POSTOPERATIVE PARAVERTEBRAL BLOCKS FOR THORACIC SURGERY
A Radiological Appraisal

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Intercostal nerve blockade is a useful adjuvant technique for the relief of pain after thoracic operations (Moore, 1975). However, a series of blocks may be necessary to produce adequate analgesia of the skin. Prolongation of the duration of analgesia can be achieved with catheter techniques, and a system in which a single catheter is utilized would be a useful addition to the armamentarium of the thoracic anaesthetist since it would lend itself to continuous infusions of the kind used in association with extradural blockade (Conacher et al., 1983).

Several studies on cadavers (Nunn and Slavin, 1980; Moore, 1981) have demonstrated that the anatomical plane in which the intercostal nerve lies is contiguous with that above and below. This explains why an injection in one intercostal space may result in analgesia over several dermatomes. Medial spread of drug from the intercostal space is also likely, as far as the extradural space according to some reports (McIntosh and Mushin, 1947; Middaugh et al., 1985).

In 1979, Eason and Wyatt revitalized interest in the paravertebral space as a repository for catheters and local anaesthetic, and described the widespread, unilateral analgesia which could be achieved by the use of two catheters. Using the same approach, we have inserted a single catheter to a series of patients following a thoracic operation; in some, contrast medium was injected through the catheter.

PATIENTS AND METHODS

Five patients, detailed in table I, to whom the procedure had been explained, agreed to be studied. At the end of surgery, while they were anaesthetized and in the lateral thoracotomy position, a single extradural catheter was inserted paravertebrally just below the wound dressing and close to the level of the intercostal space through which the operation had been conducted—in all these patients, the 6th or 7th. The landmarks for the injection were as described by Eason and Wyatt (1979). The point of a short-bevel Crawford needle was sited 3 cm lateral to the top edge of a spinous process and 90° to the skin surface. The needle was inserted down on to a rib before being worked over its upper border. Recognition of entrance to the paravertebral space was with loss of resistance to the injection of physiological saline as the needle penetrated the costo-transverse ligament. After aspiration had shown neither air nor blood, an extradural catheter was inserted through the needle and advanced 2–3 cm into the space.

In the high-dependency recovery area, 0.25% bupivacaine 20–30 ml with 1:200000 adrenaline was injected through the catheter with the patient in a sitting position. Half an hour later, analgesia...
<table>
<thead>
<tr>
<th>No.</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Lesion</th>
<th>Operation</th>
<th>Initial dose local anaesthetic</th>
<th>Dermatomal analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>M</td>
<td>Bronchial carcinoma</td>
<td>Right pneumonectomy</td>
<td>0.25% Bupivacaine 30 ml</td>
<td>Right T7–T10</td>
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<td>2</td>
<td>43</td>
<td>F</td>
<td>Mediastinal sarcoma</td>
<td>Left thoracotomy</td>
<td>0.25% Bupivacaine 25 ml</td>
<td>Left T5–T9</td>
</tr>
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<td>3</td>
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<td>F</td>
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<td>Left T6–T11</td>
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<td>F</td>
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<td>Left T3–T10</td>
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<td>5</td>
<td>67</td>
<td>M</td>
<td>Bronchial carcinoma</td>
<td>Right lobectomy</td>
<td>0.25% Bupivacaine 25 ml</td>
<td>None</td>
</tr>
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</table>

was assessed with response to pin-prick, touch with ice, gentle pressure on the wound dressing, and light traction on the pleural drains so that the retaining skin sutures were put on a stretch.

All patients received additional analgesia in the form of a continuous low-dose i.v. infusion of papaveretum.

Later, immediately before the routine postoperative chest x-ray was taken, and with the patient in a sitting position, lopamidol 10 ml (Niopam 300) was injected slowly via the catheter. No lateral-view x-rays were taken since they are not part of the postoperative routine within 12 h of operation.

RESULTS

In patients 1, 2, 3 and 4 there was evidence of unilateral loss of sensation to pin-prick and temperature discrimination in the dermatomal

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**Fig. 1.** Patient 1: radiograph, and diagrammatic representation of spread of contrast. ics = Intercostal space; ps = paravertebral space; es = extradural space; p = pleura.
distributions shown in table I. Patients 1, 2 and 3 were tender to gentle pressure on their wounds posteriorly where the incision reached into the region of the 3rd and 4th thoracic dermatomes and where there was no loss of sensation to pin-prick. Patient 2 was aware of traction on the skin when her anterior pleural drain was tugged. Patient 4 had slight discomfort on deep breathing. Patient 5 had no loss of sensation to any of the provocative test stimuli.

The anterior–posterior chest x-rays of each patient taken in the recovery area are reproduced—figure numbers 1–5 correspond to the patient numbers 1–5. Characteristically, in patients 1–4, there was marked spread of contrast laterally along a single intercostal space. In patient 1, further spread of contrast is not well delineated or depicted since it is concealed by fluid and a raised hemidiaphragm. In figure 2, contrast can just be distinguished to have spread both up and down from its prominent distribution in an intercostal space and, significantly, in a position well lateral to the vertebral bodies. In the third figure, contrast, although not well demonstrated, has moved into the paravertebral space above the site of injection and has spread in a paramedian band, parallel to the aortic shadow. There is a prominent “knuckle” of contrast two intercostal spaces lower. In the original x-ray, this paravertebral spread of contrast, as in patient 4, is well shown below the level of injection. Indeed, in both, contrast can be detected at least three spaces caudal to the level of the injection and extending, in patient 3, to below the diaphragm. In patient 4, however, there is cephalad spread of contrast. Here, beside a rib fractured during surgery, contrast can clearly be seen in the midline and up the right hand side as far as the third thoracic vertebra. It is probably in the extradural space.

In the x-ray of patient 5, the one who had no evidence of effective neurological blockade, the catheter is well outlined, but there is only a small volume of contrast visible and it appears to define no anatomical plane. The lack of clinical effect, as well as the rapid dispersal of contrast suggests that the catheter tip is intrapleural.

DISCUSSION
Lopamidol is a recently introduced, non-ionic, water soluble contrast medium which is rapidly excreted and is the agent of choice for myelo-
FIG. 3. Patient 3: radiograph, and diagram of spread of contrast.

FIG. 4. Patient 4: radiograph, and diagram of spread of contrast.
**PARAVERTEBRAL BLOCKS FOR THORACIC SURGERY**

**FIG. 5.** Patient 5: radiograph, and diagram of spread of contrast.

graphy and angiography. It was used in this study in case, as indeed happened, it should inadvertently enter the extradural space. From the inception of the paravertebral injection technique (Kappis, 1919) it was recognized that a drug could enter the extradural space via the intervertebral foramina. However, neither with large volumes (up to 30 ml of bupivacaine) nor with continuous infusions have we found clinical evidence of contralateral neurological blockade, in more than 30 patients. A more recent case report (Middaugh et al., 1985), in which radioactive technetium was used as a tracer, has reconfirmed that local anaesthetic solution can reach the extradural space even when injected to the intercostal space, and there are several reports, similar to that of Otto and Wall (1976) of total spinal anaesthesia associated with intercostal nerve blockade.

Apart from the entry of drug to the extradural space, there is some argument as to the mechanism of overlapping analgesia achieved by the injection of local anaesthetic to an intercostal groove. Nunn and Slavin (1980) found in cadavers that India ink, in addition to passing paravertebally, spread into adjacent intercostal spaces through a subpleural space anterior to and medial to the angle of the rib. This route may have been demonstrated radiologically in patient No. 2 of this study. A study in volunteers (Crossley and Hosie, 1987) using the contrast lopamidol has confirmed this mode of spread of an agent. However, Moore (1981) did not find this route in cadaver studies and thought that spread of effect was caused by medial movement of drug along the costal groove and that cephalad and caudad movement only occurred at and from the paravertebral space. We found that injection of contrast medium through a millipore filter and catheter is difficult, and at in vitro testing, contrast exits through the narrow bore catheter only drop by drop when injected from a 10-ml syringe. In order to achieve the distribution of contrast into the "potential" spaces found in our study, the tissue plane to which it was injected is likely to be of low resistance, with distal dispersal dependent, in part, on gravity. This view would tend to support that which suggests that spread of effect to other intercostal nerves is via the paravertebral space,
spread along the route demonstrated by Nunn and Slavin (1980) perhaps being a phenomenon dependent on pressure of injection, on large injectate volume (Crossley and Hosie, 1987) and, as suggested by Moore (1981), on liquid consistency.

There is also some debate about the movement of drug from the paravertebral space. McIntosh and Mushin (1947) were quite adamant that spread to an ipsilateral space was only via the extradural space, each paravertebral space being virtually sealed anteriorly, posteriorly, above and below with access or egress only from the adjacent intercostal space and intervertebral foramen. Moore, Bush and Scurlock (1980), however, have shown that spread is across the heads of the ribs along the vertebral bodies. Most of these x-ray studies suggest that this may be the usual mode of spread of local anaesthetic. Where there is extensive caudad and cephalad movement, contrast gives a picture with a smooth paramedian border rather than anything that is lipped and suggestive of spread into intervertebral foramina. This suggests that, for clinical purposes, in many patients the paravertebral spaces are in continuity above and below. Nevertheless, patient No. 4 demonstrates graphically that the extradural route is occasionally of relevance. It is of interest to note that there was a fractured rib adjacent to the point where contrast appears to have entered the extradural space. It may be coincidence, but it is possible that the cephalad spread of contrast along the usual paravertebral route has been hindered by the trauma associated with the fracture.

Several reasons, not least demonstration of the movement of contrast close to the neuraxis, have meant that the series sample has had to be kept small. Thus it cannot be stated with any certainty that these patients are representative of the usual or likely modes of spread of drug injected to the paravertebral space. However, other clinical evidence for widespread, ipsilateral analgesia from a single injection to a thoracic paravertebral space is now substantive. One of our series had evidence of blockade in six dermatomes. McKnight and Marshall (1984) reported a patient with fractured ribs in whom contrast spread from the 3rd to the 12th thoracic dermatomes and the series of Eason and Wyatt (1979) contained similar examples. These latter authors achieved certainty of extensive blockade by using a two-catheter technique. Some of these x-ray studies confirm our own view that widespread analgesia beyond the confines of individual paravertebral spaces and the contiguous intercostal space can be obtained using large volumes of local anaesthetic and sitting patients upright at the time of injection at the upper part of the zone for which analgesia is intended.

There are several advantages to using the paravertebral route to intercostal nerves, besides widespread unilateral analgesia. The posterior primary ramus of the intercostal nerve branches from the main trunk within the paravertebral space. It supplies the posterior ligaments, posterior spinal muscles and overlying skin and, since these are often traumatized at thoracotomy, blockade of their nerve supply is worthwhile (Eason and Wyatt, 1979). The sympathetic chain lies within the space and unilateral sympathetic blockade is probably a useful adjunct as local vasodilatation can be obtained without the disabling hypotension so often found when an extradural technique is used (Conacher et al., 1983).

However, two possible complications remain, both of which have been illustrated in this study. Contrast has clearly been shown to enter the extradural space under some as yet undefined circumstances with the potential for severe hypotension as an accompaniment of widespread bilateral blockade. Second, puncture of the pleura is possible, so that in the undrained chest it has to be borne in mind that a paravertebral injection may initiate the development of a pneumothorax.

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REFERENCES


