

POSTERIOR INTERCOSTAL NERVE BLOCK FOR PAIN RELIEF AFTER CHOLECYSTECTOMY

Anatomical basis and efficacy

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SUMMARY

The human intercostal space has been studied by excision of the posterior part of the rib cage at autopsy, followed by fixation, decalcification, section and staining. Injection of India ink was used to simulate local anaesthetic. At a point 7 cm from the midline, the distance from the posterior aspect of the rib to the pleura averaged 8 mm. The intercostal nerve usually comprises a number of small bundles without any enclosing fascial sheath. The bundles lie in a triangular space bounded by the rib, the posterior intercostal membrane and the intercostalis intima muscle. The first two appear impervious to the spread of an injected solution, but the last permits spread of the injection round the internal aspect of the rib to gain access to the intercostal spaces above and below that into which the injection has been made. An injection of 3 ml will also spread medially to enter the paravertebral space and surround the sympathetic chain. A small clinical study gave excellent analgesia after operation for a mean duration of 12.3 h following unilateral intercostal block with 3 ml of bupivacaine 0.5% (with adrenaline) into each of the intercostal spaces T5-11, before cholecystectomy through a subcostal incision. There were no complications in the series.

Cholecystectomy produces one of the greatest frequencies of pain after operation and the eloquent testimony of Bevan (1964) indicates the severity which may be experienced. Pain after cholecystectomy is usually controlled by opiates, though less often by extradural analgesia (Spence and Smith, 1971). The former is less than ideal, mainly because of the intermittent character of the relief afforded by administration "as required". There may also be a reluctance on the part of the patient to request an analgesic or on the part of the staff to administer it. Extradural analgesia usually gives excellent results, but there are administrative problems in arranging for the repeat administrations to be given by someone trained to handle the complication of total spinal anaesthesia should it arise.

The present study has explored the use of unilateral posterior intercostal nerve block by the technique described by Moore (1965, 1975), not as a substitute for general anaesthesia but for control of pain after operation. Since we were unable to find an account of the detailed anatomy of the human intercostal space relevant to the technique, we

undertook a study in cadavers, including spread within the intercostal space of injected India ink to simulate a local anaesthetic. In a small clinical study, we have considered the influence of the type of incision, the success rate, the duration of relief from a single injection of bupivacaine and the practical feasibility of a technique which might find widespread application.

METHODS

Anatomical study of the human intercostal space

The bony rib cage was removed in six subjects at autopsy from the posterior mid-line to the anterior axillary line and from the 2nd to the 10th rib on the left side. The rib cage was fixed in formalin and subsequently decalcified in formic acid. Blocks were taken from the following sites and sections cut so that the ribs and intercostal spaces were seen in cross-section as follows:

Posteriorly 7 cm from the mid-line:
intercostal spaces 3/4, 6/7, 9/10

In the anterior axillary line:
intercostal spaces 3/4, 6/7, 9/10

Sections were stained with haematoxylin and eosin, or with Masson's stain and mounted on 5-cm x 5-cm slides.

In one case, before removal of the rib segments, 3 ml of India ink was injected to the 6/7 intercostal

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space, 7 cm from the midline posteriorly, with the needle tip 3 mm beyond and immediately below the lower edge of the 6th rib. In a seventh subject, India ink injections were made bilaterally as described above but in the 8/9 intercostal space, and the inside of the thorax was then photographed to show the spread of the ink. Following removal of the ribs, fixation and decalcification, a vertical cut was made through the ribs at the point of the injection. The cut edge was then photographed to show the spread of ink in the fascial planes.

Clinical study

Sixteen patients (three male) received intercostal nerve blocks after the induction of anaesthesia and before the commencement of cholecystectomy through a subcostal incision. In all cases premedication was with papaveretum 10–20 mg and hyoscine 0.2–0.4 mg. Induction of anaesthesia was with thiopentone 250–400 mg and neuromuscular block was obtained with a single injection of pancuronium 5–7 mg or fazadinium 50–75 mg. Anaesthesia was maintained with 70% nitrous oxide, supplemented with small quantities of opiates. A cuffed oro-tracheal tube was passed and the lungs were ventilated artificially using a Manley ventilator which is integral in the Northwick Park anaesthetic apparatus. Surgery was usually completed within 1 h, but in a few cases lasted up to 2 h. Neuromuscular block was antagonized with neostigmine 2.5 mg given with atropine 1.2 mg.

Intercostal block was undertaken in the left lateral position and confined to the right side. The block was carried out posteriorly 7 cm from the mid-line where the angles of the ribs are superficial and easily palpated. Seven nerves were blocked extending from T5 to T11 inclusive. The needle was "walked" down the posterior surface of the rib until it just passed the inferior edge. It was then advanced 3 mm, and 3 ml of 0.5% bupivacaine (containing 1 : 200 000 adrenaline) was injected giving a total of 21 ml (105 mg of bupivacaine).

In two additional patients, the same technique was used, but cholecystectomy was carried out through a right paramedian incision.

After operation morphine 5–10 mg i.m. was prescribed for all patients "as required" and was freely available on demand.

Results were compared with a control series of 14 patients (two male) undergoing cholecystectomy by the same two surgeons using the subcostal incision and the same anaesthetic techniques.



FIG. 1. Section of 6/7 intercostal space 7 cm from the mid-line, stained with haematoxylin and eosin and showing India ink injected to the same space. Note spread of ink between pleura and ribs but lack of penetration of posterior intercostal membrane. For identification of structures see no. 2534 (fig. 2). The bar represents 1 cm.

6/7 Posterior

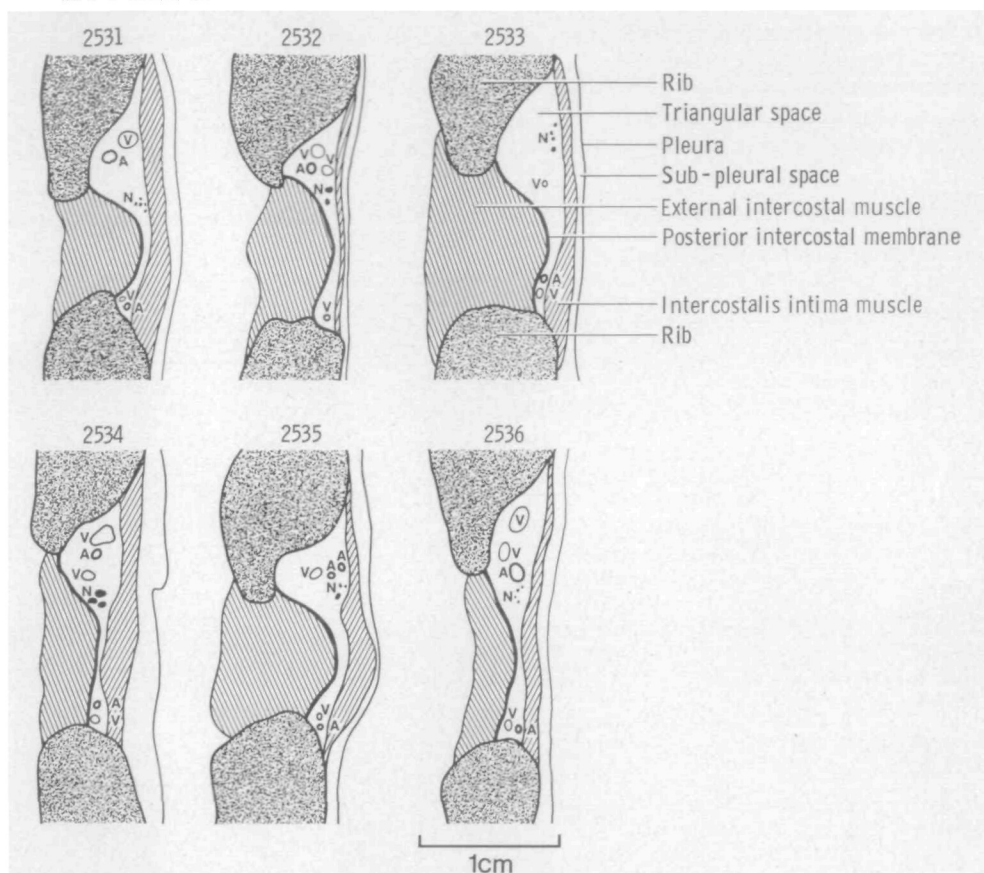


FIG. 2. Outline diagrams of 6/7 intercostal space 7 cm from the mid-line, from six subjects, to show variability in the arrangement of nerves and vessels within the triangular space. The curvature of the intercostal muscles is an artefact as a result of shrinkage of the specimen after removal from the body.

RESULTS

The anatomical study

The structure of the sixth intercostal space 7 cm from the posterior mid-line is most relevant to the nerve block technique used in the clinical study. At this point the ribs have an average thickness of about 9 mm and form one of the boundaries of a triangular space which contains the principal intercostal nerves and vessels. The triangular space (figs 1 and 2) is bounded by the inferior notched aspect of the rib (subcostal groove), the posterior intercostal membrane and the intercostalis intima. The space has an area of about 0.75 cm² and is largely filled with fat, through which runs the main intercostal vein, artery and nerve, usually in that order, from above downwards. There is, however, considerable variation in the individual relationships and sizes (fig. 2). For

example, in one subject the artery was absent and only a small vein was found. Inferiorly the space extends to the upper border of the 7th rib and smaller vessels were often found just above the rib. The nerve trunk commonly ran as three or four separate bundles with no single neural sheath.

The external intercostal muscle is a substantial structure, bounded on its internal aspect by the clearly defined posterior intercostal membrane which replaces the internal intercostal muscle in the posterior part of the intercostal space and is impermeable to India ink in the cadaver. The intercostalis intimus muscle, however, is a flimsy structure composed of separate fascicles through which injected India ink passes freely to reach the sub-pleural space. It is then able to pass between ribs and pleura to reach the adjacent intercostal spaces, again

passing through the fibres of the intercostalis intimus to reach the triangular compartments and the included nerves within these spaces (fig. 3). The pleura is free of any firm attachment to the ribs in this location (fig. 4). Figures 4 and 5 illustrate the very wide spread of injected India ink in the chest wall.

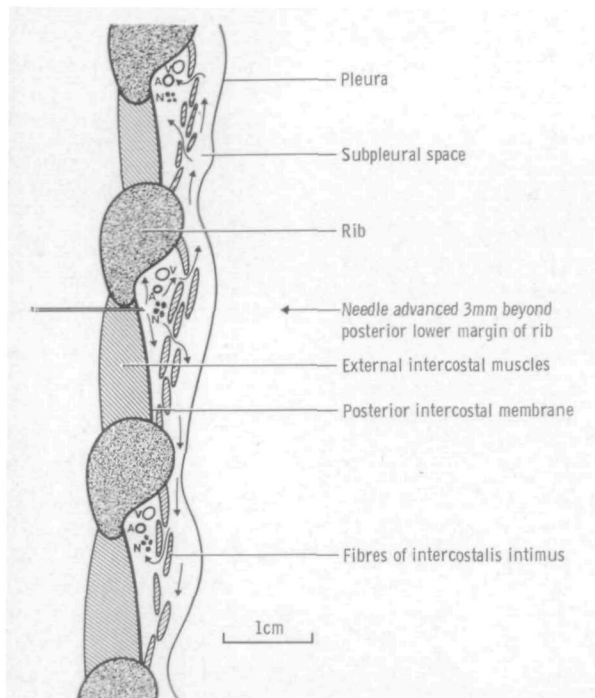


FIG. 3. Schematic diagram showing the pattern of spread of solution injected 3 mm beyond the lower edge of the rib. The fascial sheath on the internal aspect of the external intercostal was impermeable to India ink.

Figure 6 shows the full range of sections from one of the subjects to demonstrate the differences in the form of the intercostal space at the different levels, and between the posterior and lateral sections. The posterior injection site is close to the angle of the rib where the internal intercostal muscle is replaced by the posterior intercostal membrane. This membrane is clearly shown in the posterior but not the lateral sections at levels 6/7 and 9/10. The intercostalis intima is poorly developed in the upper intercostal spaces. It is not seen in figure 6 in the 3/4 space and was only visible at this level in one of our six subjects.

The clinical study

The mean duration of right abdominal analgesia was 12.3 h from the end of operation (SD 5.2) as reported by the patients. The end-point was usually

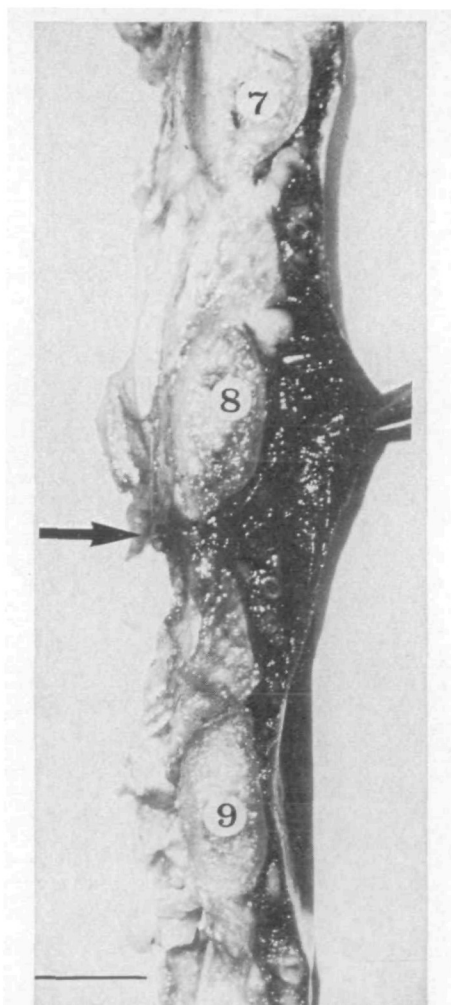


FIG. 4. Photograph of the cut ends of ribs 7, 8 and 9 to show spread of India ink (injected into 8/9 intercostal space) between the pleura and the internal surfaces of the ribs. The arrow indicates the injection site. The forceps are lifting the pleura which is quite free from attachment to the ribs. The bar represents 1 cm.

sharply defined and all patients were pain free for at least 5 h.

The pattern of administration of analgesics after operation is shown in figure 7. Sixty-four per cent of the control group required morphine in the first 5 h while no patient who received an intercostal block required morphine before 6 h. During the first 12 h, the control group received 1.36 injections of morphine per patient, while the corresponding figure for those with the block was only 0.44. The difference in morphine requirement continued up to 48 h (table I). The highest morphine requirement in a patient with

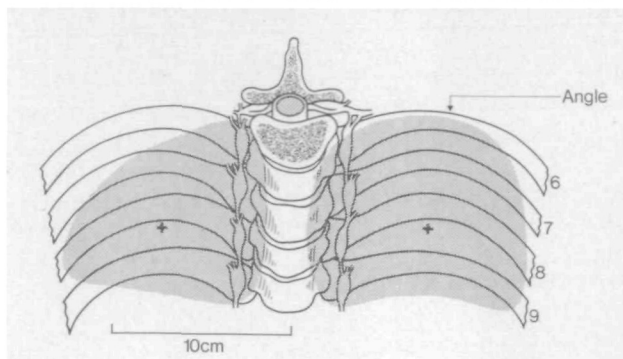


FIG. 5. The appearance of the inside of the thorax following injection of 3 ml of India ink into the 8/9 spaces at the point shown by the crosses. Note free spread of the ink into the paravertebral spaces and the adjacent intercostal spaces.

TABLE I. *Morphine requirement (mean number of injections per patient)*

	Patients receiving intercostal block	Control group
0-12 h	0.44	1.36
13-24 h	0.88	1.14
25-36 h	0.34	0.86
37-48 h	0.12	0.57
Total	1.81	3.93

intercostal block was 4 injections and, in his case, a T-tube cholangiogram showed residual stones in the common duct and there was also a klebsiella infection of the biliary tract.

All patients appeared to be completely free of pain from the area of the subcostal incision during the first few hours after operation. However, there was frequently a degree of hyperalgesia on the left side of the body. Some patients complained about discomfort from the area where a towel clip had been used on the left side. We also observed that the technique was quite unsuitable for use with a right para-median incision. There was sufficient crossing of nerve fibres in the midline for the unblocked left nerves to carry what appeared to be a quite disproportionate degree of pain.

Movement of legs and sensation in the areas of lumbar and sacral nerve distribution were normal in all patients. Five patients had normal chest radiographs with no evidence of pneumothorax. In the remaining 11 patients there was no clinical evidence of any abnormality in the chest and no radiogram was deemed necessary. No patient showed signs of chest infection after operation. One patient developed

a cough, but his chest radiogram was normal. The mean time to discharge was 9 days.

DISCUSSION

Our anatomical study revealed many features of the posterior intercostal space with which, hitherto, we had been unfamiliar. First, the distance from the posterior aspect of the lower edge of the rib to the pleura averaged 8 mm, leaving a safety margin of 5 mm after advancing the tip of the needle by 3 mm. There appeared to be no occurrence of pneumothorax in this series and this we attribute to the thickness of the rib near its angle. Second, the anatomy of the intercostal nerves, although variable, is such that the recommended site of injection (fig. 3) should ensure a very high success rate. The triangular space is bounded on two sides by tissues which were impermeable to India ink and this undoubtedly helps to direct the flow of the local anaesthetic. Nevertheless, an injection incorrectly made superficial to the posterior intercostal membrane would probably result in failure. Third, we were surprised at the extent of the spread of India ink. An injection of 3 ml easily spread medially into the paravertebral space of the same intercostal space, presumably blocking the sympathetic chain (fig. 5). Since the pleura is not firmly attached to the ribs, the injection is free to pass over the internal aspect of the ribs above and below the space, with a high probability of block of the nerves in these segments (fig. 3). Fourth, the segmentation of the nerve into small bundles lying freely amongst the fat of the triangular space without any enclosing fascial sheath makes the nerve exceptionally favourable for block.

The anatomical findings accord with our clinical experience that the block was apparently successful in every case. It should also be stressed that the block is extremely simple and seven nerves can easily be blocked in 3-4 min. The posterior approach seems to have a number of advantages. The internal intercostal muscle is here replaced by the posterior intercostal membrane which probably helps to direct the injection and prevent its diffusion outwards into the external intercostal muscle. Spread of the injection cephalad and caudad is certainly free at the posterior approach, although we cannot say whether or not this is also true of the lateral approach. The medial spread to the paravertebral space is almost certainly confined to the posterior approach. We believe there may be considerable advantages in combining a sympathetic blockade with the intercostal nerve block.

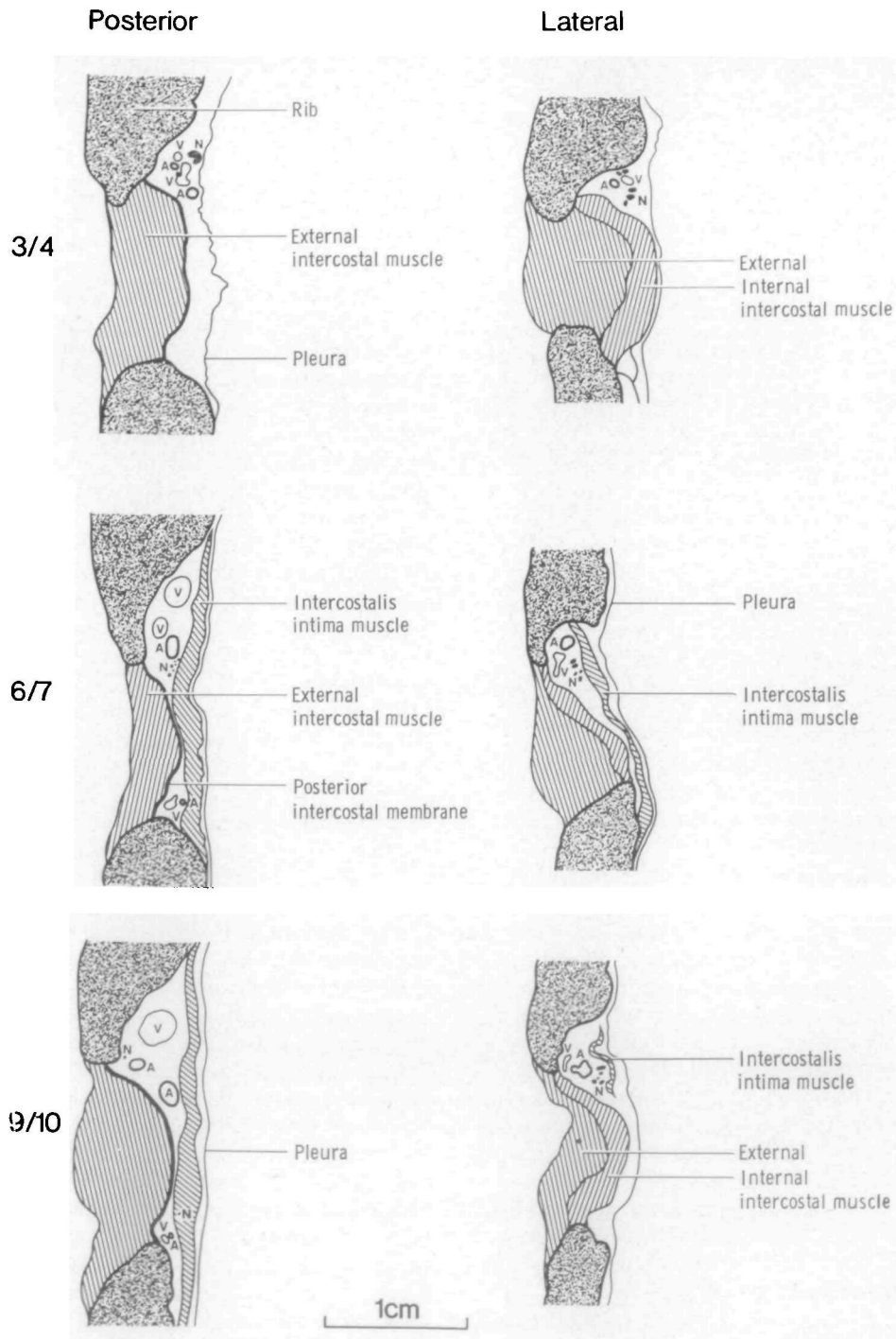


FIG. 6. Posterior and lateral sections through 3/4, 6/7 and 9/10 intercostal spaces in one subject.

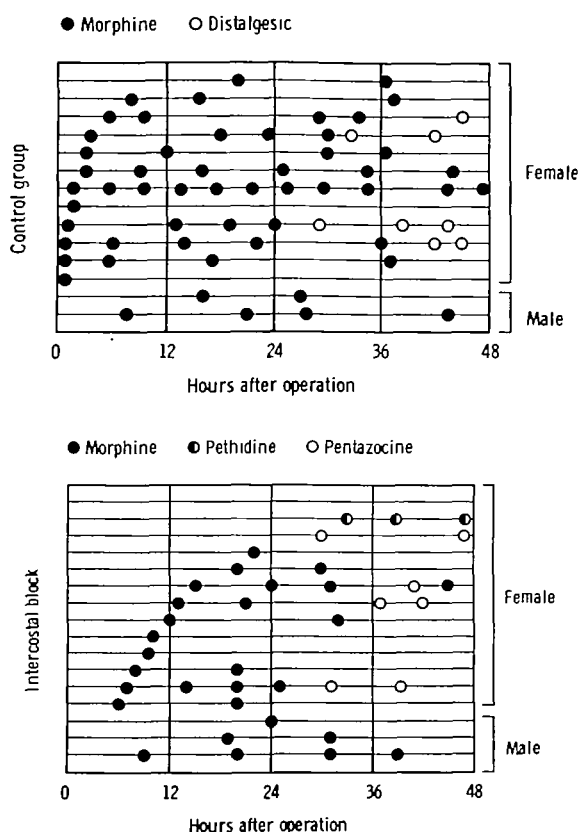


FIG. 7. Administration of analgesics after operation to a control group (upper) and to 16 patients who had right-sided intercostal block (lower).

Overall, we are convinced that right-sided lower posterior intercostal nerve block with bupivacaine is the method of choice for early control of pain after cholecystectomy through a subcostal incision. Unilateral block is unsuitable for the paramedian incision although the bilateral block would probably be suitable. The technique is much simpler than placing an extradural catheter. Intercostal block can be repeated, but none of our patients considered their pain sufficiently severe to merit this. It was, in fact, surprising that they seemed to suffer less pain during the 2nd day after operation than did the control group.

Cronin and Davies (1976) have described a series of 100 intercostal nerve blocks for relief of pain after operation, with two cases of pneumothorax. They also reviewed the literature of this complication which has a frequency of less than 1% in most series.

Engberg (1975) reported a series of 76 patients who received unilateral intercostal block for postoperative pain relief after subcostal incisions. Pulmonary function was significantly better in these patients compared with a control group who received the conventional analgesic regimen.

REFERENCES

- Bevan, P. G. (1964). Cholecystectomy in a surgeon. *Lancet*, **1**, 214.
- Cronin, K. D., and Davies, M. J. (1976). Intercostal block for postoperative pain relief. *Anaesth. Intens. Care*, **4**, 259.
- Engberg, G. (1975). Single-dose intercostal nerve blocks with Etidocaine for pain relief after upper abdominal surgery. *Acta Anaesthesiol. Scand.* (Suppl.), **60**, 43.
- Moore, D. C. (1965). *Regional Block. A Handbook for Use in the Clinical Practice of Medicine and Surgery*, 4th edn. Springfield: Charles C. Thomas.
- (1975). Intercostal nerve block for postoperative somatic pain following surgery of thorax and upper abdomen. *Br. J. Anaesth.*, **47**, 284.
- Spence, A. A., and Smith, G. (1971). Postoperative analgesia and lung function: a comparison of morphine with extradural block. *Br. J. Anaesth.*, **43**, 144.

BLOPAGE DU NERF INTERCOSTAL POSTERIEUR POUR LE SOULAGEMENT DE LA DOULEUR APRES UNE CHOLECYSTECTOMIE

Base anatomique et efficacité

RESUME

L'espace intercostal humain a été étudié en excisant la partie postérieure de la cage thoracique lors d'une autopsie, et en effectuant ensuite une fixation, une décalcification, une section et une coloration. On a injecté de l'encre de Chine pour simuler une anesthésie locale. A partir d'un point situé à 7 cm du milieu, la distance de l'aspect postérieur de la côte à la plèvre a été en moyenne de 8 mm. Le nerf intercostal comprend normalement un certain nombre de faisceaux sans qu'aucun d'entre eux ne soit enfermé dans une enveloppe aponévrotique. Les faisceaux sont disposés dans un espace triangulaire délimité par les côtes, la membrane intercostale postérieure et le muscle intercostal interne. Les deux premiers semblent être impénétrables à la dissémination d'une solution injectée, mais le dernier permet la dissémination de l'injection tout autour de l'aspect interne de la côte pour arriver aux espaces intercostaux se trouvant au-dessus et au-dessous de celui où l'injection a été faite. Une injection de 3 ml se disséminera aussi médialement de manière à pénétrer l'espace paravertébral et à entourer la chaîne sympathique. Une petite étude clinique a donné une excellente analgésie après l'intervention chirurgicale pendant une durée moyenne de 12,3 h, après blocage intercostal unilatéral à l'aide de 3 ml de bupivacaine à 0,5% (avec de l'adrénaline) dans chacun des espaces intercostaux T5-11, avant la cholecystectomie par une incision sous-costale. Il n'y a eu aucune complication dans cette série.

HINTERER INTERKOSTALER NERVENBLOCKIERUNG ZWECKS SCHMERZLINDERUNG NACH CHOLECYSTECTOMIE

Anatomische Basis und Wirksamkeit

ZUSAMMENFASSUNG

Der menschliche Interkostalraum wurde studiert, indem der hintere Teil des Brustkorbs bei einer Autopsie entfernt wurde, gefolgt von Fixierung, Entkalkifizierung, Sektion und Färbung. Indiatinte wurde eingespritzt, um ein lokales Narkosemittel zu simulieren. An einem bestimmten Punkt 7 cm von der Mittellinie war die Entfernung vom hinteren Aspekt der Rippe zum Pleura durchschnittlich 8 mm. Der Interkostalnerv besteht gewöhnlich aus einer Anzahl kleiner Bündel ohne Faszienhülle. Diese Bündel liegen in einem dreieckigen Raum begrenzt von der Rippe, der hinteren Interkostalmembrane und dem Intercostalis intima-Muskel. Die ersten beiden scheinen undurchdringlich für die Ausbreitung einer eingespritzten Flüssigkeit, der Muskel aber gestattet die Ausbreitung der Injektionsflüssigkeit rund um den internen Aspekt der Rippe, so dass die Flüssigkeit zu den Interkostalräumen über und unter demjenigen eindringen kann, in den die Injektion gemacht wurde. Eine Injektion von 3 ml verbreitet sich auch medial in den Paravertebralraum und rund um die sympathische Kette. Eine kleine klinische Studie ergab ausgezeichnete postoperative Schmerzlinderung auf eine mittlere Dauer von 12,3 Stunden nach einer unilateralen Interkostalblockierung mit 3 ml Bupivacain 5% (mit Adrenalin) in jeden der Interkostalräume T5-11, vor Cholecystektomie durch einen subkostalen Einschnitt. In der Serie gab es keine Komplikationen.

BLOQUEO DEL NERVO INTERCOSTAL POSTERIOR PARA EL ALIVIO DEL DOLOR DESPUES DE UNA COLECISTECTOMIA

Base anatómica y eficacia

SUMARIO

Se llevó a cabo un estudio del espacio intercostal en el humano por excisión de la parte posterior de la caja torácica durante una autopsia, seguida por la fijación, la descalcificación, la sección y la coloración. Se inyectó tinta de India para simular al anestesia local. En el punto situado a 7 cm de la línea media, la distancia del aspecto posterior de la costilla hasta la pleura alcanzaba un promedio de 8 mm. El nervio intercostal comprende habitualmente una serie de pequeños mazos sin ninguna vaina fascial de protección. Los mazos se hallan en un espacio triangular limitado por la costilla, la membrana intercostal posterior y el músculo intercostalis intima. Los dos primeros parecían impermeables a la penetración de una solución inyectada, pero el último dejó que se extendiera la inyección alrededor del aspecto interno de la costilla para entrar en los espacios intercostales por encima y por debajo del en que se había practicado la inyección. Una inyección de 3 ml también se extenderá medialmente y entrará en el espacio paravertebral para rodear la cadena simpática. Un pequeño estudio clínico arrojó una excelente analgesia después de la operación durante un periodo medio de 12,3 h después del bloqueo intercostal unilateral con 3 ml de bupivacaina al 0,5% (con adrenalina) en cada uno de los espacios intercostales T5-11, antes de la colecistectomía a través de una incisión subcostal. No hubo complicaciones en las series.