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AJNR Am J Neuroradiol 1987, 8 (1) 59-64
http://www.ajnr.org/content/8/1/59

This information is current as of April 19, 2024.

MR Imaging of the Mesencephalic Tectum:
Normal and Pathologic Variations

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Variations of the quadrigeminal plate (mesencephalic tectum) were determined on midline sagittal MR images of the brain in 93 patients without known mesencephalic abnormalities and in 10 patients with known aqueductal stenosis or obstruction. Measurements of the thicknesses of the superior and inferior colliculi and the length of the tectum were made on the midline sagittal section. Images were obtained with a 0.5 T system with spin-echo pulse sequences using a TE of 30 or 40 msec with a TR of 500–1500 msec. The average thickness of the superior and inferior colliculi was about 5 mm, but the range was from 2–7 mm on the midline sagittal section. Abnormally thin colliculi appeared to have no clinical significance while abnormal thickness was observed in patients with neoplastic disease, sarcoidosis, and mesencephalic "beaking." While most neoplasms have abnormal signal intensity on T2-weighted images, small lesions may be difficult to perceive on transaxial images due to volume averaging or noncontiguous sections. Measurements of the tectum, on the commonly obtained midline sagittal section, may be useful for patients with small infiltrative lesions.

The lamina quadrigemina (roof or tectum) of the midbrain is occupied by four small swellings or eminences, the superior (anterior) and inferior (posterior) colliculi. Before the advent of MR imaging subtle abnormalities of superior and inferior colliculi could be evaluated only by intracranial pneumoencephalography [1, 2], metrizamide-assisted CT ventriculography, or cisternography [3–7]. MR is able to depict the superior and inferior colliculi with a high degree of consistency but there have been no studies of the variation of the colliculi on MR. Small aberrations of the normal architecture can be easily seen, allowing early diagnosis and accurate localization of small mass lesions. This report documents the normal range of the tectum and compares the appearance of the tectum in patients with normal and abnormal MR findings.

Materials and Methods

We evaluated the midline sagittal cerebral MR examinations of 103 patients referred for a variety of indications. Two groups of patients were identified.

Group 1 included 93 patients with normal MR examinations or with abnormalities that did not involve the mesencephalon, including patients with cerebral atrophy. The group consisted of 52 females and 41 males ranging in age from 5 years to 77 years (average age, 42 years). Tectal measurements derived from these patients are not age-adjusted.

Group 2 was composed of 10 patients with aqueductal stenosis or tumors involving the mesencephalic region. There were seven women and three men in this group, ranging in age from 24 years to 38 years (average age, 31 years). Six patients had a clinical and imaging diagnosis of aqueductal stenosis, two patients had astrocytomas involving the mesencephalon, one patient had neurosarcoidosis causing aqueductal stenosis, and one patient had gliosis or a low-grade tumor of the tectum causing aqueductal stenosis.

MR examinations were performed with a single-echo 8- or 16-multisection technique on a 0.5 T superconductive magnet (Vista-MR, Picker International Corp., Highland Heights, OH). Data were acquired after two excitations using the 2 DFT method and spin-echo (SE)

Received December 30, 1985; accepted after revision July 14, 1986.

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AJNR 8:59–64, January/February 1987
0195–6108/87/0801–0059
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sequences with 256 complex samples/views and 256 views. The resultant 256 × 256 image was then interpolated to a 512-element display matrix. Field-of-view for these examinations was either 25 or 30 cm, resulting in a pixel size (before interpolation) of 0.98 or 1.17 mm, respectively. Sampling times were 24 msec, and sampling bandwidth 5 KHz. The section thickness was 5 mm. Slice profiles were approximately trapezoidal, with 1-mm transitional zones (interslice gap) on either side of a flat region of the nominal thickness.

T1-weighted or "balanced" T1-T2 images were evaluated. These were obtained with a TE of 30 or 40 msec with a TR of 500–1500 msec. In most cases an SE 500/40 sequence was used. Images that were degraded by patient motion or artifact were rejected.

Measurements to the nearest millimeter were made of the maximal cross-sectional diameter in anteroposterior plane of the inferior and superior colliculi on the midline sagittal section (Fig. 1). All measurements were made using the relative centimeter scale provided on the 2× magnified hard-copy images. The mid-sagittal section was chosen because it was the most easily recognizable and reproducible. Measurements were made from the posterior margin of the colliculus along a line drawn perpendicular to the posterior margin of the aqueduct of Sylvius. No attempt was made to separately identify right-sided colliculi from left-sided colliculi. Point-to-point measurements of the length of the tectal plate were made from the superior margin of the superior colliculus to the inferior margin of the inferior colliculus. All measurements were obtained by the same person, who used the hard-copy magnified images.

Results

Group 1

Superior Colliculus

The measurements of the diameter of the superior colliculus ranged from 1–6 mm (Fig. 2). The average diameter was 4.5 mm, and the standard deviation was 1.1 mm. The 95% confidence levels were 2.4 mm and 6.6 mm. The data distribution is portrayed in Figure 1A. Four patients fell below the 95% confidence level, three with diameters of 2 mm and one with a diameter of 1 mm. None of these patients had symptoms that could be attributed to mesencephalic abnormalities.

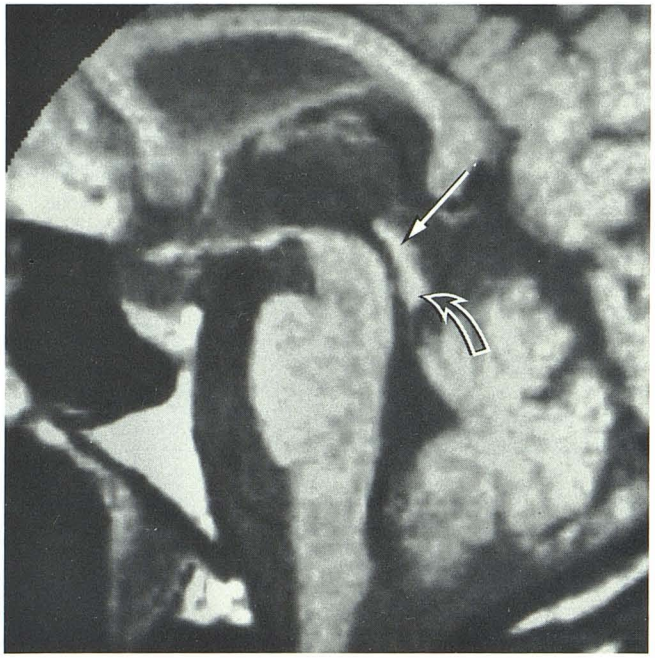


Fig. 2.—Normal patient, midline sagittal section. SE 800/40. Superior colliculus (*solid arrow*) measures 5 mm; inferior colliculus (*open arrow*) measures 6 mm.

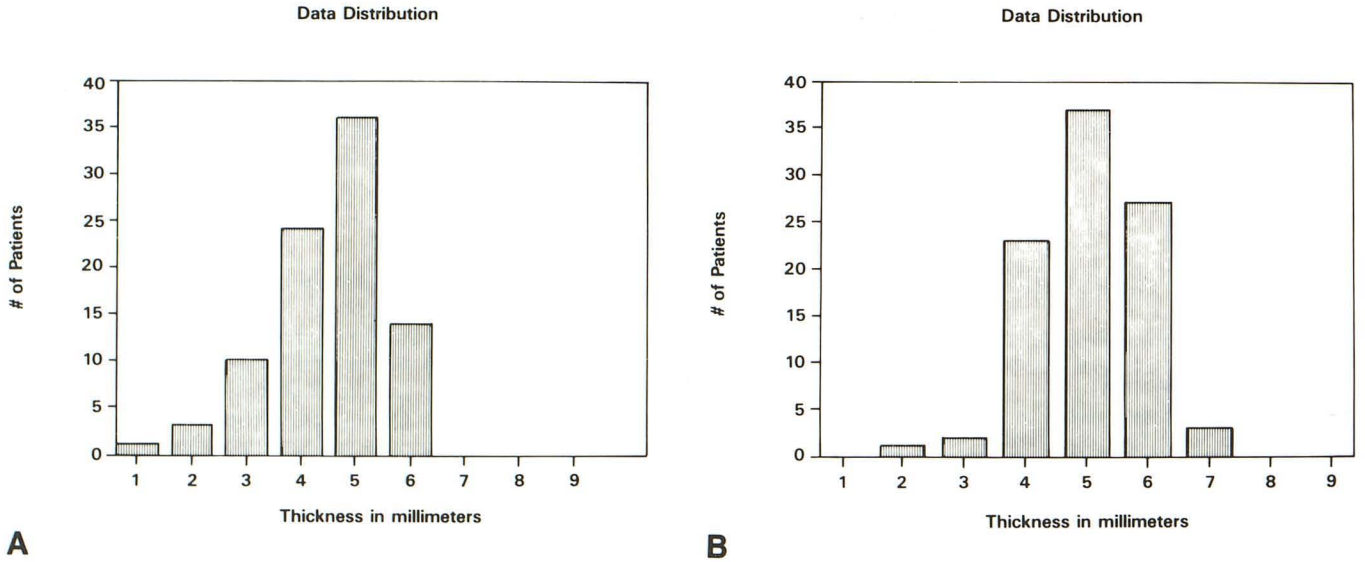


Fig. 1.—Midline measurements of the superior (*A*) and inferior (*B*) colliculus.
***A*, Distribution of thickness measurements of superior colliculus on midline sagittal T1-weighted images in 93 patients.**
***B*, Measurements of inferior colliculus.**

Inferior Colliculus

The inferior colliculus measurements varied from 1–7 mm, with an average diameter of 5 mm. The standard deviation was 1.0 mm, and the 95% confidence levels were calculated to be 3.0 mm and 7.1 mm. The data distribution is portrayed in Figure 1B. Note the slight tendency for larger inferior colliculi when compared with the superior colliculi. One patient fell below the 95% confidence level with a measurement of 2 mm. This patient was one of those with a small superior colliculus.

Size Variations Within Patients

The colliculi were equal in size in 32 cases. The inferior colliculus was 1 mm larger than the superior colliculus in 42 cases, 2 mm larger in seven cases, and 3 mm larger in one case. The inferior colliculus was 1 mm smaller than the superior colliculus in 10 cases and 2 mm smaller in one case.

Quadrigeminal Plate Length

The length of the quadrigeminal plate varied from 10–18 mm, with an average length of 13.4 mm. The standard deviation was 1.8 mm, and the 95% confidence levels were 9.8 mm and 17 mm. Two patients fell below the 95% confidence level: one is a 63-year-old woman with generalized brain atrophy but no visual symptoms and the other is a 60-year-old man with minor periventricular white-matter disease but no visual symptoms. The length of the tectum in one patient was 18 mm, which is 1 mm above the 95% confidence level. This patient is an 18-year-old man with a Chiari type I malformation with 30 mm of tonsillar herniation and normal ventricles. He was randomly selected and was not excluded because his mesencephalon initially appeared normal. He had downbeating nystagmus due to cerebellar tonsillar herniation but had no signs of a mesencephalic disorder.

Group 2

Five patients with aqueductal stenosis had normal measurements (Fig. 3) and the remaining five had collicular diameters greater than the 95% confidence levels determined in the normal series. All these patients had aqueductal stenosis or obstruction. Two of the patients with abnormal tectal measurements had proven astrocytomas involving the tectal plate, periaqueductal gray matter, and adjacent areas. In one of these patients the superior colliculus measured 8 mm and the inferior colliculus measured 7 mm (Fig. 4). The tumor was approximately 15 mm long. MR clearly showed the intraaxial location of the tumor although CT suggested an extraaxial location. In the other patient with a tumor the inferior colliculus measured 8 mm and the superior colliculus measured 7 mm. The tumor was approximately 25 mm long. One patient has systemic sarcoidosis with presumed neurosarcoidosis involving the aqueduct and tectum. The inferior colliculus measured 9 mm and the superior colliculus measured 7 mm. Increased intensity was present in the two astrocytomas and in the sarcoid lesion on SE 2500/80 pulse sequences. One patient with cerebellar tonsillar herniation of 20 mm had mesencephalic beaking and enlargement of the tectum. In this patient the inferior and superior colliculi measured 9 mm and appeared fused (Fig. 5). The tectum was 17 mm long (1 mm over the 95% confidence level for normals). The quadrigeminal plate cistern had a "V" shape on axial MR and CT images. There was no evidence of increased intensity on an SE 2400/80 pulse sequence. One patient with acquired aqueductal obstruction had diffuse enlargement of the tectum (Fig. 6). The tectal plate was 20 mm long. The superior colliculus measured 9 mm and the inferior colliculus measured 8 mm. Focal increased intensity was present in the superior colliculus on the SE 2500/80 sequence. The abnormal increased signal was more difficult to appreciate on the 10-mm axial sections using the same pulse sequence because of the bright intensity of the adjacent quadrigeminal plate cistern and the slice angulation. There was no evidence of abnormal enhancement on the CT scan. This patient has been followed for 3 years without definite change on CT. The histologic diagnosis is unknown at this time, but the MR appearance is most compatible with a low-grade glioma or extensive gliosis.

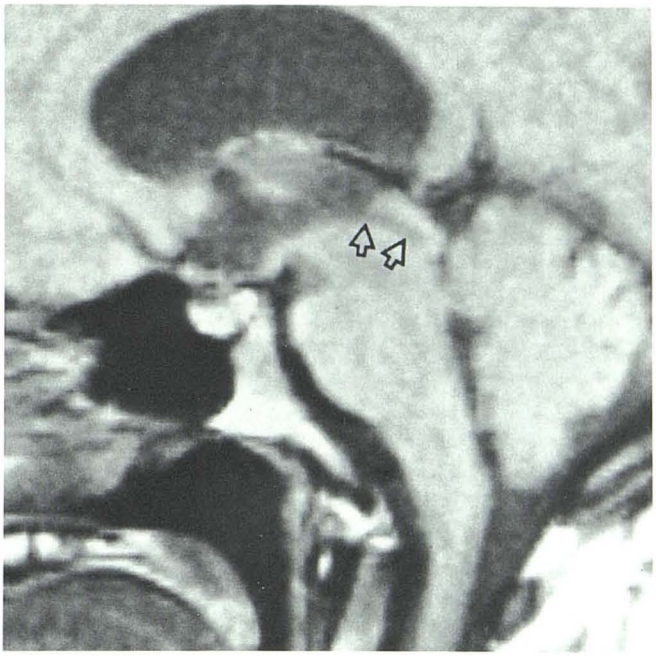


Fig. 3.—38-year-old woman with aqueductal stenosis without tectal enlargement. SE 700/40 midline sagittal section. Superior colliculus is 5 mm thick; inferior colliculus is 4 mm thick.

Discussion

There have been several reports detailing the evaluation of mesencephalic tumors using CT [8], CT cisternography, or CT ventriculography [3–5]. MR has been shown to have high sensitivity in the detection of brainstem tumors and has been advocated as a replacement for metrizamide CT cisternography [9]. While these reports have been helpful because of their depiction of the appearances of brainstem tumors, there

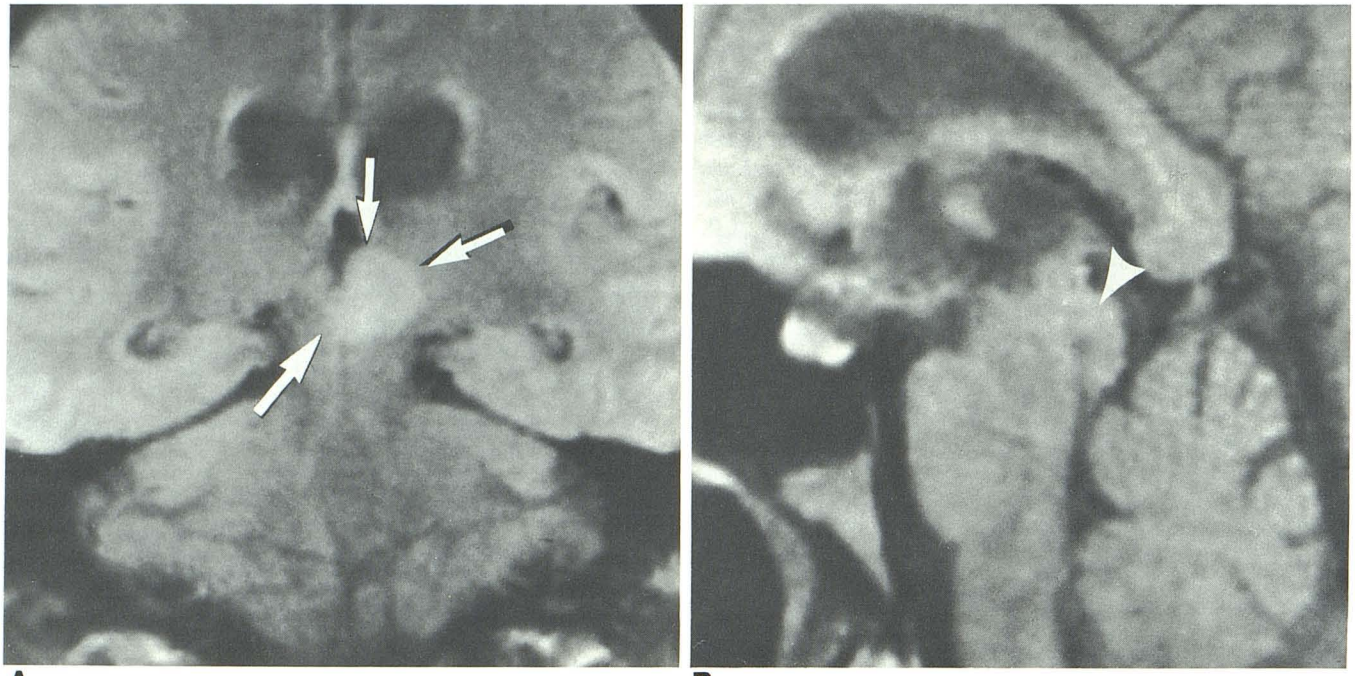


Fig. 4.—Astrocytoma.
***A*, SE 1700/40. Coronal section through tectum. Tumor is primarily left-sided but extends across midline (*arrows*).**
***B*, SE 800/40. Midline sagittal section. Superior colliculus measures 8 mm (*arrowhead*). Aqueduct is obstructed.**

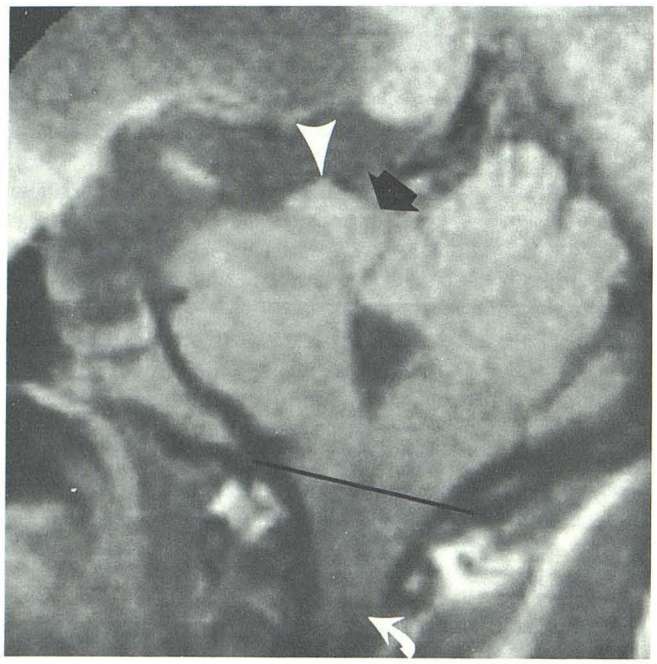
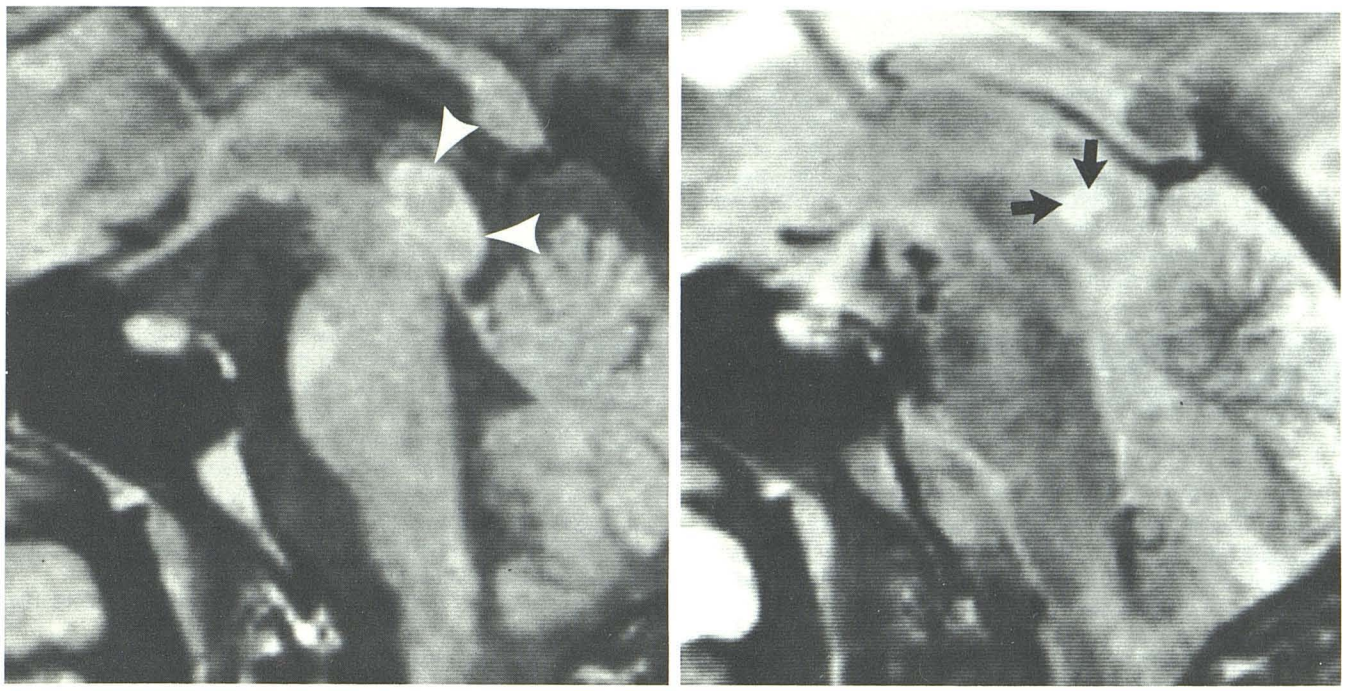


Fig. 5.—Chiari malformation with mesencephalic "breaking." Midline sagittal section. SE 850/30. Tectum is thickened (9 mm) and slightly elongated (17 mm) (*white arrowhead*). Colliculi appear fused (*black arrow*). Note cerebellar tonsillar herniation (*white arrow*). Foramen magnum is indicated by black line.

has been no mention of the normal range of variation of the superior and inferior colliculi. Most tumors will be detected because of the their prolonged T2 values. However, small lesions may be difficult to perceive on axial sections because of variable slice angulation, partial-volume effect, and low contrast compared with CSF in the adjacent quadrigeminal plate cistern. T1-weighted midline sagittal sections are commonly acquired for slice localization and also as an adjunct to the T2-weighted axial examinations. A thorough knowledge of the variations seen on these sections is therefore important.

Inversion-recovery or short spin-echo techniques are advocated for use in conjunction with intravenous contrast agents for MR imaging, such as Gd-DTPA [10, 11]. These agents will allow identification of blood-brain barrier disruption. Some infiltrating brainstem gliomas do not have alteration of the blood-brain barrier [8, 12] and thus will be detected only as an area of anatomic abnormality. Familiarity with the variations in the tectum may allow detection of small low-grade gliomas in these instances.

Our data reveals a mean diameter of 4.5 mm and 5.0 mm for the superior and inferior colliculi, respectively. The 95% confidence level range (+/− 2 SD) is between 2.4 mm and 6.6 mm for the superior colliculus and 3.0 mm and 7.1 mm for the inferior colliculus. Combining these figures and rounding the numbers to the nearest millimeter results in a mean diameter of 5 mm with a range of 2–7 mm. This correlates well with the results reported by Bentson and Keesey [2].



A B

Fig. 6.—Probable neoplasm of tectum (no pathologic diagnosis). Midline sagittal sections.
***A*, SE 800/40. Tectal plate is 20 mm long and diffusely enlarged (*arrowheads*). Superior colliculus is 9 mm thick; inferior colliculus is 8 mm thick. Aqueduct is compressed.**
***B*, SE 2500/80. Note area of abnormal increased intensity in tectal plate (*arrows*).**

They measured the diameters of the colliculi on lateral pneumoencephalographic tomograms and found that the colliculi ranged from approximately 3–6 mm with a mean value of about 5 mm (after correction for magnification). There were no patients with measurements greater than 7 mm in our normal group (Fig. 1); however, four patients had measurements below 3 mm (2 SD below the mean). None of these patients had evidence of mesencephalic disease. Variations in the tectal thickness below the mean value do not appear to have any clinical significance.

Patients with aqueductal stenosis can be divided into two groups, those with normal tectal thicknesses (Fig. 3) and those with an enlarged tectum (Figs. 4, 5, and 6). Aqueductal stenosis due to a web, localized ependymal gliosis, or viral infection (mumps, influenza, parainfluenza-2, reovirus) is not associated with enlargement of the tectum [13–15]. Patients with colliculi thicknesses of 8 mm or more must be evaluated for a possible infiltrating lesion. Primary and metastatic tumors as well as granulomatous disease, periaqueductal gliosis, and hamartomas can cause enlargement of the tectum [12, 16–19]. When the tectum is enlarged on a T1-weighted sagittal sequence, a T2-weighted sagittal sequence should be obtained in addition to, or as a replacement for, the T2-weighted axial scan. Two of our patients with proven astrocytomas and the patient with neurosarcoidosis had increased signal intensity in the lesion on the T2-weighted pulse sequences. Increased intensity was also present in the enlarged tectum of one other patient in whom we suspect a low-grade glioma, but there is no histologic diagnosis. In the latter patient and in the patient with sarcoid, the increased intensity was difficult to appreciate on the axial images and was recognized only by comparing the T2-weighted sagittal images with the T2-weighted axial images.

Patients with the Chiari II malformation may have anomalies of the mesencephalon ranging from slight loss of the intercollicular groove to fusion of the colliculi into an elongated beak-shaped structure [20, 21]. Two of our patients with the Chiari I malformation had slight elongation of the tectal plate, and in one the colliculi appeared fused and increased in diameter to 2 mm above the 95% confidence level (Fig. 5). In cases with enlarged colliculi, there should be careful analysis of the hindbrain for possible Chiari malformation. Deformity of the midbrain indistinguishable from "beaking" may rarely be observed in patients with non-Chiari aqueductal stenosis and in patients with the Dandy-Walker malformation [21].

The T1-weighted midline sagittal section is frequently obtained as part of the MR examination. The anatomy of this section is easily recognizable and reproducible. Recognition of the normal and pathologic variations of the mesencephalic tectum is important to ensure accurate interpretation.

ACKNOWLEDGMENT

Our thanks to Arlene Kisliuk and Mary Anne Thomas for their help in the preparation of this manuscript.

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