Anatomy of the Human Lumbar Epidural Space: New Insights Using CT-Epidurography

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The anatomy of the lumbar epidural space was demonstrated in 40 patients by computed tomography (CT) examinations performed after epidural injection of nonionic radiographic contrast material into the sacral caudal canal via percutaneous catheter. Radiologic evaluation of the epidural space was performed to evaluate possible disc herniation or other pathologic encroachments on the epidural space. In all 40 patients, the examinations showed the posterior epidural space to be divided by the plica mediana dorsalis and an additional transverse connective tissue plane not previously described. The compartmentalized nature of the space may be, at times, responsible for entrapment and coiling of epidural catheters, despite satisfactory technical performance of catheterization for epidural anesthesia. Thirty-one of 40 patients demonstrated a greater amount of fatty tissue within the junctions of the posterior midline epidural connective tissue structures, producing a bulky triangular-shaped structure which might be an impediment to catheterization. The divisions of the anterior and posterior epidural spaces are seen to be more complex than previously described. (Key words: Anatomy, CT, Epidural space.)

EPIDURAL ANESTHESIA is a well-established method for relief of pain during surgery, for diagnostic and therapeutic blocks in management of chronic pain, and for management of pain during labor and delivery. However, the anatomy of the epidural space as described in current textbooks fails to satisfactorily explain the occasional occurrence of difficulty in advancing the epidural catheters after successful demonstration of loss of resistance in the epidural space. Various attempts to elucidate the anatomy of the epidural space have been made in cadavers by dissection of the region and by producing casts of the epidural space.1,2 More recently, direct visualization by epiduroscopy at autopsy was used for the same purpose.3,4

We investigated the lumbar epidural space in 40 patients with caudal injection epidurography followed by computed tomography (CT) to evaluate degenerative disc disease. The anatomy of the epidural space proved to be more complex than previously described, especially in the posterior epidural space.

Materials and Methods

Forty patients underwent CT examinations of the lumbar spine after lumbar epidurography using the caudal percutaneous approach.6 Informed consent was obtained from all patients in accordance with the Human Research Committee (IRB). The patients were being investigated for radiculopathy.

Each patient was placed in the prone position on the fluoroscopic x-ray table. After infiltrating the skin with local anesthesia, a Potts-Cournand needle was percutaneously introduced through the caudal notch into the epidural space under fluoroscopic guidance. A 0.81-mm “J” guide wire was introduced through the needle and advanced to the L5-S1 disc level also under fluoroscopy. A 25 cm-long, 1.68-mm “JB one” pediatric carotid curve catheter was advanced over the wire by a modified Seldinger technique.5-7

Metrizamide (170 mg/ml) was initially used as the contrast agent. However, iohexol is currently being used with a similar concentration of iodine. These agents are nonionic and have been widely used in myelography and angiography.

Radiographs were obtained in the antero-posterior and lateral projections (fig. 1). CT examinations were performed on a General Electric 8800 scanner, and included sections through the L3-4, L4-5, and L5-S1 disc levels according to the levels clinically suspected to be involved in disc disease. Examinations were performed within 30 min after the fluoroscopic examination before significant loss of the iohexol would occur from the epidural space by absorption. Iohexol is lost most rapidly from the intervertebral foramen by absorption and dispersion. The remaining dye absorbs more slowly proportional to the volume of the individual dye localizations in the epidural spaces. The manipulation of the curved catheter tip under fluoroscopy facilitated the distribution of iohexol between the right and left sides.

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of the epidural space. The iohexol was hand injected slowly, using only enough pressure to produce continued filling. Since the epidural space is not naturally filled with free fluid, the iohexol tends to infiltrate preferentially around the catheter tip. The fluoroscopic image shows which areas in the epidural space are deficient in the spread of the iohexol. Manipulation of the catheter's curved tip, and injection of additional iohexol in these deficient areas, produces more uniform distribution of the iohexol and a better examination.

Iohexol injections were made with the catheter tip initially at L5-S1. About one-half of the iohexol material was injected at L5-S1, and the remainder was injected during slow withdrawal of the catheter into the sacral epidural space (approximately 15–20 cc total volume was used). No injections were made above L5-S1, and no intrathecal injections were made.

For gross anatomical comparison, a fresh cadaver was dissected. A laminectomy was performed at L4 so that the dorsal membranes at L3 might be approached from the space below and left intact (fig. 2A). When approached directly by the usual surgical laminectomy technique, the dorsal spaces collapse and the membranes are in the path of the dissection.

Results

The anatomy of the epidural space was well demonstrated and the plica mediana dorsalis clearly outlined in all 40 patients.

Previous descriptions of the epidural space have been varied, but they usually describe an anterior epidural space and dorsolateral epidural spaces on each side of the plica mediana dorsalis.1,6-10 Using CT images of a wide range of grey scale values (1500–4000 HU),§ we found that the iohexol agent outlined yet another intersecting connective tissue plane extending laterally from the plica mediana dorsalis on either side, which further subdivided each dorsolateral epidural space into an anterior and posterior compartment (figs. 2B, 3A). An undivided space ventral to the dural sac was present on all examinations. Filling of the compartments dorsal to the dural sac by iohexol was more prominent than that of the compartment ventral to the dural sac. These compartments are potential spaces, and are normally filled with fat and areolar tissue. Spread of the contrast material laterally through intervertebral foramina was frequently seen, and structures such as epidural vessels and nerve root ganglia could be demonstrated (fig. 3A, B).

While the plica mediana dorsalis on radiography appears to be a thin single membrane, the CT examinations demonstrated a variability of the plica anatomy in the posterior epidural spaces. Four variations of the structural pattern of the plicae and its associated membranes were noted in our study, as shown in figure 4. Of 40 patients examined, the thin, membrane-like appearance of the plica seen on radiographs was surprisingly the least common appearance on CT. Thirty-one of the 40 patients demonstrated a more complex and more space-occupying configuration of the plica and its associated membranes; however, the intervening spaces remained constant.

The fresh cadaver dissection showed conclusively that the hyperlucent septae that were seen extending laterally from the plica mediana dorsalis in CT scans were indeed membranous tissue planes, and not artefacts produced by the dye or CT technique.

Discussion

Although myelography has been the most popular method of evaluation of radiculopathy in degenerative disc disease and spinal stenosis, radiologic epidurography has been used to evaluate disease processes since 1941.1,6-16 However, problems in interpretation have been encountered, due to the difficulty of obtaining uniform distribution of radiographic contrast materials in the portion of the epidural space of clinical interest. Improvements in contrast distribution were made by Roberson et al. in 1979.6 They used a percutaneous

§ Hounsfield Unit (HU)—A computed tomographic representation of biological tissue density on an arbitrary scale on which bone is specified as +1000, air as −1000, and water as zero. The expanded grey scale represents HU as bone +2000, air −2000, and water zero. The latter scale offers more shades of grey and better descrimination of materials in the high-density range.
catheter approach through the sacral canal under fluoroscopic guidance. The plica mediana dorsalis, described by Layendijk in 1969, was consistently demonstrated as a linear midline structure in radiographic epidurography. Specific details regarding this structure were lacking, however, due to the excessive density of the radiographic contrast material and super-imposition of other structures in the radiographs. The combination of computed tomography with epidurography is now more informative than with the earlier generation of scanners, as the anatomic details outlined by the high density of epidural iohexol solution can be more clearly defined with currently available grey scale parameters. Little attention has been paid to the configuration of

![Diagram](https://via.placeholder.com/150)

**Fig. 2.** A. A fresh cadaver was dissected at levels indicated on the illustration. The total laminectomy at L4 affords a chance to view the posterior epidural membranes at L3 which are undisturbed by the surgery. The plica mediana dorsalis (white arrow) and membrane dividing the right dorsolateral epidural space into an anterior and posterior compartment (black arrow) are seen. The empty thecal sac (TS) is seen as a point of reference. B. A post-epidurogram CT section is shown with a window width of 4000 HU. Slight overdistention of the epidural space better demonstrates the division of the dorsolateral epidural spaces into anterior and posterior compartments by transverse membranes (black arrows). Plica mediana dorsalis (P), the thecal sac (T), and the ventral epidural space (V) are well seen. The section is obtained in the midline of disc level as the anulus fibrosus and nucleus pulposus are well visualized.

![Diagram](https://via.placeholder.com/150)

**Fig. 3.** A. Diagramatic representation shows the common features of the anatomy observed in 40 patients. The epidural omni-paque is represented as white material to coincide with the C.T. image, and negative defects are represented in black. In the intervertebral foramina, stippled markings represent the peripheral extent of the omni-paque infiltration into the perivertebral fat. The posterior (P) and the anterior (A) compartments of the dorsolateral epidural spaces are shown. The undivided ventral epidural space is also shown (V). On many observations, the most lateral extent of the posterior membranes is to the level of the epidural veins. These connective tissues most likely blend with connective tissues investing the veins and nerve root sleeves exiting the foramina. B. This CT section demonstrates less distinction of the spaces by omni-paque, producing a somewhat better diagnostic examination. Omni-paque exiting the intervertebral foramina is seen as high-density (white) material. The plica is less well demarcated due to the lesser volume of iohexol. The thecal sac appears as a negative defect (T). Other negative defects in the dye column represent epidural veins and more laterally in the intervertebral foramina nerve root ganglia.
the epidural space in the radiological and neurosurgical literature. In the present study, demonstration of the posterior epidural compartment anatomy was improved by using a curved tip catheter to better control the distribution of iohexol between the right and left sides of the epidural space, and by using more appropriate CT grey scale parameters to clearly outline anatomic structures previously obscured by the relatively dense radiographic contrast material. This anatomical information may have implications for the various interventional techniques employed in the epidural space. This compartmentalization may explain the difficulty sometimes encountered in threading a catheter through a Tuohy needle, or the occasional colling of a catheter in the epidural space during its introduction. The plica mediana dorsalis and associated membranes could deflect or interfere with the placement of such catheters.

Our iohexol injections by way of the caudal route revealed longitudinal extension and preferential filling of the epidural space at higher lumbar levels, even when the catheter tip was withdrawn as low as S3. While the epidural space is not comparable to the brachial plexus sheath, problems of compartmentalization and intracompartamental longitudinal flow of x-ray contrast media in the sheath, as described by Thompson and Rorie, suggest that the effects of compartmentalization may not be completely appreciated. The explanation given by Thompson and Rorie, that compartmentalization of brachial plexus due to septae may account for the not uncommon occurrence of profound block in one nerve and partial or absent block in other nerves, could possibly be applicable to the epidural space and its compartments, as well.

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References