we detected are listed in Table 1.2. They are usually associated with malposition of the catheter tip, with or without an anatomical anomaly, as discussed in subsequent chapters. The anatomical anomalies include septal barriers, bony deformities and fibrous adhesions.

1.4.2 Verification of catheter tip position

Knowledge of the precise position of the catheter tip may be of importance in several situations, although the use of a radio-opaque catheter may obviate the need for a contrast injection. However, some radio-opaque catheters are less pliable than their standard counterparts and more prone to breakage, reducing their usefulness.

In certain groups of surgical patients, including neonates, epidurography has been advocated preoperatively to confirm the catheter position. Some clinicians even site their catheters the day before major surgery. Postoperatively, epidurography may be used to indicate the position of the catheter tip when attempting to correct a poorly functioning infusion, particularly when alternative forms of analgesia are unsuitable. On two occasions we have used epidurography to verify catheter position when a post-partum patient on a short-term infusion was noted to have copious volumes of clear fluid emanating from the epidural puncture site. A normal epidurogram convinced staff that the problem was not leakage of cerebrospinal fluid or epidural solution, but simply the escape of tissue oedema in a recumbent patient, and the infusion was continued.

Demonstration of the position of the catheter tip and patency of the eyes may be valuable in the management of chronic pain. Initially, following catheter insertion, the tip location may need to be ascertained, and later, in the event of block failure, repeat epidurography may reveal the nature of the problem if catheter migration or fibrosis around the tip has occurred.

1.4.3 Definition of epidural adhesions

The use of selective catheter epidurography to demonstrate fibrous adhesions in chronic pain patients, particularly

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High epidural block (above T2)</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>Intradural block</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Subarachnoid block</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Subdural block</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Intravascular injection</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1.2 Analysis of 100 cases of failed epidural block in obstetric patients. The most likely cause of failure is listed

<table>
<thead>
<tr>
<th>CAUSE OF FAILURE</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>A septum (midline or transverse)</td>
<td>51</td>
</tr>
<tr>
<td>Scoliosis</td>
<td>23</td>
</tr>
<tr>
<td>Transforaminal escape</td>
<td>13</td>
</tr>
<tr>
<td>Retrograde flow</td>
<td>4</td>
</tr>
<tr>
<td>Expelled catheter</td>
<td>4</td>
</tr>
<tr>
<td>Lateral catheter tip</td>
<td>2</td>
</tr>
<tr>
<td>Paravertebral catheter</td>
<td>1</td>
</tr>
<tr>
<td>Faulty catheter</td>
<td>1</td>
</tr>
<tr>
<td>Adhesions post-laminectomy</td>
<td>1</td>
</tr>
</tbody>
</table>
following disc disease and spinal surgery, has been well described by Racz and colleagues. Having defined the nature and extent of adhesions, remedial treatment with epidural lysis may be undertaken. Previously, the epidural catheters were usually directed through the sacral hiatus rather than a lumbar interspace, but with the current range of narrower and more manoeuvrable catheters the lumbar percutaneous approach appears to be proving more effective.

### 1.4.4 Assessment of the design and function of epidural catheters

We have used epidurograms to study the direction followed by the catheter tips on insertion, as well as the pattern of flow of epidural contrast, as part of the process of assessing new epidural catheters manufactured from different materials, with varied eye configurations and gauges, prior to market release. Two particular designs were found to be unsatisfactory and abandoned. The congested epidural venous system of pregnancy appears to impede the spread of epidural solutions, and new catheters should be tested in both term-pregnant and non-pregnant subjects.

### 1.4.5 Departmental research or audit into the efficiency of blocks

Quality assurance audits of a departmental epidural service may be greatly assisted by knowledge of why blocks have not progressed as anticipated, and ongoing research should help to improve the efficiency and safety of the procedure. Occasionally, the results of epidurography may be helpful in medico-legal situations, when the cause of a complicated or failed block has become the subject of heated conjecture.

### 1.5 Arguments against epidurography

There are many detractors regarding the safety and usefulness of epidurography but most of their arguments can be soundly rebuffed. For example, there are claims that the technique is potentially dangerous with muscle spasms and epilepsy being particular problems. However, such comments are outdated and refer to the subarachnoid injection of the older and long-discarded oily contrast agents such as Myodil. Current contrast media are very safe, when iodine-allergic patients are excluded, with a low incidence of side-effects even when injection of large doses into the subarachnoid space has occurred.

Another complaint is that epidurography is, in most cases, a retrospective study and of no therapeutic value to the individual patient. While this is true in some cases, it may not apply to the obstetric patient who has endured an unsatisfactory block for labour or caesarean delivery, is considering returning for future childbirth and is requesting reassurance about further blocks. If an anatomical cause has been visualized radiologically, as is often the case, the patient can be informed and an alternative epidural or subarachnoid approach planned for the next occasion.

One cause for concern about epidurography has been expressed by Wedel, regarding the potential dangers, including subdural abscess, meningitis and even cauda equina syndrome, resulting from leaving misplaced (possibly subarachnoid) catheters in place for an unduly long period of time, such as overnight, while waiting for the radiology department to become available. Such concerns appear to be considerably exaggerated and without foundation, although it would seem prudent to investigate cases of suspected subarachnoid placement within a matter of hours, rather than after a lengthy delay, although the retention of accidentally placed subarachnoid catheters for up to 24 h has been recommended in the attempted prevention of post dural puncture headache. Accidental subarachnoid catheter placement is, hopefully, a rare finding and the diagnosis will usually, but not always, be made clinically apparent with the aspiration of cerebrospinal fluid (CSF), although a multicompartiment block may be overlooked.

One valid criticism of post-block epidurography is that the epidural catheter associated with the problem may have been replaced, or moved from its original position prior to investigation, producing an unreliable result. In practice this does not seem to present a problem, except on the rare occasions when the catheter has either been accidentally pulled out completely or withdrawn into the subcutaneous tissues prior to contrast injection. Adequate fixation of catheters to the skin and gentle patient handling should help to dispel this problem, but we have consistently found that where there is obstruction to the free flow of epidural solutions, back-pressure results in fluid leakage around the catheter and retrograde flow to the skin. This can soak the surrounding dressings and fixation devices and may encourage catheter extrusion.

Finally, there are several authors who claim to be able to reliably diagnose epidural complications or failures
on purely clinical grounds, without resorting to X-rays. This belief appears to be frequently misguided, although it is often expressed in published articles. Examples are seen in numerous erroneous reports of unconfirmed ‘atypical accidental subarachnoid blocks’ that have appeared over recent years. The clinical descriptions supplied have often matched those of radiologically proven subdural block, rather than subarachnoid block as claimed.

1.6 X-Ray, CT or MRI epidurography?

The early work presented in this book was undertaken in a free-standing obstetric hospital without computed tomography (CT) or magnetic resonance imaging (MRI) facilities. Most patients were unwilling to travel to another hospital for screening, so only three patients were investigated with CT scans and two volunteers with MRI, but N. Hofman (University of California Los Angeles Medical Center, CA, USA) has kindly provided some high-quality CT scans on three of his patients. The relatively unsophisticated use of X-rays did fulfil our requirements for a simple, rapid and inexpensive diagnostic method, and provided highly satisfactory results in most cases. Simple radiography is the method of choice as the relevant areas of the spine may be clearly visualized in two radiographic plates, rather than the multiple, more detailed sections of the CT scan, which may be difficult for anaesthetists to interpret.

If radiographic screening is available it is of great advantage for the anaesthetist involved to personally perform the contrast injection and observe the pattern of flow in ‘real time’, feel any possible resistance to injection and note if any patient discomfort develops. Computed tomography scans may be invaluable in the investigation of complex cases of multicompartment block (such as epidural/subdural or intradural/subarachnoid injection), as the compartments are often impossible to distinguish with X-rays. However, for routine investigation using epidurography, a CT scan is unnecessary, rather extravagant and associated with higher levels of ionizing radiation.

The role of MRI in studies of the epidural space is yet to be determined, although an increasing number of interesting reports are appearing in the literature. Some scans are included in chapter 3.) One advantage of MRI over the other diagnostic techniques is that it can be non-invasive, as contrast injection is not always required to display the epidural space. The epidural fat and associated blood vessels generate their own images, and most types of epidural catheter may be clearly displayed without contrast.

1.7 Conclusions

We believe that there is a place for X-ray epidurography in the practice of every clinician performing epidural block, to help explain their own sporadic incidence of unusual results and to improve or modify their techniques, while advancing their knowledge and that of their colleagues. This should lead to increased patient satisfaction and decreased morbidity. Epidurography has allowed us to discover the main causes of block failure, as well as developing our awareness of complications, particularly those involving the subdural and intradural spaces.

REFERENCES