Computed Tomography of the Brain Stem with Intrathecal Metrizamide. Part II: Lesions in and around the Brain Stem

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Computed Tomography of the Brain Stem with Intrathecal Metrizamide.

Part II: Lesions in and around the Brain Stem

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The practical usefulness of computed tomography with intrathecal metrizamide in imaging the brain stem is illustrated in six examples where the lesions were misdiagnosed on intravenously enhanced computed tomography, angiography, or air study. Focal and diffuse atrophic changes of the brain stem were demonstrated in symptomatic patients where none of the other radiographic or clinical investigations were conclusive. Metrizamide computed tomography is probably the most sensitive method for imaging lesions in and around the brain stem and cerebellopontine angle.

The application of the anatomic detail described in part 1 of this paper (in this issue) can be illustrated by a few clinical examples in which the correct diagnosis was reached only by computed tomography (CT) with intrathecal metrizamide. In these cases, conventional studies were either incomplete, falsely positive, or falsely negative.

While conventional CT with intravenous contrast material can demonstrate abnormalities in brain stem density, metrizamide cisternography shows the subtle changes in brain stem shape and surface features. For descriptive purposes, we classified the morphologic changes of the abnormal brain stem into three categories: (1) expansion and deformity of the brain stem by intraaxial masses; (2) distortion and displacement of the brain stem by pressure from extraaxial masses, and (3) generalized and focal atrophic changes.

Abnormalities of the Brain Stem

Intraaxial Mass

Intraaxial masses can produce the following changes: (1) obliteration of the surface features of the medulla, especially with the loss of bilateral concave symmetry and blunting of the sulci; (2) flattening and backward displacement of the fourth ventricle with blunting of the median sulcus; and (3) persistent unilateral enlargement of the medulla, pons, midbrain, or any of the cerebellar peduncles [1].

A generalized increase in the size of the medulla without deformity of its shape is not likely to occur. Previous radiologic measurements of the various diameters of the brain stem are useful only in the late condition (e.g., after the overall size of the medulla has already increased). Earlier changes occurring in the brain stem are the loss or deformity of local surface features. Hence, metrizamide CT cisternography is potentially a very sensitive test for the early diagnosis of intraaxial brain stem lesions.

Extraaxial Mass

Extraaxial masses in the posterior fossa can be outlined directly by metrizamide

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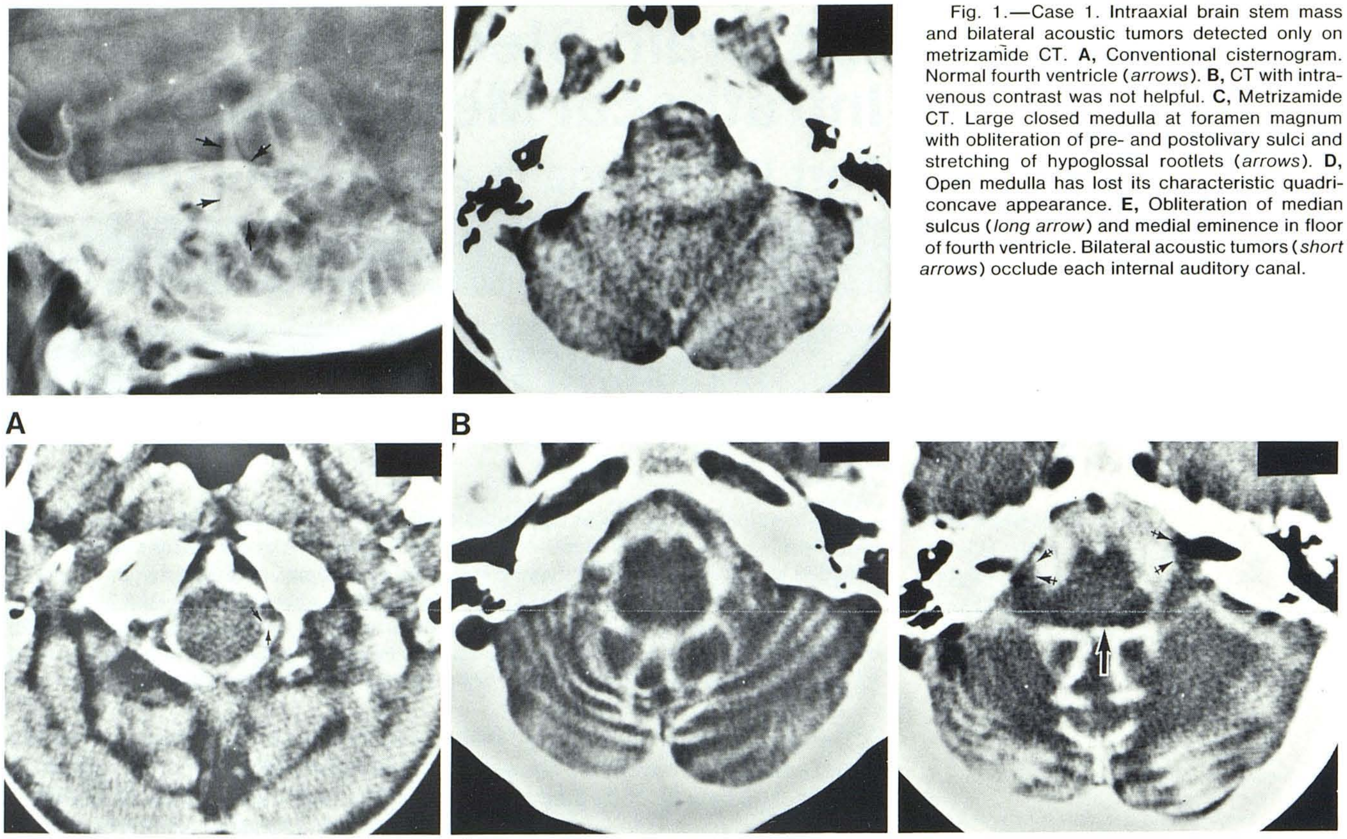

A B C D E

Fig. 1.—Case 1. Intraaxial brain stem mass and bilateral acoustic tumors detected only on metrizamide CT. **A,** Conventional cisternogram. Normal fourth ventricle (*arrows*). **B,** CT with intravenous contrast was not helpful. **C,** Metrizamide CT. Large closed medulla at foramen magnum with obliteration of pre- and postolivary sulci and stretching of hypoglossal rootlets (*arrows*). **D,** Open medulla has lost its characteristic quadriconcave appearance. **E,** Obliteration of median sulcus (*long arrow*) and medial eminence in floor of fourth ventricle. Bilateral acoustic tumors (*short arrows*) occlude each internal auditory canal.

CT of the subarachnoid space. This method is particularly helpful in distinguishing between an exophytic brain stem glioma and an extraaxial neoplasm. It is also very useful in differentiating between a small neoplasm and a normal structure (e.g., between an acoustic neuroma and the flocculus). Brain stem changes secondary to an extraaxial mass include pressure deformity, shift, and displacement.

Atrophic Changes

Atrophic changes of the brain stem are of two types: (1) *Generalized atrophy* produces a relative enlargement of all surrounding subarachnoid spaces and of the fourth ventricle. All sulci and fissures on the surface of the brain stem are preserved and exaggerated, particularly the ventral median fissure and the ventrolateral sulcus. (2) *Focal atrophy* may result from focal pressure by an extraaxial mass or a tortuous vessel, a local vascular accident, or a primary degenerative process involving tracts or nuclei. Metrizamide CT cisternography is uniquely able to provide information that can be correlated with the clinical findings; it is unsurpassed in showing general or focal brain stem atrophy.

Representative Case Reports

Case 1. Intraaxial brain stem glioma and bilateral acoustic tumors demonstrated only on metrizamide CT. Conventional cisternogram and intravenous contrast-enhanced CT were normal.

A 15½-year-old patient presented with brain stem symptoms, bilateral hearing loss, paralysis of the vocal cords, and facial paralysis. The conventional cisternogram showed a normal, nondisplaced fourth ventricle (fig. 1A). The CT scan with intravenous contrast was not helpful (fig. 1B). The metrizamide CT cisternogram demonstrated a ballooned closed medulla with complete obliteration of the ventral fissure and anterolateral sulcus (fig. 1C). The rootlets of the hypoglossal and first cervical nerves were stretched. There was obvious loss of the bilateral concavity of the open medulla. The features of the floor of the fourth ventricle were completely obliterated because of the infiltrating tumor (fig. 1D). The higher sections showed bilateral acoustic neuromas filling the internal auditory canals and protruding into the cerebellopontine angle cisterns (fig. 1E).

Case 2. Intraaxial neoplasm in the brain stem and cervical spinal cord shown in its entirety in a single study.

A 47-year-old man had brain stem symptoms including ataxia, vertigo, vertical nystagmus, and right facial weakness. The angiogram (fig. 2A) showed evidence of a mass effect in the pons and medulla. The metrizamide CT delineated the intraaxial tumor in the pons (fig. 2B) and medulla (fig. 2C) and also showed the lower extension of the tumor into the cervical cord, which was expanded down to the C5 level (fig. 2D). Accordingly, the radiotherapy portal was extended to cover the entire tumor. A myelogram would have outlined the cervical component of this lesion. A second study would have been necessary to outline the extent of the intracranial component. Metrizamide CT cisternography outlined the entire tumor.

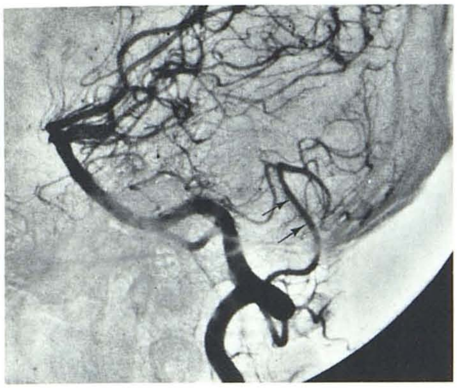

Fig. 2.—Case 2. Intraaxial brain stem neoplasm extending into spinal cord. **A,** Vertebral angiogram shows posterior displacement of retromedullary segment of posterior inferior cerebellar artery (*arrows*). **B–D,** Metrizamide CT. Diffuse swelling of pons, medulla, and cervical cord down to C5. Entire extent of lesions was demonstrated on single study.

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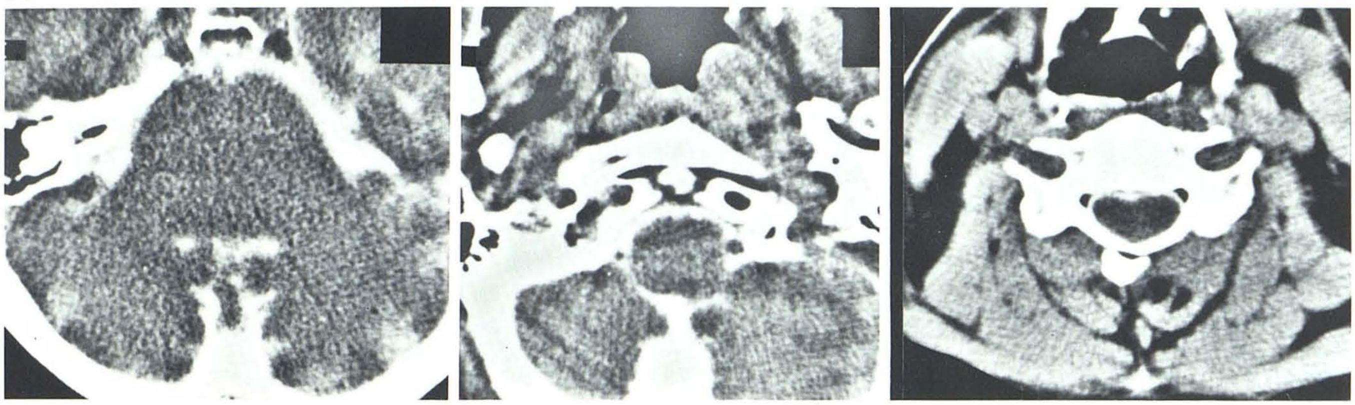

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Case 3. An exophytic intraaxial brain stem tumor presenting by conventional CT as an extraaxial mass.

A 30-year-old woman had occasional episodes of left facial numbness, decreased taste sensation, decreased left corneal reflex, and horizontal nystagmus on lateral gaze. The conventional CT scan after intravenous contrast enhancement showed an enhancing extraaxial mass in the left cerebellopontine angle region with a questionable intraaxial component (fig. 3A). The metrizamide study showed the presence of an intraaxial brain stem tumor extending from the closed medulla to the superior collicular level of the mesencephalon. The closed medulla was expanded and had lost its surface features (fig. 3B). The fourth ventricle was distorted and deviated toward the right; the left brachium pontis was swollen (fig. 3C). The higher sections showed asymmetry of the cerebral peduncles with flattening of the left lateral mesencephalic sulcus and expansion of the left cerebral peduncle as well as the left superior colliculus (fig. 3D). In addition, there was a filling defect in the interpeduncular fossa due to an exophytic component arising from the mamillary bodies and projecting downward into the cistern.

Case 4. Generalized atrophy of the brain stem secondary to viral meningoencephalitis.

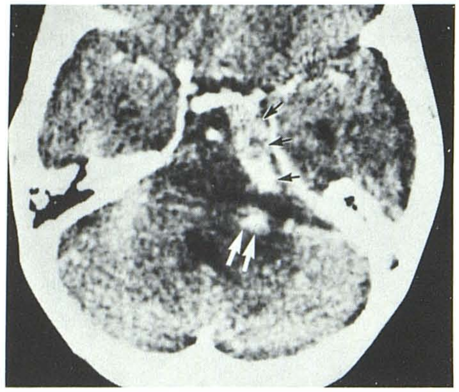
A 47-year-old man had a proven viral meningoencephalitis that left him with partial deafness and a constant noise in the right ear. He subsequently presented with intermittent diplopia on downward gaze, diffuse hyperreflexia, and left arm weakness. His cerebrospinal fluid (CSF) was negative for oligoclonal bands.

The conventional CT scan (fig. 4A) showed a large cisterna magna and a capacious fourth ventricle. Metrizamide CT cisternography showed an atrophic closed medulla (fig. 4B) with a narrow transverse diameter and effaced pyramidal protuberance; there was also unusual prominence of the dorsal median fissure. The isthmus of the pons was atrophic with a large upper fourth ventricle and attenuated brachium conjunctivum bilaterally (fig. 4C). The cerebral aqueduct was strikingly dilated and the cerebral peduncles were small relative to the size of the midbrain (fig. 4D).

While the exact etiology of these structural changes in the brain stem remains unclear, one can relate them to the previous episode of meningoencephalitis. The atrophy demonstrated on conventional CT is not an uncommon finding; the metrizamide study, however, reveals in great detail the extent of the pronounced atrophic changes that match the clinical findings.

Case 5. Normal brain stem in which a pneumoencephalogram and conventional enhanced CT scan were falsely positive for a brain stem mass.

A 60-year-old woman had dysphagia, tongue immobility, hoarseness, and right abducens nerve palsy. The diagnosis of brain stem glioma was suspected on the basis of the clinical findings. The conventional CT scan (fig. 5A) and the pneumoencephalogram (fig. 5B) suggested a brain stem mass with enlargement of the pons and lower medulla and backward displacement of the fourth ventricle. Metrizamide CT, however, showed a rather capacious fourth ventricle with preservation of the median sulcus and no evidence of a space-occupying lesion or mass effect (fig. 5C). The pons and both brachium pontii were unremarkable (fig. 5D). Further clinical and



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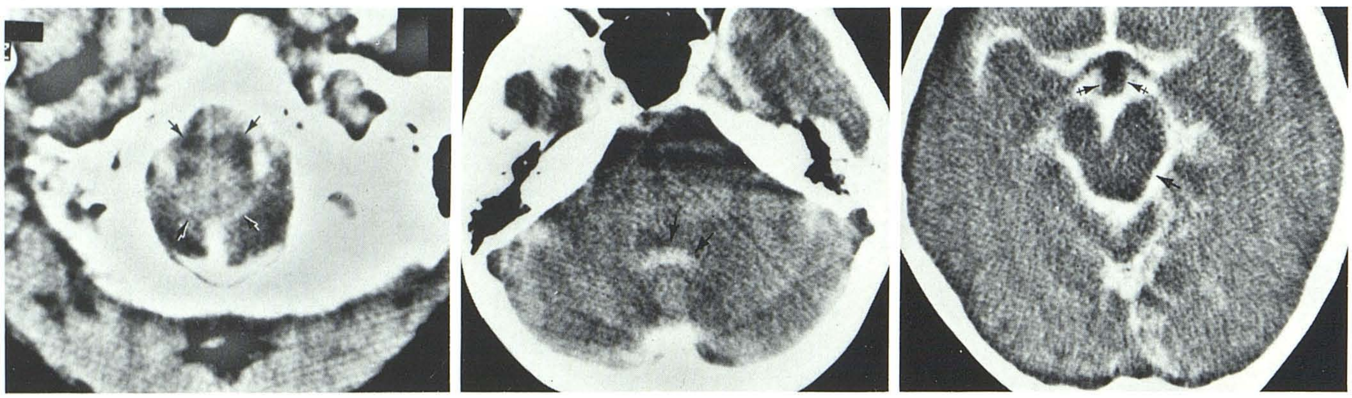

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Fig. 3.—Case 3. Intraaxial tumor of brain stem demonstrated by metrizamide CT while conventional CT suggested an extraaxial mass. **A,** Enhancing mass in left cerebellopontine angle appears mostly extraaxial extending through incisura (*black arrows*). Enhancing nodule (*white arrows*) is adjacent to displaced fourth ventricle. **B,** Metrizamide CT at closed medullary level. Enlarged medulla has lost its surface features (*arrows*). **C,** Fourth ventricle is shifted (*arrow*) and left brachium pontis is swollen. **D,** Metrizamide surrounds swollen and deformed midbrain with flattening of lateral mesencephalic sulcus (*uncrossed arrow*) showing true intraaxial nature of lesion. Involvement of mammillary bodies behind optic chasm (*crossed arrows*).

laboratory workup revealed the diagnosis of multiple sclerosis with corresponding CSF findings. The misleading findings on pneumoencephalography were probably the result of a meniscus formation between the air and CSF around the floor of the fourth ventricle.

Case 6. Local atrophic changes of the brain stem and its deformity by adjacent tortuous vascular structures.

A 59-year-old man with malignant hypertension had a 10 year history of left lower motor neuron facial nerve palsy and complete deafness of the left ear. The rest of his cranial nerves were normal. The admitting clinical diagnosis was a tumor in the left cerebellopontine angle. The metrizamide cisternogram (figs. 6B and 6C) showed a tortuous vertebral basilar artery on the left side causing an atrophic extrinsic pressure deformity on the medullary pontine segment and the left brachium pontis at the level of origin of the seventh and eighth nerves. The rest of the brain stem was normal (figs. 6A and 6D). This examination unequivocally ruled out an intra- or extraaxial tumor and at the same time offered an explanation for the patient's decreased hearing and facial palsy. The evaluation of focal atrophic changes and pressure effects by vascular structures is probably impossible to obtain with other radiographic methods, including CT with air contrast, because these offer a limited view of the anatomy.

Discussion

Metrizamide CT cisternography has rapidly replaced both angiography and pneumoencephalography at our institution for the evaluation of brain stem pathology. Most brain stem gliomas are astrocytomas [2] that infiltrate in a diffuse and insidious fashion, seldom causing localized mass effect or abnormal vascularity on angiography. When they displace vessels, however, they are usually eccentric and have reached an advanced stage [3]. We find the new imaging method very reliable and sensitive to early changes and subtle deformities of the brain stem that can be easily overlooked with other diagnostic procedures including CT enhanced with intravenous contrast media. In the group of patients who clinically appear to have slowly developing brain stem lesions with cranial nerve and long tract signs, the diagnostic workup should include a metrizamide CT cisternogram despite "normal" conventional investigations. In a study performed by DuBoulay and Radu [4] with vertebral angiography, air studies, and conventional CT, before the use of metrizamide, less than 10% (5/59) of their patients had a "diagnostic" investigation.

In our series of 10 cases of brain stem masses either suspected or diagnosed on routine CT, vertebral angiography, or air studies, metrizamide not only confirmed the presence of the neoplasm but also accurately demonstrated a level of extension (e.g., into the midbrain) that would not have been suspected otherwise. In addition, it offered good display of the cervical cord for evaluation of caudal extension of the lesion or a possible coexisting syringomyelic cavity.

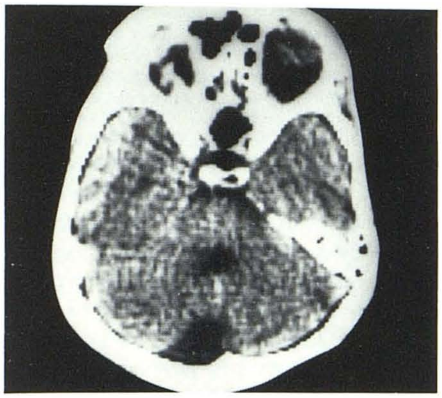

Fig. 4.—Case 4. Generalized brain stem atrophy optimally demonstrated by metrizamide CT. **A,** Capacious fourth ventricle with prominent cisterna magna. **B,** Metrizamide CT of closed medulla. Prominent dorsal median fissure (*uncrossed arrow*) and effaced pyramidal protuberance (*crossed arrow*). **C,** Isthmus of pons. Large upper fourth ventricle and small attenuated brachium conjunctivum (*arrows*). **D,** Upper mesencephalon. Cerebral aqueduct is unusually large (*long arrow*) and cerebral peduncles are small compared with body of midbrain. Lateral mesencephalic sulcus is prominent (*short arrows*).

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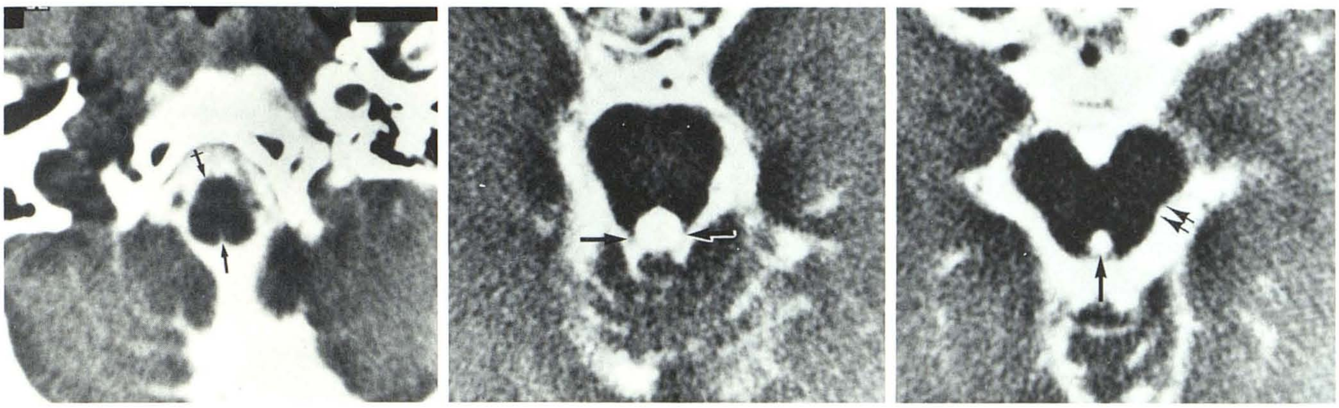

B C D

Arnold Chiari malformations are ideally evaluated with this method [5]. The foramen magnum, medulla, and cervicomedullary junction, as well as the position of the cerebellar tonsils and the shape and location of the fourth ventricle, are demonstrated in great detail.

Cerebellopontine angle lesions such as small or intracanalicular acoustic neuromas are also best studied with metrizamide CT cisternography. This includes the evaluation of cranial nerve syndromes presumed secondary to a tortuous basilar artery. Although CT enhanced with intravenous contrast media demonstrates the abnormal ectatic vessels [6], metrizamide shows to better advantage the resulting deformity of the brain stem and helps to exclude a coexisting neoplasm. CT of the cerebellopontine angle with air contrast is useful for the demonstration of small acoustic neuromas provided that hearing loss can be predictably attributed to a neuroma; other causes of deafness should be ruled out clinically.

Transverse and sagittal linear measurements of the brain stem, both on CT with intravenous contrast [7] and CT cisternography [8], have been proposed in the evaluation of displacement of the fourth ventricle and swelling of the surrounding structures. We find that standardized measurements are difficult to obtain and fixed anatomic landmarks are often elongated or hard to reproduce. Also, a significant range of variation in normal values exists, thus precluding the detection of early swelling or atrophy by measurements alone. Instead, we rely mostly on the fine morphologic details described in part 1 of this paper, and we consistently try to recognize the different eminences, fissures, and sulci in order to detect asymmetry, distortion, or exaggeration of surface grooves. The use of air as a contrast agent for CT is inadequate for the demonstration of surface features of the brain stem because of partial filling of the cisterns and meniscus formation that precludes a detailed outline.

High-resolution scanning using primary reconstruction and thin tomographic sections of no more than 5 mm thickness are a necessity. Also, consecutive scans should not be spaced more than 5 mm apart, especially around the medulla. To reduce the morbidity of metrizamide we limit the concentration to an isotonic 170 mg/ml; however, newer nonionic aqueous media with less neurotoxicity than metrizamide [9] will undoubtedly encourage and facilitate the use of CT cisternography.

Conclusion

Our current impression is that metrizamide CT is excellent for imaging the brain stem in the evaluation of both intra- and extraaxial lesions. We find it superior to pneumoencephalography, angiography, and routine contrast-enhanced CT, although the latter procedure should be the

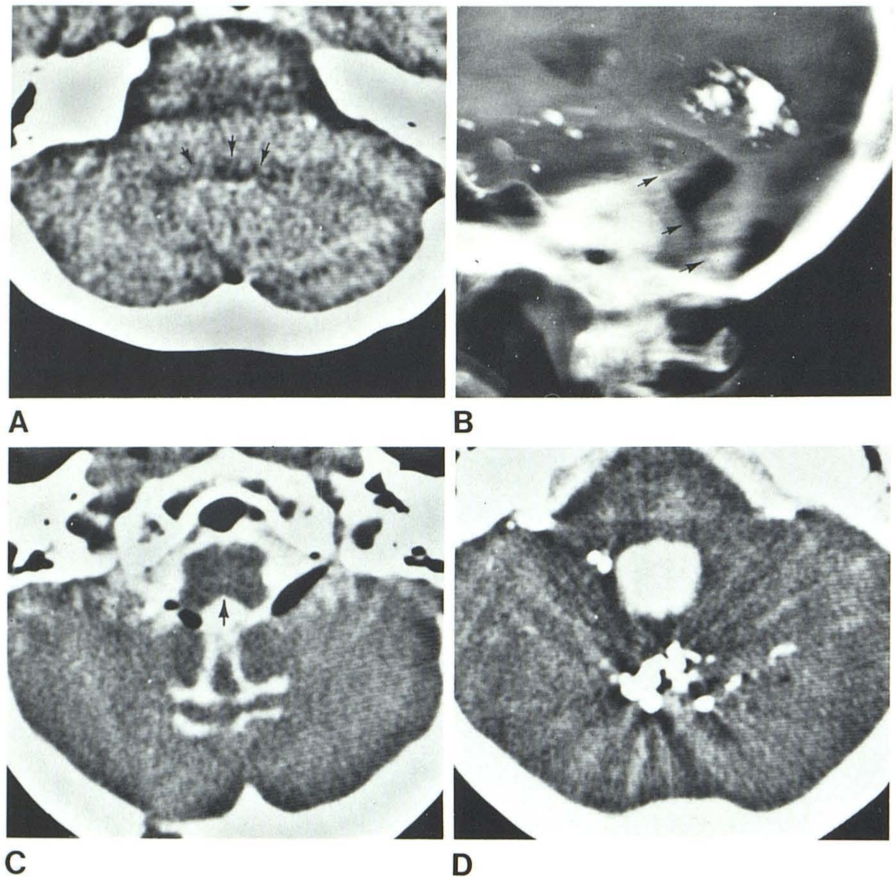

Fig. 5.—Case 5. Brainstem tumor suspected on conventional CT and air study proven normal on metrizamide CT. **A,** Fourth ventricle appears displaced on routine CT (*arrows*). **B,** Pneumoencephalogram. Apparent posterior displacement of floor of fourth ventricle at level of medulla (*arrows*). **C,** and **D,** Metrizamide CT. Normal median sulcus in floor of fourth ventricle (*arrow*) and normal pons.

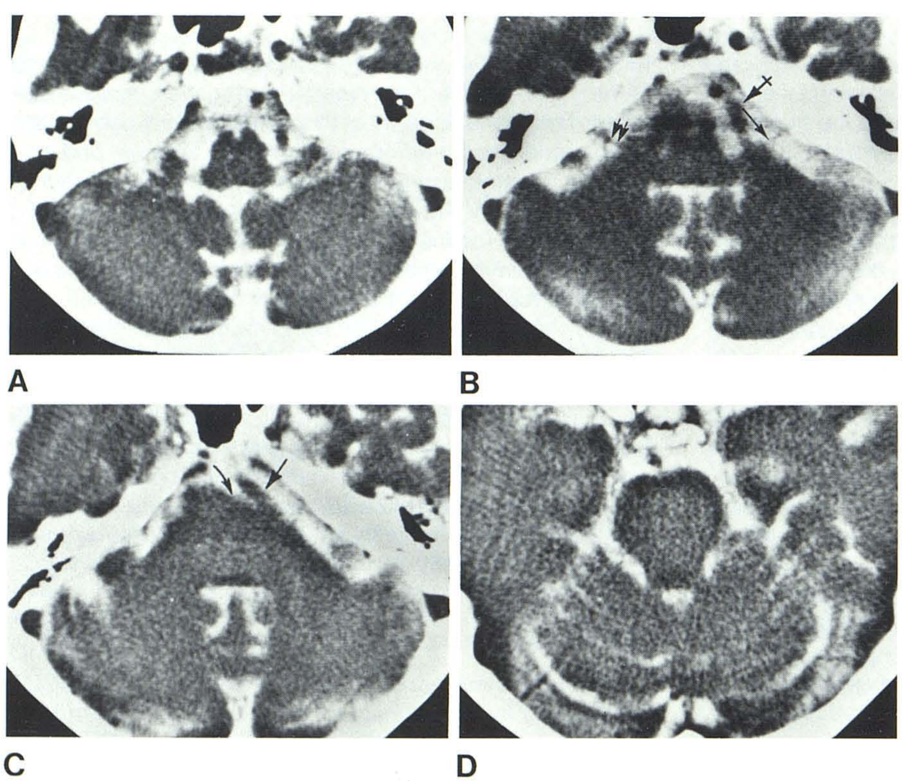

Fig. 6.—Case 6. Focal atrophic changes demonstrated by metrizamide CT. **A,** At level of open medulla. Normal brain stem and cerebellar hemispheres. **B,** Left eighth nerve (*long arrow*) is consistently smaller than right (*short arrows*) on all sections. Left vertebral artery is large and tortuous and appears to be pressing on eighth nerve (*crossed arrow*). **C,** Extrinsic pressure deformity on left brachium pontis and medullary-pontine junction (*curved arrow*) caused by tortuous basilar artery (*straight arrow*). **D,** At level of pons. Normal pons. Deafness and facial palsy are explainable by tortuous vertebral artery.

initial study and angiography is often complementary. In the case of brain stem tumors, metrizamide cisternography will accurately define the vertical extension into the mesencephalon or the upper cervical cord. Extraaxial masses are readily identified and easily differentiated from intraaxial tumors. Posterior fossa vessels and cranial nerves are both demonstrated accurately. This imaging method is ideally suited for the evaluation of syndromes attributed to neural pressures caused by tortuous vessels. The unique value of metrizamide cisternography, however, is the detection of focal or generalized atrophy in the brain stem, especially in patients with long tract signs, cranial nerve symptoms, or both. The clinical and radiologic workup in this group of patients has heretofore been frustratingly negative or inconclusive.

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