INTERCOSTAL NERVE BLOCK: SPREAD OF INDIA INK INJECTED TO THE RIB'S COSTAL GROOVE

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SUMMARY

Three and five millilitre of india ink were injected bilaterally into the costal groove of the 9th or 10th ribs of 14 cadavers. The spread was observed and the costal groove of the rib injected was dissected, with the one above and one below. Nunn and Slavin's study (1980) of similar injections in two cadavers indicated that an injection of one costal groove blocked not only the intercostal nerve of that groove, but at least the one above and below it. The present study verified the author's previous report that only the intercostal nerve in the costal groove of the rib injected is anaesthetized.

Two recent anatomical studies of block of the intercostal nerves have been published (Moore, Bush and Scurlock, 1980; Nunn and Slavin, 1980). Both studies used the same technique of injection and marker solution was injected into the costal grooves of the ribs of two cadavers. Nunn and Slavin (1980) removed the bony rib cages after postmortem, injected 3 ml of india ink at the 6—7 or the 8—9 intercostal space, visualized the spread, fixed the thoracic cages in formalin, decalcified them with formic acid, sectioned them, stained them with haematoxylin and eosin or Masson's stain, mounted them on 5 cm x 5 cm slides, and examined the slides. On the other hand, to simulate as closely as possible the technique of performing an intercostal nerve block under clinical conditions, Moore, Bush and Scurlock (1980) injected 5 ml of blue liquid latex into the costal groove of the 9th or 10th ribs with the cadaver in the prone position. After the viscera had been removed, the spread of the latex was visualized and the tissue dissected away from the intercostal nerves so that the spread of latex could be determined.

Nunn and Slavin observed the india ink to spread to the paravertebral space and "...to pass between ribs and pleura to reach the adjacent intercostal spaces, again passing through the fibers of the intercostalis intimus to reach the triangular compartments (costal grooves in the ribs) and the included nerves within these spaces." They "presumed" that the intercostal nerves of the ribs above and below the one injected had at least a "high probability" of being blocked. Moore, Bush and Scurlock (1980) concluded that only the intercostal nerve of the rib injected was blocked.

Solutions of india ink and blue liquid latex have markedly different consistencies. This may have been the basis for the differences in results reported by Nunn and Slavin (1980) and by Moore, Bush and Scurlock (1980). The present study was undertaken to determine whether this was so.

METHODS

The grooves in the 9th or 10th ribs of 14 cadavers were injected bilaterally with india ink 7.5 cm lateral to the spinous process of the vertebra. The injection was made through a short-bevelled (2 mm) 22-gauge, 3.8-cm needle. The technique of injection was identical to that used in our previous study, except for the following.

In six of the corpses, the method simulated the injection of Nunn and Slavin: that is, the needle, after being advanced 3-4 mm past the caudad edge of the rib and into the costal groove, was fixed in position and the india ink was injected. In the other six, the needle, after being placed in the costal groove, was jiggled 2 mm as the india ink was injected. The latter type of injection was the same as that which has been used by us for bilateral anaesthesia of the lower seven intercostal nerves in more than 12 000 surgical patients for upper intra-abdominal surgery (Moore, 1965).

In 12 cases the injection was performed with the cadaver in the prone position before autopsy. In four of those injected in the prone position, 3 ml of india ink was injected; in another six, 5 ml was injected; in two, 3 ml was injected on one side and
Fig. 1. Injection before postmortem of 3 ml of india ink as the needles were moved forward and backward in the grooves in the 10th ribs. (A) Right side of cadaver after removal of viscera. INK and arrows = spread of ink. P and open arrows = approximate point of injection. (B) Left side of cadaver after removal of viscera shows ink in blood vessels anterior to surface of rib. (c) Dissection of right side of corpse shows no spread of india ink to intercostal grooves of the ribs above or below the one injected. E = cut pleura, subserous fascia, endothoracic fascia and internal intercostal muscle covering groove of 9th rib reflected cephalad. Note, no ink in these tissues. N-9 = nerve of costal groove of 9th rib. N-11 = nerve of costal groove of 11th rib. a = artery. v = vein (both contain some blood).
Fig. 2. Injection before postmortem of 5 ml of india ink with the needles fixed in the grooves of the 10th rib. (A) Thorax of cadaver after removal of viscera. Endothoracic fascia cut at vertebra and removed from it. S and arrow = spread of ink behind this fascia. P and open arrows = approximate point of injection of india ink. INK and arrows = spread of india ink. F = fat. (a) Dissection of nerves in costal grooves above and below ones in which 5 ml of india ink was injected. N-9 = 9th intercostal nerves (vein above one on left contains small amount of blood). N-11 = 11th intercostal nerves. E = cut pleura, subserous and endothoracic fascia, and internal intercostal muscle below 9th rib which has been reflected caudad from it to expose contents of its groove. The same technique was used to expose contents of the groove of the 11th rib. Note, no ink in muscles. (c) Dissection of the costal groves of the 10th ribs into which india ink was injected. N-10 and arrows = 10th intercostal nerves with forceps under them. Note the extent of the spread of the india ink following dissection of 10th intercostal on left side of cadaver—compare c with B.
5 ml on the other side. Two cadavers were injected after postmortem (removal of the heart, lungs, great vessels, abdominal viscera). These cadavers were turned first on one side and 3 ml of india ink injected. They were then turned on the other side and 5 ml was injected.

In the first 12 cadavers, approximately 90 min elapsed from the time of injection until the areas of injection were examined. In the two cadavers with autopsy before injection, it was possible to visualize the spread of the india ink in the rib injected within 30 s. In all 14 cadavers, the spread of the india ink was photographed before dissection.

The costal grooves of the ribs injected, and the ribs above and below them, were dissected and photographed. In the first cadaver, an attempt to dissect the grooves of the ribs injected met with disaster. Not only did the manipulation (lifting of pleura, the subserous fascia and the endothoracic fascia with forceps) spread the india ink, but when these tissues which confined it were opened, the india ink rapidly diffused over the pleura, staining the adjacent tissues. Therefore, in the remaining 13 cadavers the costal grooves of the ribs injected were dissected last.

RESULTS
In all but one side of the 14 cadavers, the spread of the india ink was similar. Spread was the same whether the needle was fixed in place or moved forward and backward as the injection was made. Spread observed 90 min after injection was no greater than that observed after 30 s.

The india ink had distributed itself as follows. From the point of injection, it spread in the costal groove of the rib injected 7.5 cm towards the midline to lie alongside the homologous vertebra, and it spread 7–8 cm peripherally (fig. 1A, fig. 2A). As reported by Nunn and Slavin (1980), the ink entered the internal intercostal muscles below that rib, remaining under the pleura, the subserous fascia, and the endothoracic fascia covering that muscle (fig. 1A, fig. 2A). Contrary to the observation of Nunn and Slavin, it did not pass over the rib below the groove injected (fig. 1C, fig. 2B) and it did not spread into the internal intercostal muscle above the rib injected (fig. 2B). When dissected, the intercostal nerves above and below the one injected showed no evidence of being bathed by the india ink (fig. 1C, fig. 2B). Exposure of the nerves in the costal grooves injected showed them to be completely blackened by india ink (fig. 2C). Finally, cutting of the endothoracic fascia at the point of adherence to the periosteal covering of the thoracic vertebrae, as was done when the anterior portion of the vertebrae were cut off at postmortem, confirmed our previous observation that this fascia confined a solution injected to the costal grooves (fig. 2A) (Moore, Bush and Scurlock, 1980). Therefore, when a solution reaches the vertebrae, it spreads only cephalad and caudad along the posterior half of the sides of the vertebrae, but not further anteriorly into the prevertebral space (fig. 2A).

In one cadaver, and only on one side, some of the india ink must have entered a vessel in the costal groove as it was jiggled because the fine network of vessels under the pleura became visible (fig. 1B). The vessels of the rib injected appear to communicate with those at least one rib above and below the one injected.

DISCUSSION
It is difficult to explain why Nunn and Slavin (1980) observed a different spread of dye from that found in these 14 cadavers studied here. They used essentially the same technique of injecting the groove in the rib as was done in six of the present specimens in which the needle was fixed in position as the india ink was injected. They did not state the length of bevel of the needle. A disposable needle with a long (4 mm) bevel could account for distribution of the india ink into more fascial planes. On the other hand, moving a short-bevel needle to and fro as the ink was injected should give the same result as a long-bevel needle fixed in place. Perhaps in both of the cadavers studied by Nunn and Slavin, the needles entered blood vessels, and spreads similar to that observed on one side of one cadaver in our study resulted (fig. 1B). From our study the chance of this occurring is one in 28, but it is unlikely that it could escape from the vessels to bathe the nerves.

India ink can be spread easily and rapidly by manipulation of, pressure on, lifting of, or cutting of tissue; this was learned during the dissection of the 14 cadavers (fig. 2C and B, compare left sides). Therefore, the removal of the thoracic cage before injection by Nunn and Slavin (I could not do this because the bodies were to be embalmed for burial), its preparation for sectioning, or sectioning itself, might explain the differences in observation.
This study confirmed that the optimal site to block the intercostal nerves is at the angle of the rib, not only because the groove in the rib is broadest and deepest at this point, but because the fat which accumulates in the thoracic cage of a well-nourished patient lies over the ribs and anterior to its groove in this area. Therefore, it provides additional protection against pleural puncture (fig. 2A).

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REFERENCES