MRI of the incisural plane: assessment of normal brain stem position by age and transtentorial brain stem shift in disease

Abstract

The standardization on MRI of an anatomic plane passing through the tectum of the midbrain based on fixed landmarks allows assessment of the position of the brain stem during development and in normal adulthood, and comparison with its position in disease states. The level of the tectum relative to this incisural plane changes during normal cranial growth as well as in the presence of masses, frank brain stem herniation correlating with altered consciousness.

Key words

Brain stem · Tentorial hiatus · Herniation

Introduction

A review was undertaken to ascertain the position on MRI of the tectum with respect to the tentorial hiatus in patients of different ages without intracranial lesions and in patients with diverse pathology.

Materials and methods

Five separate groups of subjects were studied by MRI on a 1.5 T unit using sagittal and axial T1-weighted (500/15/2: TR/TE excitations) and axial T2-weighted (2500/30-80/1) conventional spin-echo images (Table 1). Group I consisted of 35 infants and children below the age of 10 years with normal cranial MRI. Group II was made up of 150 individuals above the age of 10 years in whom cranial MRI was normal. In group III, 100 patients were judged on MRI to have severe cerebral atrophy. The 30 patients in group IV were judged to have idiopathic communicating hydrocephalus on MRI criteria: pronounced, generalized enlargement of the ventricular system, including the temporal horns, at the expense of the overlying subarachnoid space. Group V comprised subjects with intra- or extra-axial mass lesions which were supratentorial (group Va) or in the posterior cranial fossa (group Vb), but not both simultaneously; these included 40 true neoplasms and 10 acquired/developmental lesions (2 cysts, 3 idiopathic spontaneous cerebral hematomas, vascular lesions, including giant aneurysm or infarcts, and abscess). The primary pathology was acute, or of less than 7 days’ duration, in only 7 patients (14 %). No patient was included who had an expanding sellar lesion, tentorial or tectal tumor, developmental or acquired anomaly of the skull base, or known developmental tentorial anomaly (e.g., Chiari malformation).

In each case the “incisural plane” (IP) was defined on the midline sagittal T1-weighted image as a plane originating from the lowest point floor of the sella turcica and terminating at the anterior margin of the tentorium (i.e., the posterior margin of the incisura) (Fig. 1a). No absolute measurement was made, but simply whether the IP passed through the upper, middle or lower third of the tectum (as shown in Fig. 1b). When the IP traversed no part of the tectal plate, transtentorial herniation of the brain stem was judged to have occurred. In each patient with a mass lesion the level of consciousness was recorded for correlation with transtentorial herniation.

Results

The major findings are given in Table 1. The 50 patients in group V, with intracranial mass lesions, yielded 11 cases of frank transtentorial herniation: upward herniations: 3, downward herniations: 8 (Figs. 2, 3). With the exception of one colloid cyst, which was classed as a developmental lesion, all were associated with tumors. Alterations in consciousness from lethargy to stupor were seen in 10 of the 11 patients with transtentorial herniation (90.9 %), but none was in frank coma. None of the group V patients without brain stem herniation manifested altered consciousness.

There was a higher incidence of cerebellar tonsillar herniation linked with posterior fossa mass lesions (7,
Fig. 1a–c Normal incisural plane (IP). a Group II (over 10 years of age): midline sagittal T1-weighted MRI in a 16-year-old reveals the most common position (72.7%) brain stem relative to the IP (solid line) which traverses the upper third of the quadrigeminal plate. b Diagram demonstrating the normal IP (dashed line) passing from the lowest point of the floor of the sella turcica (S) to the free margin of the tentorium (T) in the midline (Q quadrigeminal plate, P pons, C cerebellum, G vein of Galen, CC corpus callosum). c Division of the tectum into upper (1), middle (2), and lower (3) thirds. (M midbrain, asterisk aqueduct of Sylvius)

Fig. 2a, b Group Va: downward transtentorial herniation with and without obstructive hydrocephalus. a Midline sagittal image in a 39-year-old patient with a large cerebral astrocytoma illustrating downward displacement of the entire tectum (arrow) below the IP (solid line). b Midline sagittal image in a 39-year-old patient with a mass asterisk in the third ventricle and obstructive hydrocephalus, the latter leading to early downward transtentorial herniation of the tectum below the IP (solid line). Tonsillar herniation is present (arrow)

Fig. 3a–e Group Vb: upward transtentorial herniation. a Midline sagittal image in a 19-year-old patient with a cerebellar astrocytoma and obstructive hydrocephalus demonstrating no tectal herniation relative to the IP (solid line). Note cerebellar tonsillar herniation (arrow). b Midline sagittal image in a 2-year-old patient with a medulloblastoma showing tectal herniation (curved arrow), above the IP (solid line), cerebellar tonsillar herniation (straight arrow) and hydrocephalus. c Midline sagittal image in a 2-month-old infant with a medulloblastoma showing marked herniation of the tectum (curved arrow) and part of the tumor above the IP (solid line) after decompression of the lateral ventricles