

SPREAD OF RADIOPAQUE SOLUTIONS IN THE EPIDURAL SPACE OF THE HUMAN ADULT CORPSE

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A LARGE number of segmental spinal epidural (peridural) blocks are being performed each year, and there are two particular questions concerning this type of anesthesia which are being debated. First, what volume of the local anesthetic solution need be injected into the epidural space to effect satisfactory analgesia? And, second, if the dura has been inadvertently punctured during the placement of the bevel of a needle in the epidural space, does solution injected into the epidural space enter the subarachnoid space via the hole or holes in the dura? In the hope of clarifying to some degree one or both of these questions, it was decided to study the spread of a radiopaque solution in the epidural and subarachnoid spaces.

METHOD OF STUDY

Seventy per cent iodopyracet (Diodrast) solution was injected from a 10 cc. lock-type syringe through a 19 gauge, 3 inch spinal (Quincke) needle at the rate of approximately one cubic centimeter per second into either the epidural or subarachnoid space of corpses. The injections were performed on the roentgenographic table within one to three hours after the death of the patients and prior to autopsy. The second lumbar interspace was used as the site of injection. The corpses were placed in the lateral decubitus position for the tap of either the epidural or subarachnoid space. Immediately following the injection of the iodopyracet solution the bodies were turned to the supine position. The roentgenographic table was horizontal at all times. Approximately twenty minutes after the injection, the spread of the iodopyracet solution was studied by anteroposterior and lateral roentgenograms of the vertebral column.

Three separate studies were conducted. First, 20, 30 and 40 cc. of the iodopyracet solution was injected into the epidural space. Each of the stated volumes of solution was injected into 5 corpses. Second, 20 cc. of iodopyracet was purposely injected into the subarachnoid space of 2 corpses. And third, in order to test the effect on the spread of the local anesthetic solution of inadvertent punctures of the dura

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during attempts to place the needle in the epidural space, the dura of 2 corpses were purposely punctured one or two times, the needle withdrawn from the subarachnoid space and dura, placed in the epidural space via the same (second) lumbar interspace, and 20 cc. of iodopyracet solution injected.

RESULTS

Nineteen corpses, ages 31 to 73 years, were included in this study. The roentgenograms following the injection of 20, 30 and 40 cc. of the

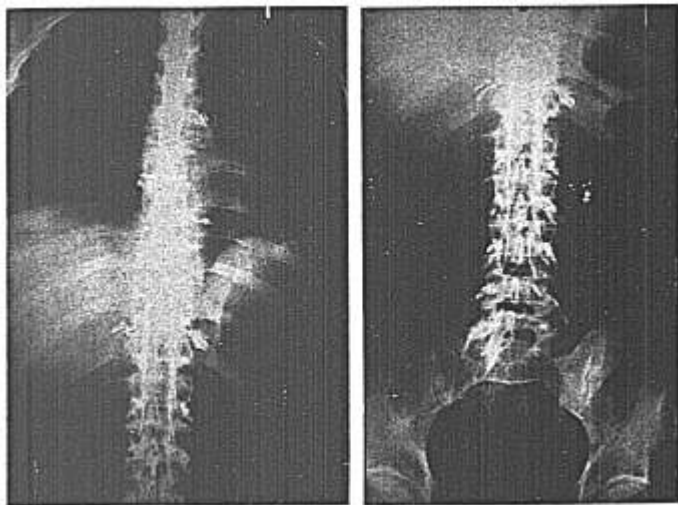


FIG. 1. The spread through the intervertebral foramina of 30 cc. of 70 per cent iodopyracet injected into the epidural space at the second lumbar interspace. (Reduction of roentgenograms for publication, as well as photographic difficulties in reproducing contrast, makes determination of spread of the iodopyracet in the illustrations less accurate than when the roentgenograms themselves are viewed.)

iodopyracet solution revealed that this solution tracked out the intervertebral foramina through the entire length of its visible shadow (fig. 1). With 20 cc. of the solution, the shadow extended from the fifth lumbar interspace to approximately the fourth thoracic vertebra (fig. 2). When either 30 or 40 cc. of the solution was injected, the shadow extended from the second sacral vertebra to approximately the lower border of the seventh cervical vertebra (figs. 3 and 4).

In the 2 corpses in which 20 cc. of the iodopyracet solution was injected subarachnoidally, the shadow extended from the most caudad

extent of the dura to approximately the fourth cervical vertebra (fig. 5).

In the 2 corpses in which the dura was punctured and then the iodopyracet solution injected into the epidural space, the shadow of the iodopyracet solution was visible from the fifth lumbar interspace to approximately the fourth thoracic vertebra (fig. 6). There was no evidence that any of the iodopyracet solution had entered the subarachnoid space.

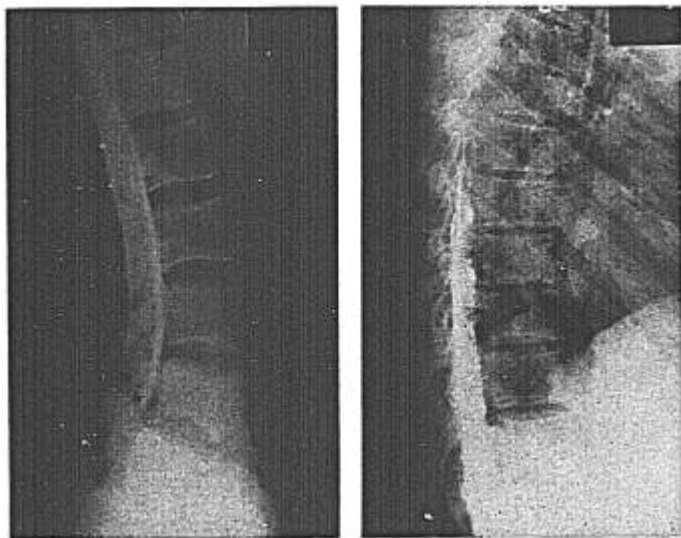


FIG. 2. The spread caudad (left) and cephalad (right) of 20 cc. of 70 per cent iodopyracet injected into the epidural space at the second lumbar interspace.

DISCUSSION

We do not believe that this study could be conducted in living patients inasmuch as 70 per cent iodopyracet might irritate the nervous tissues. Therefore, recently deceased bodies, that is, those dead less than three hours, were selected for the study because the conditions of their epidural spaces would seem to closely approach that of the epidural space in the living patient.

Seventy per cent iodopyracet was selected because: (1) its shadow gives a distinct contrast with that of the vertebral column and (2) being an aqueous solution, it more closely approaches the physical

characteristics of a local anesthetic solution than does an oily medium such as iodized oil U.S.P. (Lipiodol) or ethyl iodophenylundecylate (Pantopaque). Thirty-five per cent iodopyracet solution was injected in one corpse and found to be unsatisfactory because the contrast shadow between its shadow and that of the vertebral column was not marked enough to allow accurate study of its spread. This corpse was not included in this study. The volumes of iodopyracet solution injected were selected because most authors reporting on epidural blocks

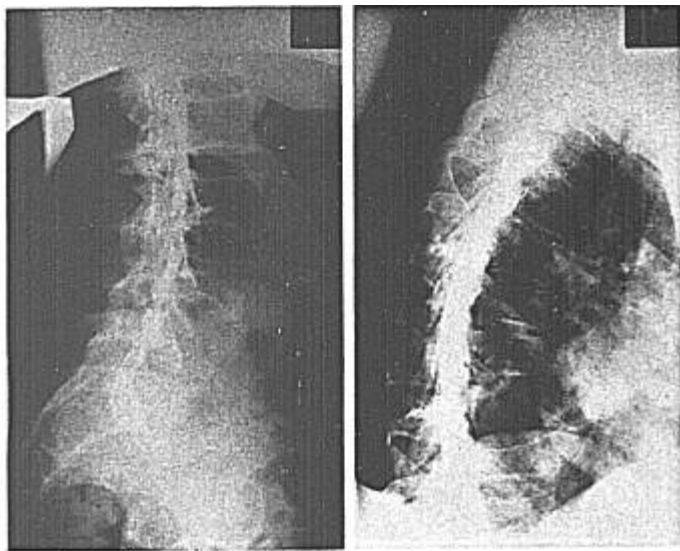


FIG. 3. The spread caudad (left) and cephalad (right) of 30 cc. of 70 per cent iodopyracet injected into the epidural space at the second lumbar interspace.

have employed a dosage of the local anesthetic solution which ranged in volume from approximately 20 to 40 cc. (1-7).

The "loss of resistance" test as described by Sicard and Forestier (8) and Dogliotti (9) was the method used to determine when the bevel of the needle had entered the epidural space (10). A lumbar interspace was selected for the site of the tap because the following factors make the lumbar area as compared to either the thoracic or the cervical region the easiest in which to execute a tap of the epidural space: (1) the angles of the slopes of the spinous process of the lumbar vertebrae are less acute, (2) the interspinous ligaments and ligamentum

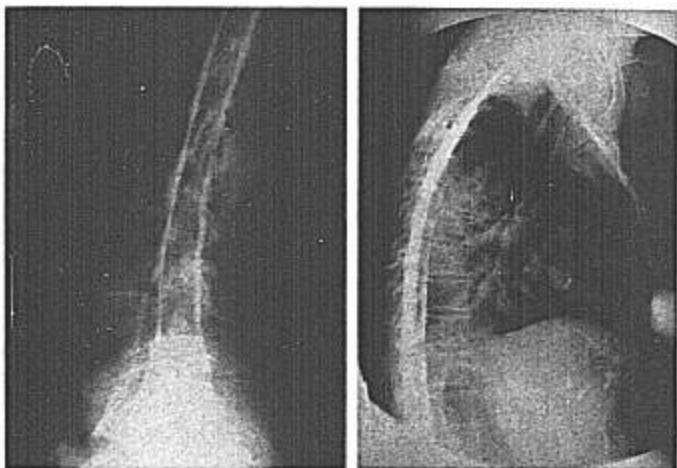


FIG. 4. The spread caudad (left) and cephalad (right) of 40 cc. of 70 per cent iodopyracet injected into the epidural space at the second lumbar interspace.

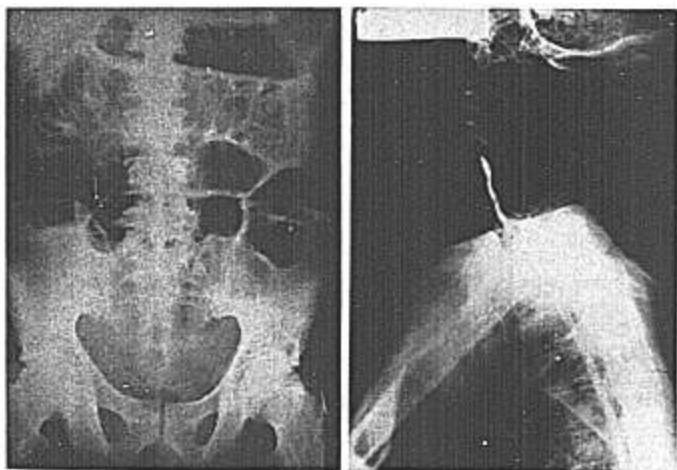


FIG. 5. The spread of 20 cc. of 70 per cent iodopyracet injection into the subarachnoid space at the second lumbar interspace.

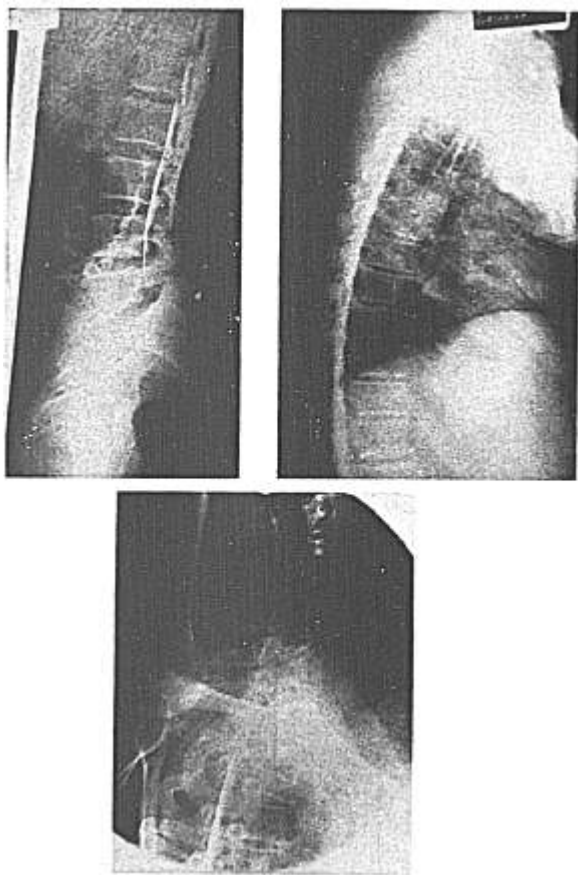


FIG. 6. The spread of 20 cc. of 70 per cent iodopyracet injected into the epidural space at the second lumbar interspace after the dura had been purposely punctured. No iodopyracet has entered the subarachnoid space.

flava are thicker in the lumbar area, and (3) the epidural space is wider in the lumbar area.

What Volume of Local Anesthetic Solution need be Injected into the Epidural Space to Effect Satisfactory Analgesia.—While some authors have advocated doses of local anesthetic drugs for epidural

block as high as forty or more cubic centimeters of solution, the results of this study would seem to indicate that it is seldom necessary to exceed 20 cc. of the local anesthetic solution. Twenty cubic centimeters of the iodypyracet solution consistently spread 13 to 14 dermatomes and if it had been a local anesthetic solution, it would have produced analgesia of a sufficient number of dermatomes for almost any surgical procedure for which an epidural block might be selected. Therefore, it could be concluded that in the average case the slightly greater spread, that is, 5 more dermatomes, obtained with either a 30 or a 40 cc. volume as compared with a 20 cc. volume does not add much to the required area of analgesia and does not warrant the use of these larger volumes. When larger volumes of the highly concentrated local anesthetic solution necessary to effect epidural anesthesia are employed, the chances of a systemic toxic reaction are greatly increased.

Our clinical observations would support the finding that 20 cc. of the local anesthetic solution need not be exceeded to produce satisfactory analgesia provided: (1) the epidural space is tapped at the correct vertebral interspace, (2) the entire calculated dosage of the local anesthetic solution is deposited in the epidural space, (3) the effect of gravity on fluids placed in the epidural space is allowed to exert its effect, that is, solutions gravitate to the dependent part of the space, (4) the local anesthetic solution is injected at the rate of not less than one cubic centimeter per second, and (5) the interval of time taken in refilling the 10 cc. syringe after the first syringe-full has been injected must be kept to a minimum for spread of solution within the epidural space is improved by the pressure created by the injection of the local anesthetic solution. In this study, the visible shadow of the iodypyracet very closely approximated the level of anesthesia which we have obtained in surgical patients with a 16 to 20 cc. dosage of a local anesthetic solution (2 per cent lidocaine [Xylocaine] plus 2 mg. of tetracaine [Pontocaine] per cubic centimeter of lidocaine plus 0.2 cc. of epinephrine 1:1000). We have performed over 3,000 segmental spinal epidural blocks for various surgical procedures of the chest, abdomen, and perineum and have never exceeded a maximum of 20 cc. of the local anesthetic solution. We seldom use this volume, for example, 12 to 15 cc. of local anesthetic solution are administered for inguinal herniorrhaphies, 14 to 16 cc. for cesarean sections, and 16 to 18 cc. for intra-abdominal operations. Our percentage of unsatisfactory epidural anesthesia using these volumes is small, that is, approximately four per cent, and could be due either to technical difficulties encountered in the placement of the needle, or errors in judgment in selecting the correct lumbar interspace at which to execute the tap, rather than the relatively small doses of the local anesthetic solution employed.

Selecting the Appropriate Interspace for Entry of the Epidural Space.—This is the most important single factor in assuring adequate

analgesia with a segmental spinal epidural block when the previously mentioned volumes of the local anesthetic solution are employed. We have always relied on this rather than on a larger, possibly toxic, dosage of the local anesthetic solution to assure the correct level of anesthesia. If an upper abdominal operation is to be performed, the anesthetic solution is injected at the interspace between the twelfth thoracic and the first lumbar vertebrae. If the operation is to be in the lower abdomen, the interspace between the first and the second or the second and the third lumbar vertebrae is used. When the operation is to be on the lower extremities of the perineum, the interspace between the third and the fourth or the fourth and the fifth lumbar vertebrae is preferred. If the thorax is to be opened, the entry is performed in the upper lumbar area rather than in the thoracic area. A needle with a Tuohy directional point is used so that a plastic catheter may be inserted through it and advanced up the epidural space until the end of the catheter is positioned at about the sixth thoracic vertebra. Entry into the epidural space in the thoracic area is made difficult by the greater angle of the thoracic spinous processes.

If the Dura has been Inadvertently Punctured During an Attempt to Place the Bevel of a Needle into the Epidural Space, does Solution Injected into the Epidural Space Enter the Subarachnoid Space Via the Hole or Holes in the Dura?—The 2 corpses in which the dura was purposely tapped and the iodopyracet solution injected into the epidural space showed no evidence of leakage of the radiopaque material through the hole in the dura. If leakage did occur, it was minimal in nature and could not be detected when the roentgenograms were compared with the films of the subarachnoid injected iodopyracet (figs. 5 and 6).

It has been cautioned that once the dura is tapped, a spinal or general anesthetic should be given because a subsequent epidural injection may result in a high or total spinal anesthesia. However, in approximately 100 of our 3,000 cases of segmental spinal epidural block the dura was inadvertently punctured, the needle was withdrawn into the epidural space or moved to another interspace and an epidural block established. In none of these cases has a high or total spinal block occurred, perhaps because 20 cc. or less of solution will not exert enough pressure in the epidural space to overcome the pressure which the spinal fluid exerts within the subarachnoid space and permit the anesthetic solution to enter the subarachnoid space. The results of our iodopyracet studies would seem to substantiate this reasoning.

SUMMARY

Seventy per cent iodopyracet (Diodrast) solution was injected into the subarachnoid or epidural space of 19 corpses. Twenty minutes following the placement of the radiopaque material, its spread was

checked by anteroposterior and lateral roentgenograms. From the study of these films, it was found that: (1) the iodopyracet solution tracked out the intervertebral foramina through the entire length of the visible shadow of the radiopaque material; (2) that it is seldom or never necessary to inject more than 20 cc. of a local anesthetic solution into the epidural space to obtain a level of anesthesia which is satisfactory for most surgical procedures; (3) that when 20 cc. or less of solution is injected into the epidural space following inadvertent puncture of the dura, little, if any, of the solution entered the subarachnoid space; and (4) that even if 40 cc. of the solution is injected, a segmental type of anesthesia is produced.

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