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Serial Biplane Magnification and Subtraction Myelocisternography: Normal and Pathologic Findings

T. El Gammal[1]
Betty Sue Brooks[1]

A modified technique for performing Amipaque myelocisternography is described and results obtained in the first 100 patients are analyzed. Diagnostic quality examinations were obtained in 90% of patients in whom the technique was employed. The complication rate was comparable to studies using C1-C2 puncture and to other reports using Amipaque contrast medium. This examination is valuable for high cervical and craniocervical junction lesions, cervical cord atrophy or enlargement, cerebellar ectopia, lower cranial nerve neuropathies, and cerebellopontine angle problems, especially the early detection of small acoustic neurinomas.

The value of positive contrast examination for the study of the craniocervical junction and posterior fossa contents has been well established. Amipaque is considered a useful contrast medium for this examination [1]. The addition of magnification and subtraction to the technique and serial biplane filming in oblique projection has been described [2]. We present our experience with this modified technique in our first 100 cases, including both normal and pathologic findings in the posterior fossa, craniocervical junction, and cervical regions.

Materials and Methods

The examination is performed on a 90°-90° tilting table and remote control fluoroscopic unit, with a detachable table top that can be advanced over a Phillips Poly-N isocentric device with biplane two to one magnification capability. Lateral C1-C2 puncture is performed with the patient prone with the neck extended. Preliminary scout films are obtained after placing a lead marker as an aid to localizing the puncture site posterior to the spinal cord. Fluoroscopy in frontal projection is also used occasionally to assist needle placement; however, this has not been found necessary on a routine basis.

After needle placement, the patient's head is carefully rotated to a 45° oblique position. Observation of the continued free cerebrospinal fluid flow from the needle is made during this entire maneuver to ensure proper position of the needle. If the flow stops, which occurred in only two cases, the needle should be withdrawn and the head returned to neutral position. The needle can then be carefully readvanced in 2 mm increments. When satisfactory needle position has been obtained, the head is secured with tape in the oblique position. Amipaque is injected in a concentration of 220 mg/ml with a total volume of 12 ml. Four to six serial biplane exposures are made while the patient remains in the head oblique position. The first exposure is obtained immediately before injection of contrast material to serve as the subtraction mask. After needle removal, the patient's head is returned to neutral position and single biplane and right and left oblique cervical views are obtained with the isocentric device without moving the patient's head to complete the examination. The procedure is modified for patients with a cervical kyphosis by performing the needle puncture in the supine straight position.

For bilateral cerebellopontine angle examinations, one-half the contrast may be injected in the initial oblique position and the patient's head then returned to neutral after the first series of films. The head of the table is elevated for approximately 2 min to assist the flow of contrast material out of the cranial cavity to ensure adequate subtraction of the opposite

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[1]All authors: Neuroradiology Section, Department of Radiology, Medical College of Georgia, Augusta, GA 30912. Address reprint requests to T. El Gammal.

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cerebellopontine angle. The head may then be positioned in the opposite 45° oblique, the remainder of the contrast material injected, and a repeat set of films obtained.

The degree of neck extension is an important aspect of the procedure. For routine cervical spine examination, a good deal of neck extension in the prone position is necessary to keep the amount of contrast entering the cranial cavity to a minimum. When the head is returned from the oblique to neutral position, excellent filling of the craniocervical junction posteriorly is obtained as the Amipaque passes from posterior fossa to the upper cervical region. Less extension is used for posterior fossa study of craniocervical junction problems, and where single or bilateral examination of the posterior fossa subarachnoid recesses is indicated, the least degree of neck extension is required. Care must be taken, however, as passage of more contrast material above the tentorium will occur with increasing flexion of the neck.

A few patients received prophylactic phenobarbital postexamination when there was a special indication. Anticonvulsant medication was not used routinely, although some authors recommend it [3-5].

TABLE 1: **Visualization of Nerves, Vessels, and Subarachnoid Spaces at Amipaque Myelocisternography**

Anatomic Structure	No. Visualized (No. procedures)
Cranial nerves:	
V	63 (86)
VI	13 (86)
VII	54 (86)
VIII	70 (86)
XI	24 (86)
IX, X, or XII	5 (86)
Subarachnoid spaces:	
Cerebellopontine angle	86 (86)
Internal auditory recess	80 (86)
Cavum trigeminale	31 (86)
Jugular foramen recess	24 (86)
Posterior craniocervical junction	92 (100)
Artery:	
Vertebral	88 (100)
Posterior-inferior cerebellar	82 (100)
Basilar	30 (86)
Anterior-inferior cerebellar	42 (86)

Note.—Bilateral cerebellopontine angle examination was performed in eight patients but subtraction of the second angle examined was inadequate in two.

Results

This technique affords consistently excellent delineation of various nerves and vessels traversing the pontine and cerebellopontine angle cisterns, and posterior fossa subarachnoid recesses, including the internal auditory recess, cavum trigeminale, and jugular foramen diverticulum (table 1). In 18 of 100 examinations the study was performed only for the cervical spine; in two additional cases subtraction was inadequate due to patient motion. In these cases, increased neck extension was used in the head oblique position to allow just enough contrast material to enter the cranial cavity to outline the craniocervical junction posteriorly on returning the head to neutral position. These 20 cases were excluded from the analysis of visualization of posterior fossa structures. Of the remaining 80 cases in which the posterior fossa examination was included, cranial nerves V-XII were visualized with varying incidence (figs. 1-8). The eighth nerve is seen in more than 80% of cerebellopontine angle examination, and noted to be larger than and lying posterolateral to the seventh, which will also be delineated in more than 60% of cases. The fifth nerve is visualized with an approximate 73% incidence, while the spinal tract of the 11th is seen about 28% of the time. Less frequently observed are the sixth (15%), and occasionally the ninth, 10th, and 12th nerves. One or both vertebral arteries and the posterior inferior cerebellar artery are demonstrated in many cases. Less often the basilar artery and anterior inferior cerebellar artery may also be seen.

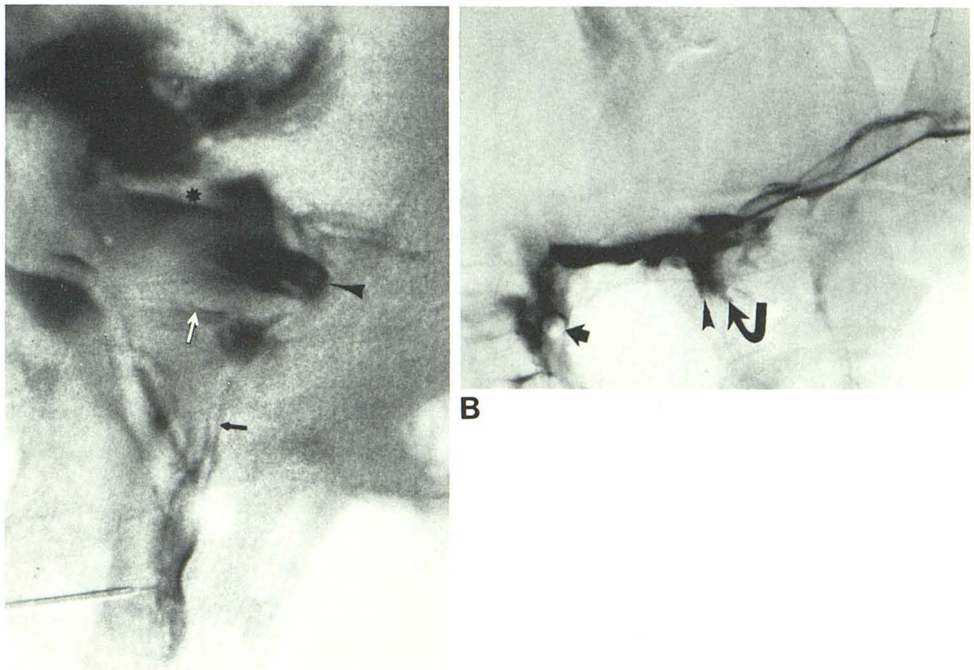
The cervical spinal cord, subarachnoid space and especially, the posterior craniocervical junction are well outlined in more than 90% of cases (fig. 9). With the prone position used in this technique, normal cerebellar tonsils have been visualized in only a few cases (fig. 9A). Usually, superimposition of mastoid air cells on the cross-table lateral (nonsubtracted) film prevents their adequate delineation, however, cerebellar tonsillar herniation can easily be seen, and this occurred in five cases in this series. The cisterna magna has also been infrequently identified despite the prone position (less than 10% of cases).

Tables 2 and 3 describe procedure failures and complications related to Amipaque injection. Of 111 attempts, 100 examinations were technically adequate for the purpose of the requested study. In addition, there were eight patients in whom bilateral cerebellopontine angle examination only was performed. Of these 16 cerebellopontine angles studies, two were inadequate due to poor subtraction. In one of these, however, the normal internal auditory recess was easily seen on the horizontal beam lateral oblique nonsubtracted film. Thus, the examination was diagnostic in 15/16 cerebellopontine angles examined in eight cases.

Among the failed procedures, four were due to inability of the patient to cooperate sufficiently for this type of examination and three were directly related to the patient's attendant disease (dry or bloody taps associated with arachnoiditis and tumor). Three examinations were considered technical failures due to improper patient positioning during the injection (one case), or improper needle position (two cases). Operator failure rate of less than 2% is not unduly high at a teaching institution where a significant number of procedures are performed by relatively inexperienced examiners.

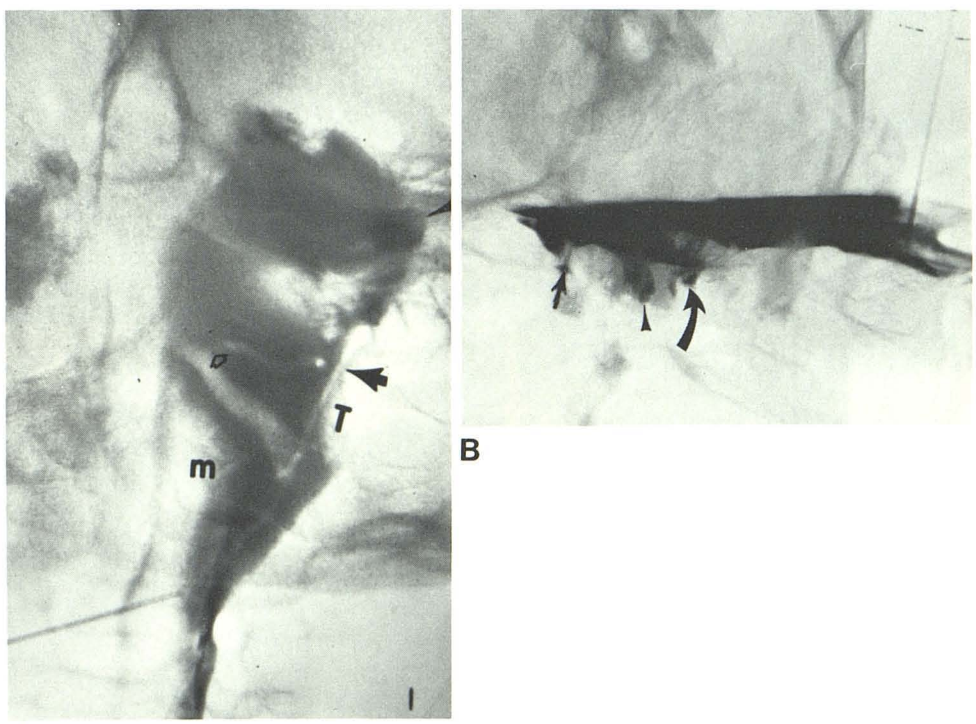
We have seen only one case of injection into the spinal cord central canal during the several years in which C1-C2 punctures were employed at our institution. The real incidence of this unusual complication may actually be less than the 1% rate indicated in this series of 111 attempted examinations. The patient developed transient weakness of the left upper extremity and painful paresthesia of the left upper chest and limb at injection; recovery was nearly complete within 24 hr. Two-month follow-up examination revealed minimal paresthesia of the left upper extremity and a Pantopaque myelogram demonstrated normal size of the cervical cord with no evidence of the hydrosyringomyelia which was thought to account for the free flow of cerebrospinal fluid before the injection of contrast into the center of the cord.

The neck pain that occurred in 12 patients was unilateral, on the same side as the needle puncture in all cases, and was associated with earache as well in three patients. The



A B

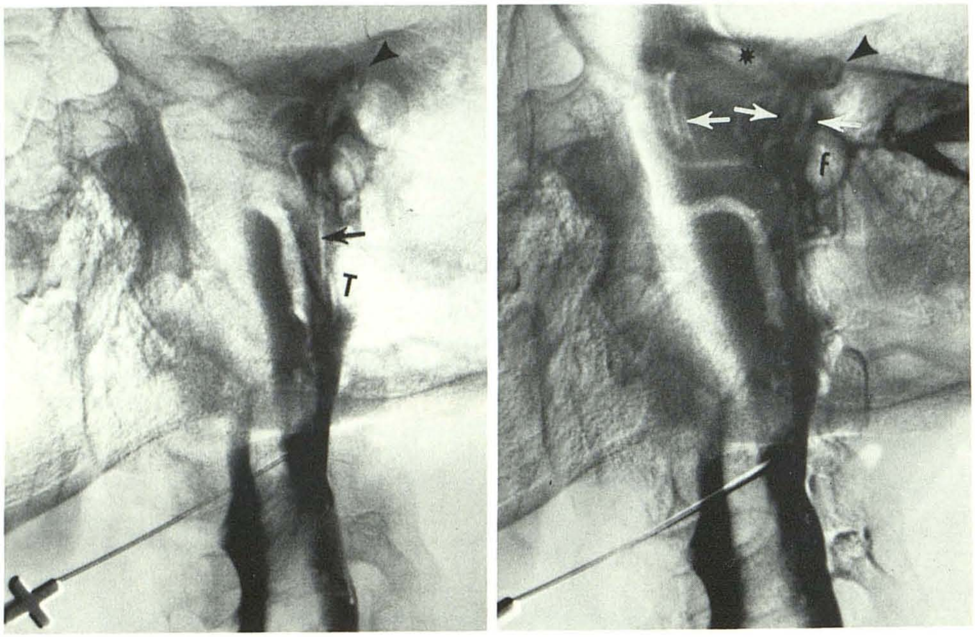
Fig. 1.—Cisternogram after 6 ml contrast material shows posterior fossa subarachnoid recesses. **A**, Posteranterior oblique view with subtraction delineates internal auditory recess containing seventh and eighth nerves (*arrowhead*) and fifth nerve (*asterisk*). Jugular subarachnoid recess is caudal to internal auditory recess. Ninth or 10th nerve ends in recess (*white arrow*). Spinal tract of 11th nerve arises from recess (*arrow*). Vertebral and posterior inferior cerebellar arteries are more medial. **B**, Cross-table lateral oblique shows lateral end of internal auditory recess (*arrowhead*), cochlear aqueduct (*curved arrow*). Contrast above tentorium delineates internal carotid artery (*arrow*).



A B

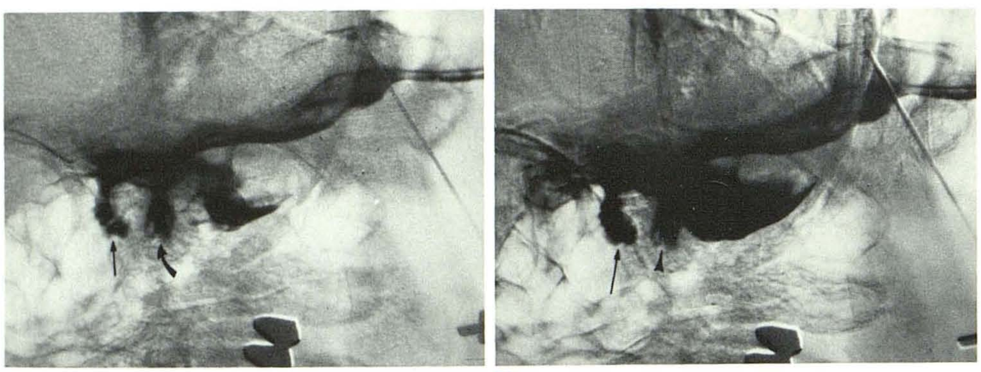
Fig. 2.—Cisternogram after 12 ml contrast and more extension of neck. **A**, Posteroanterior oblique view with subtraction. Internal auditory recess (*arrowhead*); linear defects represent seventh and eighth nerves. Also seen are spinal accessory nerve (*arrow*), origin of posterior inferior cerebellar artery (*open arrow*), medulla (M), and cerebellar tonsil (T). **B**, Cross-table lateral oblique shows internal auditory recess (*arrowhead*), incompletely filled cavum trigeminale (*arrow*) and jugular recess (*curved arrow*). Jugular recess is partly obscured by amipaque around cerebellum.

etiolology is thought to be passage of the spinal needle through a large cutaneous branch of the second cervical nerve. Most cases of headache and nausea were not severe. The single instance of a grand mal seizure occurred early in the study and was controlled without difficulty with anticonvulsant medication without further sequellae. In this patient, inadvertent injection of most of the contrast material above the tentorium was due to flexion of the patient's neck. Overall this method did not seem to increase or change the known complications which may be associated with the C1–C2 puncture and with the use of Amipaque contrast material [6–8].



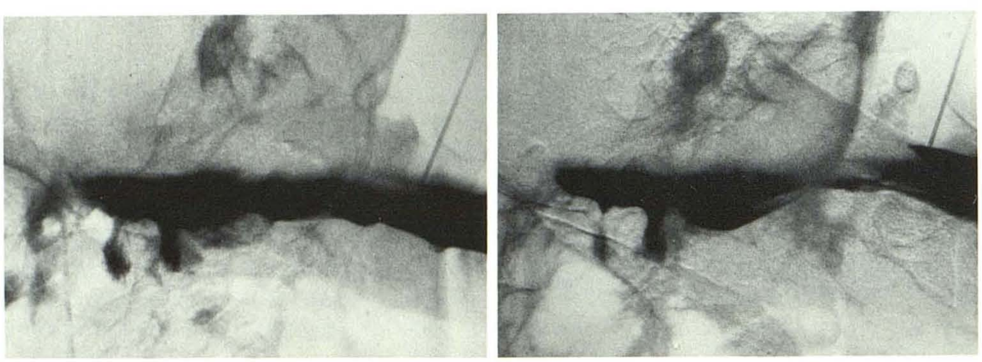
A B

Fig. 3.—Serial posterior fossa study. Posteroanterior oblique view **A**, Early phase shows internal auditory recess (*arrowhead*), spinal accessory nerve (*arrow*), and cerebellar tonsil (T). **B**, Later phase with more filling of cerebellopontine angle. Also shown are: internal auditory recess (*arrowhead*), fifth nerve (*asterisk*), seventh and eighth nerves (*arrows*) above flocculus of cerebellum (F), and sixth nerve (*medial arrow*). Contrast obscures spinal accessory nerve.



A B

Fig. 4.—Serial myelocisternography. Cross-table lateral oblique views. **A** and **B**, Internal auditory recess well outlined with filling defects representing seventh and eighth nerves (*arrowhead* and *curved arrow*). Cavum trigeminale (*straight arrows*). In Later phase, **B**, medial part of internal auditory recess is obscured by contrast passing around anterior aspect of cerebellar hemisphere.



A B

Fig. 5.—**A** and **B**, Cross-table lateral oblique view in two patients shows normal appearance of internal auditory recess. More cranially, cavum trigeminale diverticulae fill.

Discussion

Description of the normal anatomy in the posterior fossa after the introduction of Pantopaque was first made by Baker [9], with contributions by others [10, 11]. The improved delineation of the anatomy afforded by our modified technique may be attributed to the use of a contrast medium of lesser density, and the value of adding serial biplane

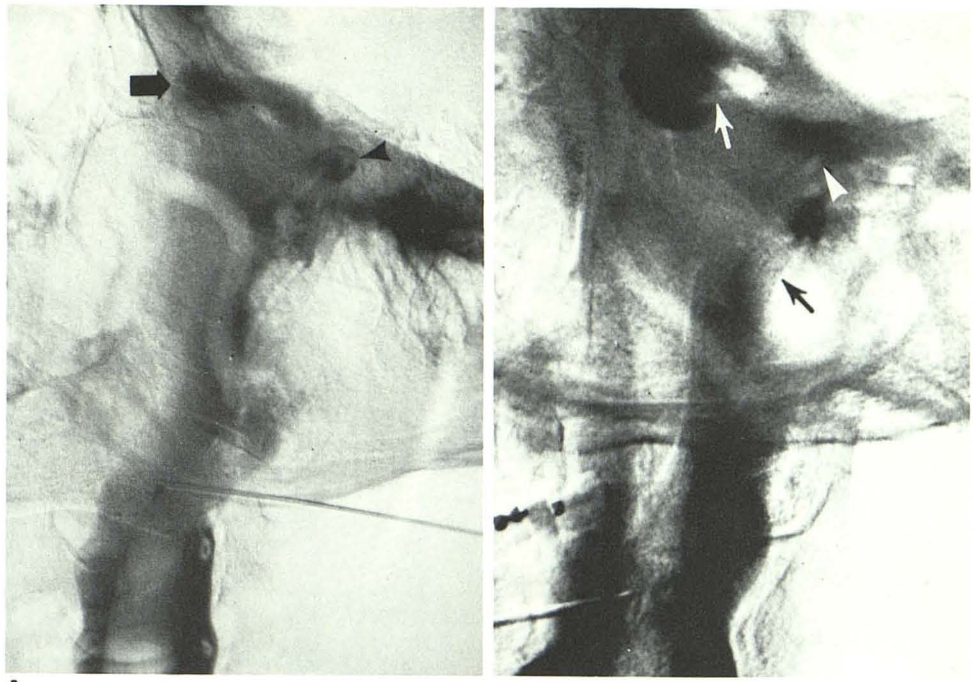


Fig. 6.—Posteroanterior oblique views in two patients show normal size range of cavum trigeminale. **A**, Average size (*arrow*). Internal auditory recess with seventh and eighth nerves (*arrowhead*). Spinal accessory nerve and vertebral artery are also seen. **B**, Large. Division of fifth nerve (*white arrow*), eighth nerve (*arrowhead*), spinal accessory nerve (*arrow*).

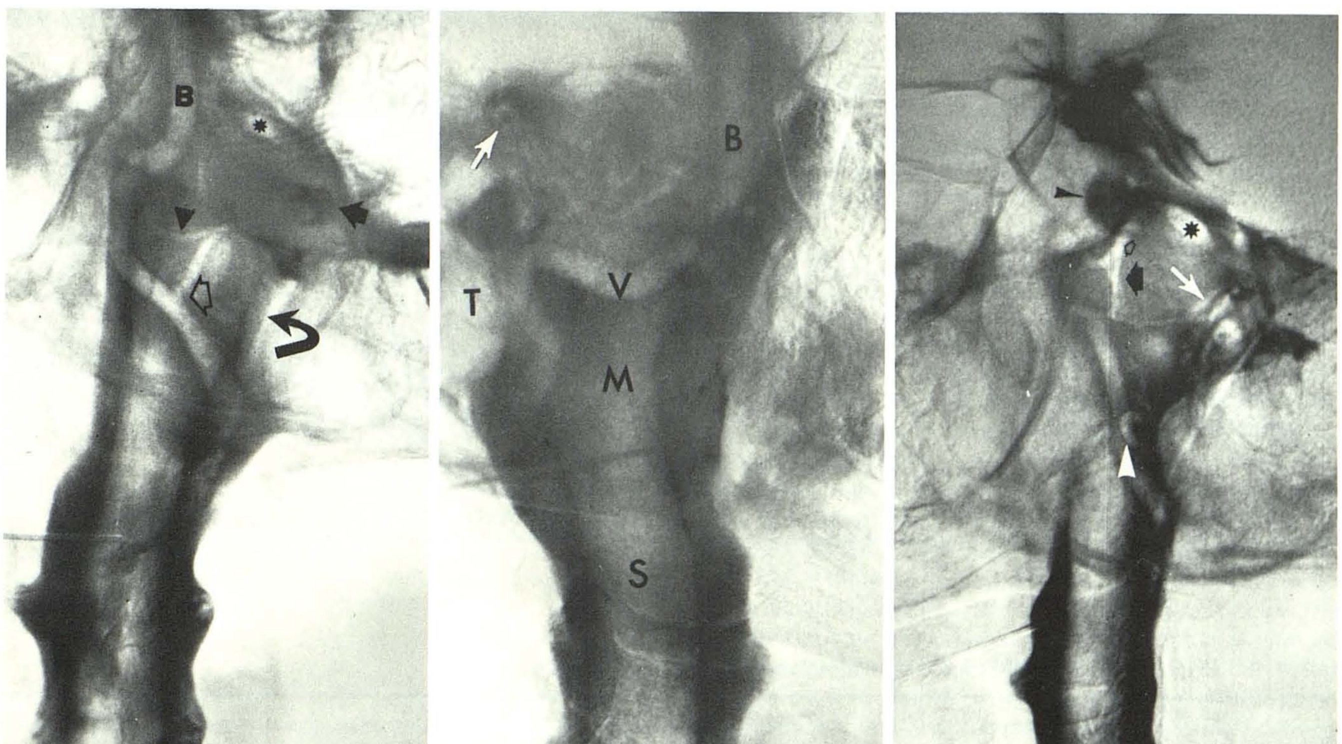
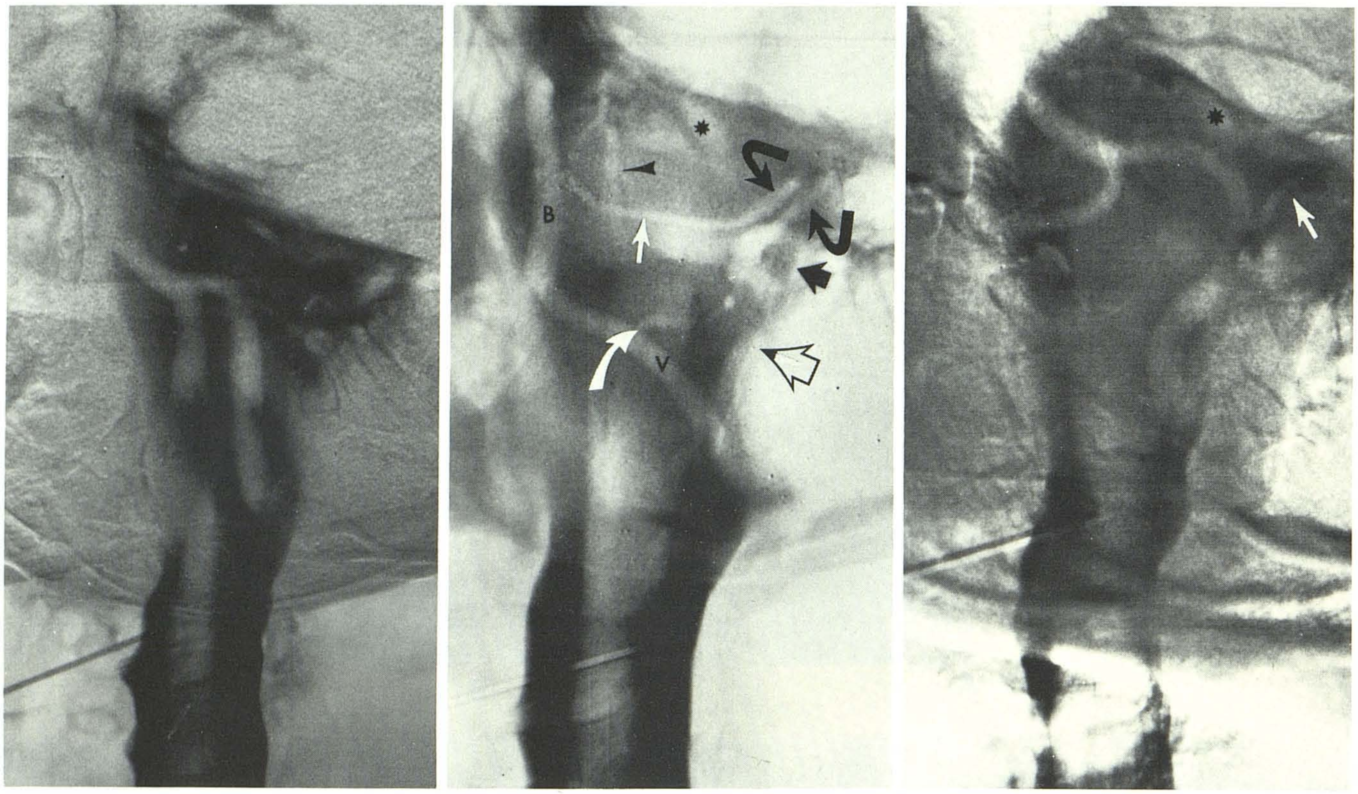


Fig. 7.—Posteroanterior oblique views in three patients demonstrate normal internal auditory recess with amipaque in cerebellopontine angle. **A**, Right vertebral and basilar arteries (B) and branches are well outlined. Vessels lie away from seventh and eighth nerves in internal auditory recess (*arrow*) and from fifth nerve (*asterisk*). Spinal accessory nerve (*curved arrow*), anteroinferior cerebellar artery (*arrowhead*), origin of posteroinferior cerebellar artery (*open arrow*). **B**, Internal auditory recess (*arrow*), vertebral artery (V), basilar artery (B), medulla oblongata (M), upper cervical cord (S), and cerebellar tonsil (T). **C**, Seventh and eighth nerves (*white arrow*) in relation to auditory recess. Fifth nerve and ganglion (*asterisk*), sixth nerve (*arrows*), cavum trigeminale (*arrowhead*), and low posteroinferior cerebellar artery forming loop superimposed on right vertebral artery (*white arrowhead*).



A B C

Fig. 8.—Posteroanterior oblique projections in three patients demonstrate normal vascular anatomy. **A**, Junction of right and left vertebral arteries to form basilar. **B**, Vertebral artery (V), basilar artery (B), origin of posterior inferior cerebellar artery (*curved white arrow*), and anterior inferior cerebellar artery (*white arrow*). Cranial nerves include: fifth (*asterisk*), sixth (*arrowhead*), spinal accessory (*open arrow*), seventh and eighth entering internal auditory recess (*curved arrows*). Jugular subarachnoid recess (*arrow*). **C**, Tortuous right vertebral artery close to eighth nerve (*arrow*) and fifth nerve (*asterisk*). Patient did not have trigeminal neuralgia.

TABLE 2: **Failures at Amipaque Myelocisternography**

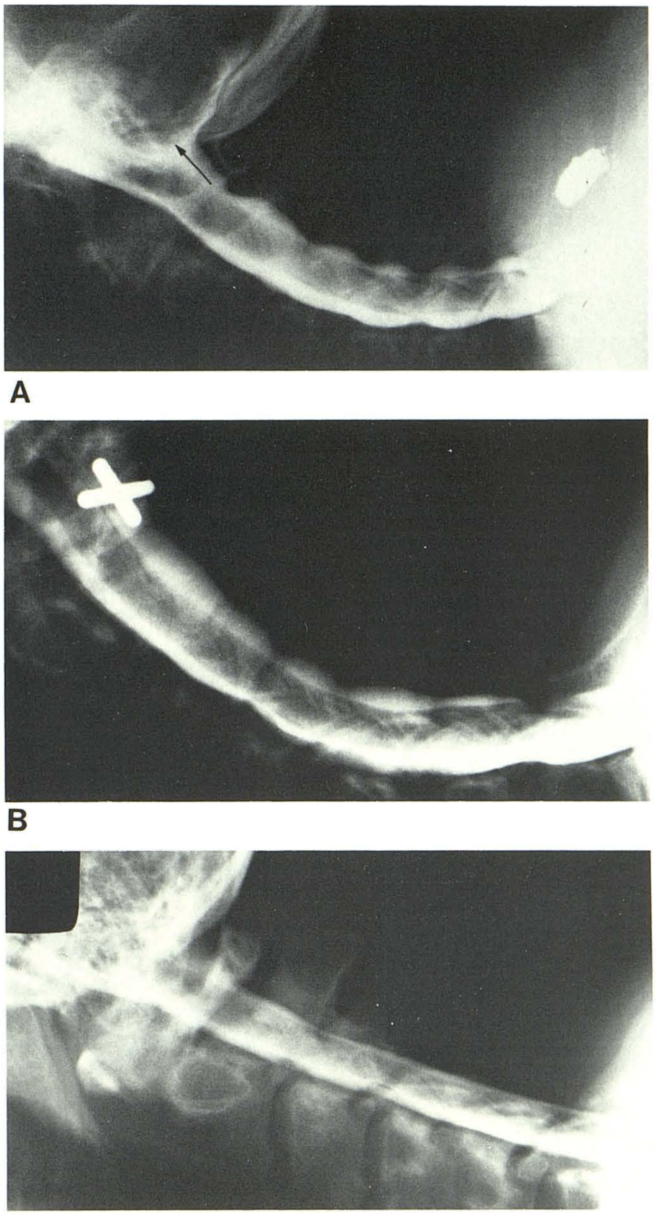
Result	No.	Comment
Excessive contrast spillage above tentorium	1	Occurred early in series from inadvertent injection while neck was in flexion
Unsuccessful C1–C2 puncture and/or discontinued exam	9	4 cases uncooperative; 1 case partial subdural injection; 1 case injection into spinal cord central canal; 2 cases dry taps related to meningeal inflammation or malignancy; 1 case with bloody tap had glioma of medulla oblongata and upper cervical cord
Inadequate subtraction	1	Occurred on one side of bilateral cerebellopontine examination 3 other patients had inadequate subtraction but examination was diagnostic

Note.—There were 111 attempted examinations.

TABLE 3: **Complications Related to Amipaque Injection at Myelocisternography**

Complication	No.	Comment
Minor:		
Headache	58	Severe in 8
Nausea	37	Severe and with vomiting in 12
Leg pain	3	2 had complete cervical thoracolumbar myelograms; 1 had associated lower extremity muscle spasms for about 12 hr
Major:		
Seizure	1	Inadvertent injection of most contrast above tentorium
Confusion, disorientation	2	77-year-old woman had symptoms 1 hr postprocedure, duration 24 hr; moderate supratentorial extension of contrast noted 45-year-old woman had small quantity contrast injected in cerebellopontine angle and internal auditory recess. No supratentorial extension of contrast during study

Note.—There were 111 attempted examinations.



A B C

Fig. 9.—Lateral cervical spine views in three patients after partial amipaque injection in cerebellopontine angle. Prone oblique position. **A** and **B**, Patients with normal lordosis. **A**, Cervical subarachnoid space, cerebellar tonsil (*arrow*), and cisterna magna. **B**, Cervical spine cord. × = marker to facilitate C1–C2 puncture. **C**, Patient with straight cervical spine. Atrophic spinal cord after severe trauma to cervical spine.

filming and magnification and subtraction.

In the first 30 patients this examination was performed as a prospective study for most patients with cervical and posterior fossa problems [2]. Based on this initial experience, we now use this technique for all posterior fossa examinations and for upper cervical and craniocervical junction problems and suspected cord lesions. There is no definite advantage over the usual C1–C2 procedure for cervical myelography [1, 12] for the routine evaluation of cervical nerve root and intervertebral disc disease. However, the consistent detailed delineation of cervical cord and posterior craniocervical subarachnoid space obtained with this procedure provides an excellent means for evaluating high cervical and craniocervical junction problems.

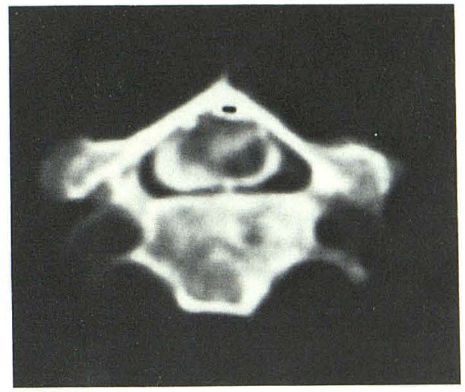


Fig. 10.—Hydromyelia. Transaxial CT scan of upper cervical spine 4 hr postamipaque myelogram. Contrast media within widened cord.

When the examination reveals cord atrophy or cord enlargement, additional pertinent information may be provided by performing a postmyelogram CT scan [13–17]. Figure 10 shows Amipaque within a widened cord on a CT scan obtained 4 hr after the myelocisternogram in a patient with hydromyelia. The use of Amipaque allows much better filling than Pantopaque around an obstructing lesion. The added value of subtraction is demonstrated by figure 11 in a case of high cervical meningioma. Displacement of the spinal cord and delineation of the tumor bed within the cord and the tumor lobulation are well outlined on the subtraction views.

In evaluating the posterior fossa, examination of both cerebellopontine angles may be made with one C1–C2 puncture using this technique. Visualization in two projections is provided by the simultaneous biplane filming. Amipaque, being less viscous than Pantopaque, provides better filling of the internal auditory recess, and of the fifth nerve and jugular foramen diverticulae as well. The latter structure, in line with and caudal to the internal auditory recess on the cross-table lateral oblique projection, was previously reported as representing the anterior condylar recess [2, 18]. Superimposition of the nonsubtracted preliminary posteroanterior oblique projection, however, with films later in the series after filling of this recess, confirms that it does in fact represent the jugular foramen diverticulum as was formerly reported by Reese and Bull [11], and is not related to the anterior condylar foramen which is more medial in location. The oblique frontal view usually provides the best delineation of the jugular foramen diverticulum because of obscuration in the lateral oblique by Amipaque around the cerebellar hemisphere (figs. 1 and 2).

Optimum filling of the internal auditory recess and jugular foramen recess is often obtained after injection of the first few milliliters of contrast (fig. 1), while the cavum trigeminale cistern is best outlined in the later phase of the serial cisternogram (fig. 6). Serial films are helpful because in many cases more complete filling of the internal auditory and other recesses may occur later in the series than on the

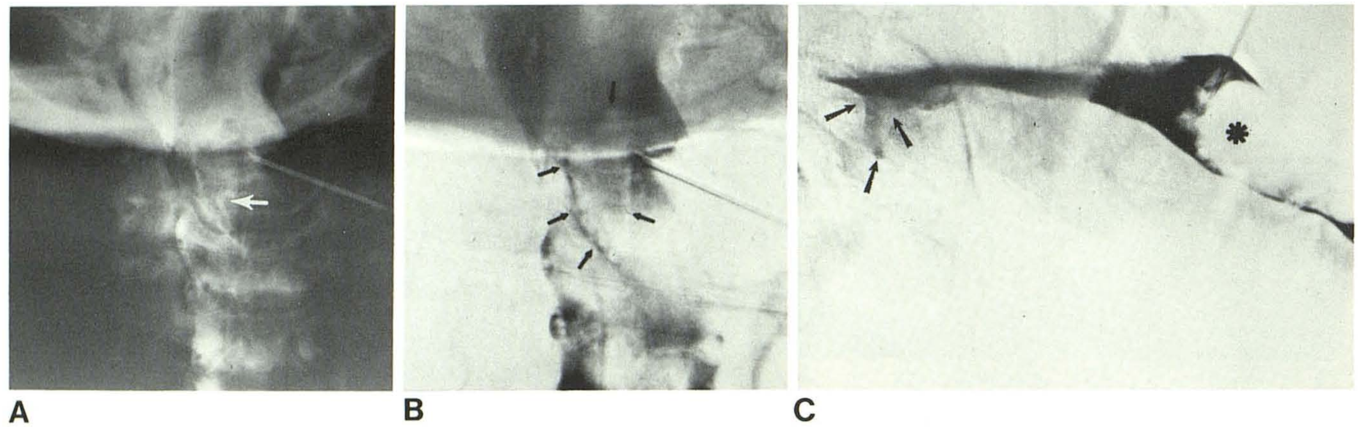


Fig. 11.—Meningioma of upper cervical spine (C3). **A**, Posteroanterior view shows filling defect of tumor (*arrow*). **B** and **C**, With subtraction. **B**, Posteroanterior oblique view shows tumor bed and displaced spinal cord (*arrows*). **C**, Lateral cross-table oblique view. Tumor (*asterisk*) with lobulated upper border. Internal auditory recess (*arrows*).

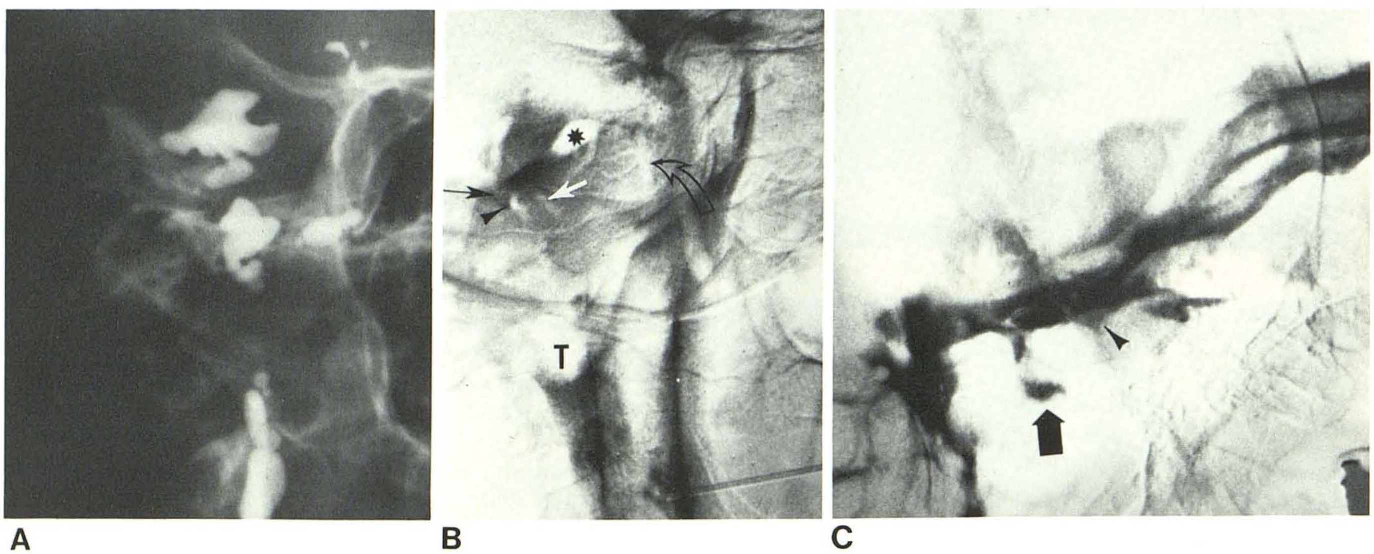


Fig. 12.—Intracanalicular acoustic neurinoma. **A**, Pantopaque, **B** and **C**, amipaque cisternograms. **B**, Posteroanterior oblique projection shows filling defect in internal auditory recess (*arrow*), facial nerve (*white arrow*), and kinked eighth nerve (*arrowhead*). Cerebellar tonsil = T, sixth nerve = *open arrow*, fifth nerve = *. **C**, Cross-table lateral oblique view shows nonfilling of internal auditory recess. Minimal contrast enters medial aspect of auditory canal and well-defined convex filling defect (*arrowhead*). Cavum trigeminale diverticulum (*arrow*).

first subtraction. Different nerves are also often visualized to better advantage at various stages during the injection (fig. 3). On the lateral oblique projection, normal variation in size and length of the internal auditory recess may cause the medial portion to become partly obscured by the rotation of the head and excess filling of the contrast material around the cerebellar hemisphere in some patients. Again, the serial films are useful as this portion can be demonstrated on an early film before superimposition of Amipaque around the cerebellar hemisphere occurs (figs. 4 and 5). In the posteroanterior oblique projections, it has previously been noted that the internal auditory recess cannot be adequately evaluated when Pantopaque contrast medium is used, because it is obscured by additional Pantopaque in the cerebellopontine angle cistern [11, 19]. With Amipaque and serial filming, adequate evaluation in this projection is usually obtained. The auditory recess can be seen through the contrast material in the cerebellopontine angle (fig. 7).

We believe this is an excellent technique for optimal delineation of the auditory recess, which is essential for the early diagnosis of intracanalicular acoustic neurinomas. Figure 12 compares a Pantopaque examination from another hospital and the Amipaque examination in a patient with a small intracanalicular acoustic neurinoma. While the Pantopaque study is equivocal, nonfilling of the auditory recess and a small filling defect due to the tumor was disclosed by the Amipaque myelocisternogram. A moderate sized acoustic neurinoma is seen in another patient in figure 13 with an additional 11th nerve neurinoma as well. This patient had neurofibromatosis and also had multiple neurofibromas in the cervical subarachnoid space.

An additional advantage of this examination is the contribution of the "extravascular angiogram" that is obtained (fig. 8.) The basilar artery is best visualized when less rotation in the head oblique position is used, although care must be taken as this risks more spillage of contrast media

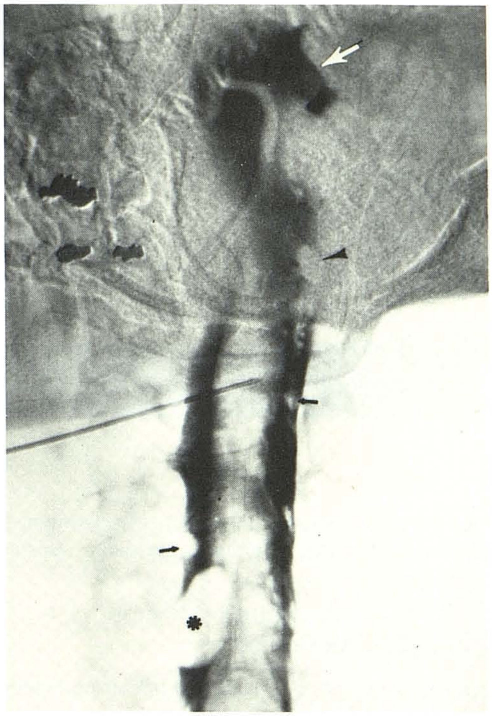


Fig. 13.—Multiple neurofibromatosis. Subtracted posteroanterior oblique view during contrast injection shows well defined defect in right cerebellopontine angle (*white arrow*) due to medium-sized acoutic neurinoma. Small filling defect along course of spinal accessory nerve may represent neurinoma (*arrowhead*). Multiple neurofibromata in cervical spine (*asterisk* and *arrows*).

above the tentorium. Visualization of the posterior fossa vessels also makes this technique of interest in the evaluation of patients with trigeminal neuralgia. This procedure is useful to exclude a lesion in relation to the fifth nerve when the cavum trigeminale is filled. This has been found to occur, however, in only about 30% of cases, and there is considerable range of normal variation in the size of this recess (fig. 6). Nonfilling, therefore, cannot be considered an indication of pathology. A vascular cause for the neuralgia may be excluded when the vertebral and basilar arteries and major branch vessels are visualized without close relationship to the nerve, but the reverse does not appear to hold true. Figure 8C demonstrates a right vertebral artery coursing adjacent to the fifth and eighth nerves in a patient who had no symptoms of neuralgia.

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