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Opacification of Epidural Venous Plexus and Dura in Evaluation of Cervical Nerve Roots: CT Technique

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Thin-section computed tomography (CT) after bolus high-volume, intravenous contrast enhancement of the cervical epidural and intervertebral foraminal venous plexus was undertaken in eight patients. Visualization of exiting cervical nerve root by opacification of the surrounding intervertebral plexus was evaluated in 38 foramina. Visualization was judged as excellent in 77% and good in 21%. Thus the nerves were seen satisfactorily in all but one foramen. As the CT scan parallels the long axis of the cervical roots as they pass through the intervertebral foramen, anatomic delineation of the root out to the level of the vertebral artery is excellent. A local widening of the root, which was thought to represent the dorsal root ganglion, was seen in most foramina examined. Excellent filling of the epidural plexus was seen in seven of eight subjects; good opacification was seen in the other subject. In no instance did the study fail to satisfactorily fill the epidural plexus in the cervical vertebral canal. This technique appears to be an excellent method for evaluating the cervical nerve roots and the epidural space.

While computed tomography (CT) of the lumbar spine has been quite successful in showing intervertebral disk disease, CT for cervical disk disease has been slower in development [1, 2]. The intervertebral disk in the cervical region is thinner, and there is much less fat in the cervical epidural space. The exiting lumbar nerve roots are easily seen against the hypodense fat in the lumbar region. Thinner CT slices must be used to image the thinner cervical disks to solve the first problem. A method of adding contrast would be helpful in solving the second. After noting marked opacification of the cervical epidural venous plexus with visualization of the cervical nerve roots in patients receiving bolus, high-volume contrast enhancement for CT study of the carotid arteries, we investigated this technique as a method for displaying the cervical nerve roots. Thirty-eight exit foramina in eight patients were evaluated for the degree of visualization of the cervical nerve roots and the degree of filling of the cervical epidural venous plexus.

Subjects and Methods

The opacification of the cervical epidural venous plexus after intravenous contrast enhancement was analyzed in eight patients 40–60 years old. All patients were undergoing a CT evaluation of the extracranial carotid arteries for transient ischemic attacks using a bolus, high-volume contrast enhancement technique.

Technique

All CT scans were obtained on a General Electric 8800 or 9800 unit using "infant mode" on the 8800 or "small body mode" on the 9800 [3]. An anteroposterior and lateral ScoutView of the cervical region from C1 to C7 was obtained; if the shoulders obscured the level of interest in the lower cervical area, the technologist switched to medium or large file at that level. The shoulders were pulled down as much as possible [4]. Prospective soft-tissue target of 1.4 was used all the way through. The exposure factors were 9.6 sec at 400 or 500 mA. The patient was instructed to hold his breath for each exposure.

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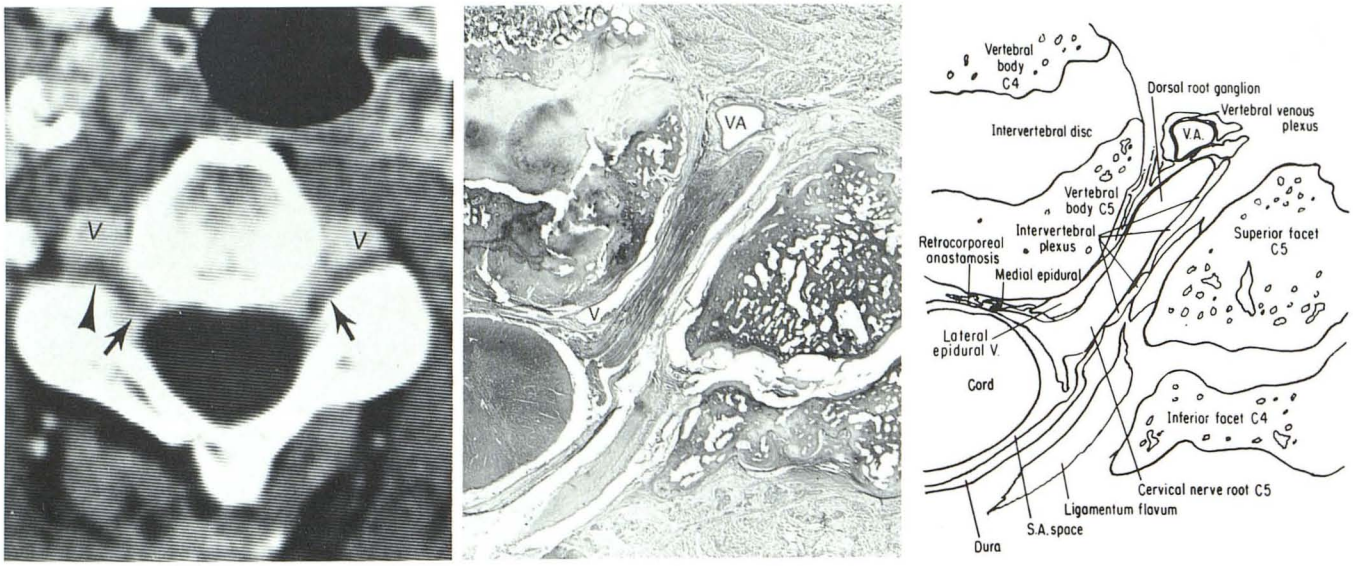
TABLE 1: **Quality of Dural and Epidural Venous Opacification**

Case No.	No. of Disks Examined	Dural Opacification	No. of Foramina by Degree of Opacification			
			4+	3+	2+	1+
1	3	2+	6	...	...	...
2	3	2+	6	...	...	...
3*	2	1+	...	4	...	...
4	3	2+	4	2	...	...
5*	3	2+	1	2	2	1
6	2	2+	4	...	...	...
7	2	2+	4	...	...	...
8	2	2+	4	...	...	...

Note.—Dura opacification: 2+ = dura well opacified; 1+ = dura somewhat opacified; 0 = dura not enhanced. Intervertebral foraminal plexus opacification: 4+ = entire exit canal filled and nerve outlined; 3+ = canal well filled but nerve not seen in entirety; 2+ = canal well seen, but nerve is poorly seen; 1+ = some filling of canal, nerve not seen.

* These two patients had consistently lower scores.



A B C

Fig. 1.—Cervical nerve roots exiting from dura and passing through intervertebral foramen. **A**, CT scan after bolus, high-volume contrast enhancement. Enhancement of venous plexus surrounding cervical roots. Nerve root is linear hypodensity running through foramen (*arrows*). Slight widening of root (*arrowhead*) as it passes behind vertebral artery (V) is the dorsal root ganglion. Venous enhancement between vertebral body and ventral dura. **B**, Anatomic section through plane of exiting nerve root. Empty space (V) surrounding nerve root in canal is venous plexus of lateral foramen, which is collapsed postmortem. This plexus joins plexus of veins surrounding vertebral artery (VA), and is almost totally collapsed in this illustration. **C**, Schematic drawing of vertebral canal in cervical region shows epidural veins. Venous retrocorporeal anastomosis unites longitudinal epidural veins, medial epidural vein, lateral epidural vein, cervical nerve root surrounded by plexus of intervertebral foramen, and vertebral artery surrounded by vertebral venous plexus. SA = subarachnnoid.

Contrast Medium

A 150 ml bolus of Renografin-60 was injected through a 19 gauge needle followed by a rapid trip of a second bottle of Renografin-30. Scanning was started after the second bottle began to run in. A rapid drip at 50–60 drops/min was continued for the duration of scanning.

Scanning Program

The scan angles paralleled the disk space. Using the GE 8800 four CT scans of 1.5 mm thickness were obtained at each disk space. The table was moved 1.5 mm. Using the GE 9800 two scans of 3 mm thickness were obtained at each disk space. The table was moved 3 mm after each scan.

Results

Table 1 reports the degree of opacification of the dura and the epidural venous plexus after bolus, high-volume contrast enhancement. The dura and the plexus immediately adjacent to the dura were well filled in seven (88%) of eight patients (fig. 1). The dura and the epidural venous plexus were seen moderately well in one (12%) of eight (fig. 2). In no case did the dura and the extradural venous plexus fail to fill to some degree.

Table 1 also shows an analysis of the degree of venous opacification of each of 38 intervertebral foramina in the eight subjects. Visualization of the venous plexus in the intervertebral foramina was graded as excellent (4+) (figs. 2 and 3),

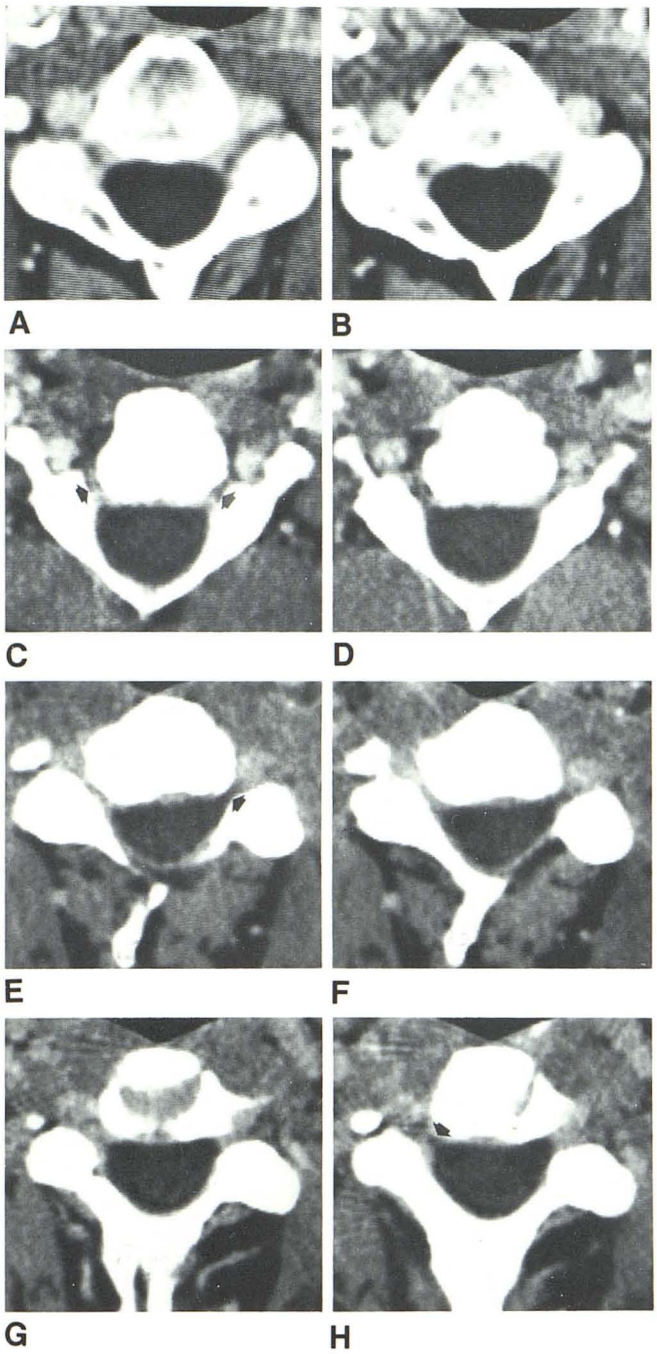
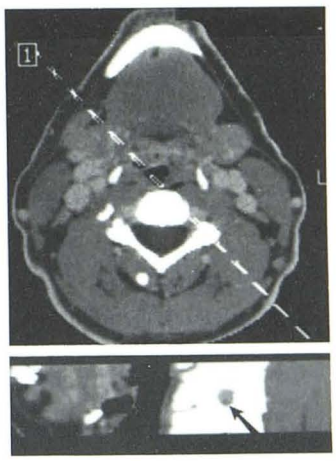


Fig. 2.—Opacification of dura and epidural/intervertebral foraminal venous plexus after intravenous bolus, high-volume contrast enhancement. Dural opacification is rated zero to 2+ (good opacification), and degree of plexus opacification with cervical nerve root visualization is rated 1+ (poor) to 4+ (excellent). **A** and **B**, 2+ opacification of dura and 4+ visualization of cervical nerve roots. Dorsal and ventral roots are already united when cervical nerve roots pass through dura. **C** and **D**, 2+ opacification of dura and 3+ visualization of nerve roots (*arrows*). **E** and **F**, 1+ opacification of dura and 2+ visualization of nerve roots (*arrow*). Root on viewer's left (patient's right) is almost imperceptible. **G** and **H**, 1+ opacification of dura and 1+ visualization of nerve roots. Cervical root on viewer's right (patient's left) is not visualized. Right root is partly visualized (*arrow*).

Fig. 3.—Oblique reformation of exit foramen after intravenous enhancement. Reformation is 6 pixels in width. Entire exit foramen is filled with venous opacification, except for small hypodense defect for exiting root (*arrow*). This reformation was made from patient with 4+ nerve root visualization.



good (3+), fair (2+), or poor (1+). Of 38 exit foramina, 29 (77%) showed excellent visualization of the exiting cervical nerve roots. Eight (21%) other foramina showed good visualization. Therefore the exiting nerve roots were well visualized in 98% of all intervertebral foramina studied.

While visualization of the nerve root is the important finding, one could frequently identify a local enlargement of the nerve root in the region peripheral to the exit foramen just posterior to the vertebral artery. This enlargement is thought to represent the dorsal root ganglion, and it was seen in most of the 38 roots examined.

Discussion

Studies of patients with cervical spine disease have already shown the value of thin-section CT scanning [2]. However, while one can often see the dura on high-quality thin CT scans of the neck, one cannot see the individual nerve roots in the intervertebral foramen. Certain herniated disks can be visualized by thin-section CT without intravenous contrast enhancement. The herniated disk, which is more dense than the dura and its contents, may be seen protruding posteriorly or it may be seen posterolaterally against the hypodensity of the intervertebral foramen. However, these changes, when present, are usually quite subtle. Therefore, CT scanning might be more sensitive for the detection of the cause of radiculopathy if a suitable contrast technique could be developed that would allow routine visualization of the nerve roots in the epidural compartment and in the exit foramen. We believe that intravenous bolus, high-volume enhancement of the epidural veins with thin-section CT scanning makes these cervical roots clearly visible (fig. 1). Our study is an analysis of the consistency and degree of filling of the epidural and intervertebral venous plexus using this technique.

Excellent visualization of the intervertebral foramen plexus of veins (90%); excellent visualization of the nerve root and, in many cases, the dorsal root ganglia (87%); as well as the significant opacification of the dura and the epidural venous plexus around the dura (100%) indicate that filling of the venous plexus after bolus, high-volume contrast enhance-

ment can be a dependable feature in studying the cervical spine. In two subjects, the scores for degree of opacification of the intervertebral foramen plexus were lower than 4+, as were the scores for dural and epidural plexus opacification. This raises the question as to whether these patients received a technically adequate study, as all other subjects had optimally enhanced venous opacification. The important finding is that we do see the roots quite well in essentially all cases.

While the epidural venous plexus is particularly well seen ventrolaterally, the central area may show little opacification apart from the enhanced dura because of the small size of the venous retrocorporeal anastomosis uniting the longitudinal epidural veins [3] and the small epidural space anteriorly. Opacification of the dura alone is very important in the assessment of cervical disk pathology. The normal cervical intervertebral disk is not seen on the CT scan. Therefore, if the opacified dura can be seen adjacent to the cortex of the posterior vertebral body, the observation provides reassurance that no posterior disk herniation has occurred.

We have established that there is consistent filling of the epidural and intervertebral plexus with dural opacification in subjects without cervical spine symptomatology. This normal anatomy may be useful in the evaluation of cervical spine pathology, especially in cervical root compression syndromes. This investigation, based on CT planar studies that lay open the exit canal from end to end, is issued at a time when the foundation of plain-film radiographs, the oblique cervical spine film for the intervertebral foramina, is being challenged [5].

As this investigation neared completion, a report using intravenous contrast enhancement in studying the cervical spine with CT appeared [6]. These authors used 37.5 g of iodine but did not state whether or not it was given by bolus. While the images shown in their article demonstrate opacification of the epidural plexus, we have found that we need to use bolus injection followed by rapid intravenous drip totaling 50–60 g of iodine to give superior opacification of the epidural plexus; even at these doses, a few of the images were less than optimal (table 1).

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