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MR Imaging of Corpus Callosotomy

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MR findings in 13 patients who underwent corpus callosotomy for medically intractable seizures were reviewed. Preoperative MR studies were available in nine patients: five showed at least one morphological and/or MR signal abnormality including corpus callosal thinning (four cases), cerebellar atrophy (two cases), cortical atrophy (two cases), and periventricular hyperintensity on T2-weighted images (one case). Four patients had normal MR studies. Postoperative MR studies were obtained in 11 patients with subtotal callosotomy and two with total callosotomy. Of all pulse sequences, sagittal T1-weighted images best showed the surgical division, although two cases displayed a coaptation artifact, which was misleading. A surgical clip placed at the posterior extent of the callosotomy was best visualized with sagittal T1-weighted imaging. Two patients (15%) had MR findings consistent with subacute blood in the callosum, and three patients (23%) demonstrated parafalcial hyperintensity on T2-weighted images 1 week after callosotomy. Motion artifact was a significant problem with coronal imaging and T2-weighted pulse sequences in postoperative patients.

Patients selected for corpus callosotomy may have a normal baseline MR or show nonspecific abnormalities. MR imaging is an effective method for evaluating callosal division, and in some cases, may demonstrate signal changes consistent with surgically related edema and/or blood.

Neurosurgical intervention for medically intractable seizures is an established therapy in selected patients. In cases in which a resectable epileptogenic focus can be identified, the optimal surgery is removal of the offending region [1]. For many patients without a discrete epileptic focus, corpus callosotomy, the surgical division of a portion or all of the corpus callosum, has been shown effective in eliminating or reducing seizure activity [2]. Postoperative MR has been useful in defining the extent of surgery and has correlated well with neuropsychological testing of callosotomy patients in several recent series [3–7].

We reviewed the preoperative and postoperative MR studies of patients who underwent corpus callosotomy at our institution between January 1987 and July 1988 to determine the spectrum of MR findings in this group of patients. On the basis of our findings, we suggest an MR protocol for optimal postoperative evaluation of such patients.

Materials and Methods

We retrospectively reviewed the MR examinations of 13 corpus callosotomy patients, including nine males and four females 9 to 42 years old (mean, 27 years).

Baseline preoperative MR studies were available for review in nine patients. Because most of these studies were from outside institutions, a variety of pulse sequences was used. All had sagittal T1-weighted images. Additionally, three patients each had coronal T1- and axial T2-weighted images, and a single patient had coronal T2-weighted images. Corpus callosum morphology and structural and signal intensity abnormalities were noted.

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All patients had postoperative MR at 1.0 T* anywhere from 4 days to 17 months after surgery. Spin-echo pulse sequences were used in all patients. T1-weighted sagittal images, 600/17/2 (TR/TE/excitations), were obtained in all patients. Additionally, 10 patients had coronal T1-weighted images (800/17). Intermediate and T2-weighted images (2000–2500/28–40/56–80/1) were obtained in eight patients: in the axial plane in seven and coronal plane in one. For all pulse sequences, slice thickness was 6–8 mm with a 1–2 mm interslice gap.

Postoperative MR findings were analyzed in conference by the authors. The various imaging planes and pulse sequences were compared for three features pertinent to corpus callosotomy: visualization of the surgical commissurotomy, detection of ferromagnetic artifacts created by a surgical clip placed at the posterior margin of a partial callosotomy, and presence of surgically related MR signal changes. In addition, the degree of image degradation by patient motion artifact was recorded.

Results

Preoperative MR studies were normal in four patients. In five patients, MR showed one or more structural/signal abnormalities. Four patients were judged subjectively to have thinning of the corpus callosum. Three patients had marked cerebellar atrophy, one patient had moderate cortical atrophy, and one patient had marked cortical and cerebellar atrophy. One patient had bifrontal periventricular white matter hyperintensity on T2-weighted images. One patient had artifactual signal loss in the posterior fossa caused by metallic cerebellar electrodes previously implanted for seizure control.

Subtotal callosotomy was performed in 11 patients and total callosotomy in two patients. The surgical defect was clearly delineated on sagittal T1-weighted images in 11 (85%) of 13 patients and on coronal T1-weighted images in seven (70%) of 10 patients. In the sagittal sections, the defect appeared as partial or total absence of the surgically divided corpus callosum on the midline image (Fig. 1A). Coronal sections showed the commissurotomy as a low-signal cleft in the midline of the callosum, extending from the interhemispheric fissure down to the underlying ventricular ependymal surface (Fig. 1B). Axial (in seven patients) and coronal (in one patient) T2-weighted images did not adequately demonstrate the commissurotomy defect.

The major cause of suboptimal visualization of the callosotomy was motion artifact. Coronal images and T2-weighted pulse sequences were particularly prone to this problem. An artifact unique to the sagittal images, a coaptation effect, was present in two cases (Fig. 2). This artifact resulted from the sectioned callosal fibers returning to close approximation after the commissurotomy, creating the false appearance of a normal or incompletely divided corpus callosum on the midline sagittal views.

The surgical clip placed at the posterior extent of the division in a subtotal callosotomy appeared as a focal signal void (Fig. 2B). It was clearly depicted with sagittal T1-weighted images in nine (69%) of 13 cases and in four (40%) of 10 cases on coronal T1-weighted images. Axial T2-weighted images showed the clip artifact in three (43%) of seven cases. Motion artifact accounted for all cases of nonvisualization of the clip.

In 11 patients with scans obtained 4 days to 17 months after surgery, there were no MR signal changes to suggest subacute or chronic hematoma at the surgical site. Two patients scanned 1 week after surgery had MR evidence of blood. In one patient there was a large fluid collection at the commissurotomy site with signal characteristics reflecting a subacute hematoma. The second patient showed hyperintense signal on both T1- and T2-weighted images in the callosal bed tracking up the interhemispheric fissure into the subdural space over the convexities.

Surgically related hyperintensity was present in three of eight patients with T2-weighted postoperative studies. All three patients had studies 1 week after surgery and showed confluent areas of prolonged T2 in the supracallosal gray and white matter adjacent to the falx (Fig. 3). Follow-up studies on these patients were not available. In the patient with the longest interval between surgery and MR (15 months), no parafalcial signal abnormalities were noted.

Discussion

Corpus callosotomy has an 80% success rate in eliminating or reducing the frequency of seizures in patients with medically intractable epilepsy [2]. This operation is presently performed at approximately 15 referral centers in the United States. It is important for radiologists outside these sites to be aware of the normal postoperative MR appearance of the corpus callosotomy patient, because a significant number of these patients may require imaging for persistent seizures or other neurologic problems at locations remote from the neurosurgical center.

Preoperative MR in this series, as expected in patients without a focal epileptogenic lesion, showed nonspecific findings such as cerebellar and cortical atrophy. These abnormalities may in part be related to chronic anticonvulsant therapy. Because we recently diagnosed a case of agenesis of the corpus callosum in a patient referred for callosotomy, we now obtain a preoperative MR study in all patients. While a preoperative CT scan may exclude callosal agenesis, we prefer MR for its superior visualization of the callosum and as a baseline for postoperative studies. Sagittal T1-weighted images are generally adequate for evaluating the callosum.

At our institution, the surgery is limited to division of the major commissure and underlying posterior hippocampal commissure. Via microsurgical technique, the callosum is divided down to the underlying ventricular ependymal surface. A partial callosotomy is performed initially in most patients, usually the anterior one-half to two-thirds of the corpus callosum. A titanium clip is placed at the posterior extent of the division for two reasons: to facilitate imaging of the limit of surgical division and to serve as a surgical marker should a subsequent complete callosotomy be required. Postoperative gliosis may obscure the boundary of the previous resection, increasing the technical difficulty of the second operation [2].

The procedure usually does not result in significant bleeding, a finding confirmed by MR, which showed surgically

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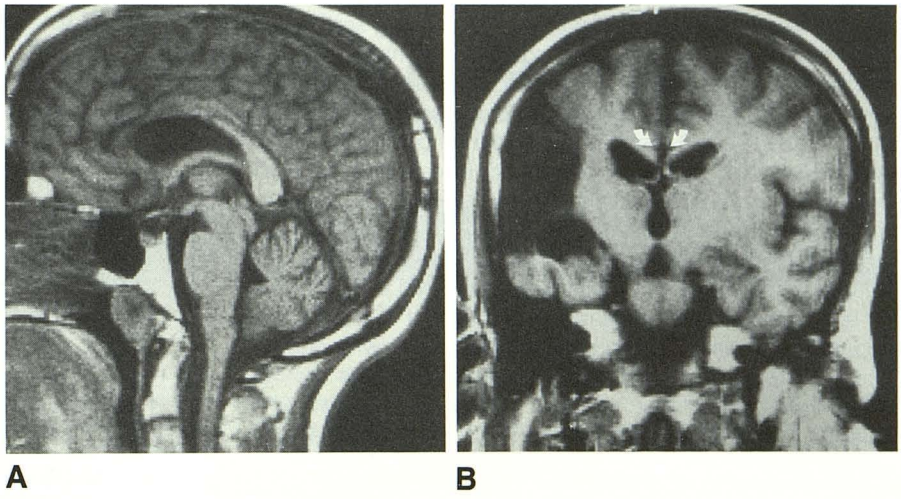

Fig. 1.—Corpus callosotomy defect.
A, Sagittal midline image (600/20) shows absence of normal signal in anterior and mid corpus callosum after partial callosotomy. Artifact from surgical clip placed at posterior margin of division is not clearly seen on this image.
B, Coronal image (800/17) in a different patient shows surgical division completely transecting callosum (*arrows*). Note marked right cerebral hemiatrophy and porencephaly caused by old middle cerebral territory infarction.

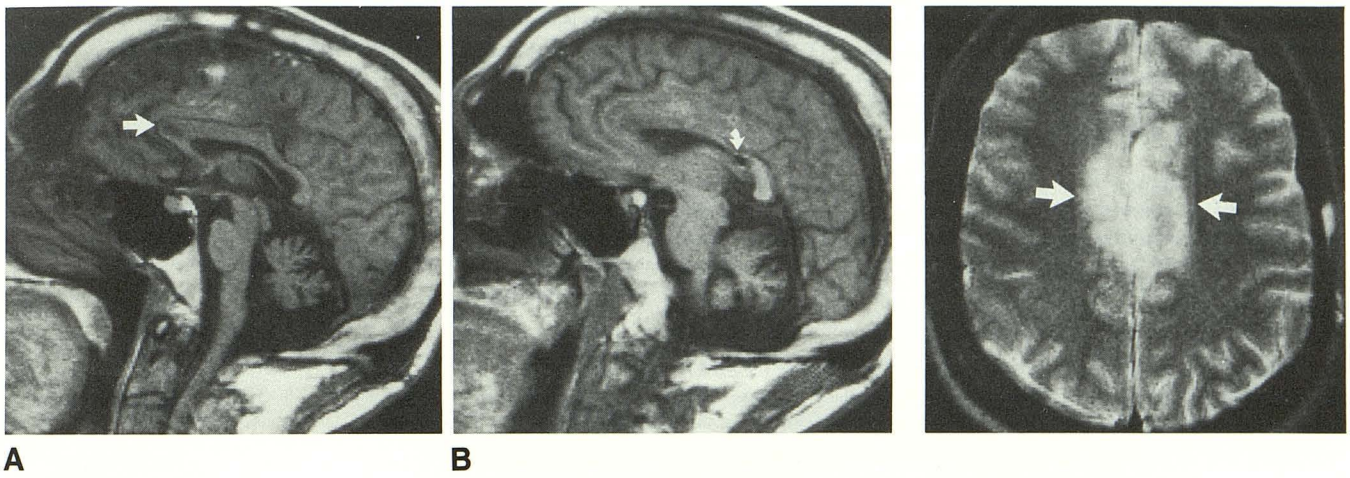

Fig. 2.—Coaptation artifact.
A, Midline sagittal image (600/17) shows apparently undivided corpus callosum in a patient 2 weeks after subtotal callosotomy. Low-signal area in genu (*arrow*) is only indication of any abnormality.
B, Adjacent parasagittal image shows titanium clip artifact clearly (*arrow*), documenting posterior extent of surgery. The absence of normal callosal fibers anterior to the clip contrasts with the intact splenium.

Fig. 3.—Acute postoperative signal change. Axial image (2000/80) demonstrates circumscribed, bilateral parafalcial hyperintensity consistent with edema in a patient 1 week after callosotomy.

related subacute blood in only two of 13 patients. It does appear that parafalcial hyperintensity may be seen in some cases, probably representing acute edema related to surgical retraction along the falx to expose the callosum. Our study lacks adequate follow-up to determine the evolution of this signal abnormality and to assess other long-term MR signal changes. Sussman et al. [3] reported four patients who had hyperintense signal changes in the corpus callosum 3 or more years after surgery. In their series, hyperintensity increased with longer postoperative intervals, a finding they attributed to gliosis from surgery. In the only patient in our series with long-term follow-up (15 months), no signal abnormalities were present in the callosum or along the parafalcial cortex.

The clinical importance of MR in assessing the extent of callosal section has been documented by Gates et al. [4, 5]. They described three patients whose suboptimal response to callosotomy resulted from unintentionally spared callosal fibers, which were seen on postoperative MR. The seizures became better controlled after further callosal surgery.

The previous reports have primarily used the sagittal plane for optimal visualization of the surgical defect [6, 7]. In two of our patients, the coaptation artifact on the sagittal images provided misleading information about the extent of surgery, and coronal T1-weighted images were required for complete assessment. We believe that the coronal view, theoretically the optimal plane for imaging callosotomy in that it is orthogonal to both the callosal fibers and the surgical division, may be suboptimal in a significant number of patients because of motion artifact, particularly in examinations performed shortly after surgery. The finding in our series that T1-weighted coronal images were more susceptible to motion artifact is attributable to several factors. Coronal scans were always obtained after sagittal scans, with the resultant prolonged imaging time presumably accompanied by increasing patient

motion. In addition, movement of the head during scanning is more likely to occur in a lateral or rotating (coronal) orientation than in the anterior to posterior (sagittal) direction. Blurring and phase-encoding errors will be exaggerated for images obtained in the same plane as the major component of motion. Routine sedation is not recommended, since adequate postoperative information can usually be obtained in the presence of mild or moderate motion artifact.

We presently perform MR 2 or more weeks after surgery to assess the extent of callosotomy. This time period allows for examination of the patient prior to hospital discharge and appears to minimize motion artifact compared with shorter postoperative periods. Sagittal T1-weighted images are obtained to visualize the surgical clip and the commissurotomy defect. If coaptation artifact is suspected, coronal T1-weighted images are obtained. In addition, axial T2-weighted images are acquired in cooperative patients to assess the MR signal changes related to surgery.

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