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## The Bright Choroid Plexus on MR: CT and Pathologic Correlation

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Fourteen patients studied with MR imaging were found, incidentally, to have unusually bright, large choroid plexus glomera on T2-weighted sequences. A group of 167 patients was then examined retrospectively for size and intensity of the choroid plexus glomera on T2-weighted images. In the latter group of 167 patients, 66 (39.5%) had bright choroid plexus glomera. Of those who had bright choroid plexus glomera, eight of the 14 initial group and 11 of the 66 patients studied retrospectively had previous CT scans. The typical CT appearance of these bright glomera consisted of nonenhancing central regions of low (but not negative) attenuation with peripheral calcifications in the majority. The remainder showed noncalcified glomera. Fifty-two glomera were obtained at autopsy and examined retrospectively. Eight showed small, variably sized masses with lipid deposits, neuroepithelial microcysts, and peripheral psammoma body calcifications. One patient who died had a bright choroid plexus glomus on MR, and his glomera showed the same pathologic findings. The autopsy findings were believed to be typical pathologically for early xanthogranulomata formation. These early xanthogranulomatous changes appear to be of little clinical significance but must be differentiated from other lesions that can produce bright or enlarged choroid plexus glomera on MR.

The choroid plexus has shown a highly variable appearance with MR imaging. While this variability is often dependent on technique and sequence characteristics, it has become apparent that even when sequence parameters are held constant, the intensity patterns of choroid plexus tissue can be highly variable. We have noted that, generally, with T1-weighted MR images, choroid plexus glomera in the lateral ventricles show medium- to low-intensity signal compared with white matter. With T2-weighting the glomera usually show a relatively intermediate signal intensity. This can, however, be highly variable. In patients with highly calcified choroid plexus glomera the signal intensity may be quite low on both the T1- and T2-weighted images. We have noticed in some patients that the glomera may be quite bright on T2-weighted images even though some calcifications are present. Our objective was to determine the choroid plexus tissue differences necessary to produce the highly variable signal intensities seen predominantly with T2-weighted images. In particular, the object was to determine the tissue pattern necessary to produce the intensely bright and often enlarged choroid plexus glomera noted sometimes with T2 weighting.

### Materials and Methods

A group of 14 patients who had MR imaging of the brain were found incidentally to have prominent bright choroid plexus glomera on T2-weighted images. One hundred sixty-seven previously completed MR examinations of the brain were then evaluated retrospectively. Sixty-six of these patients were found to have large, bright glomera. The average age of the group of 167 patients was 45 years (range, 4–88 years); 103 (62%) were female and 64 (38%) were male. The 66 patients in this group with bright glomera had an average age of 43 years (range, 4–80 years); 45 (68%) of these were female and 21 (32%) were male.

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Eight of the initial group of 14 patients and 11 of the retrospective group of 66 patients who had bright glomera had previous CT scans, which were reviewed. All MR examinations were completed on a 0.5-T Siemens Magnetom MR system. T2-weighted sequences used a TR of 2500 and TEs of 35 and 70 in the transverse plane. Most studies also included a T1-weighted sequence with a TR of 500 and a TE of 30 in the sagittal plane. Section thickness was 7–10 mm

## Results

The size of the glomera varied from 6–20 mm in the initial group of 14 patients. Ten patients in this group had bilaterally bright glomera, whereas a glomus was bright unilaterally in the other four. Eight of these patients had previous CT scans and six of the eight demonstrated a typical CT appearance. Two of the eight had totally uncalcified glomera on CT. The typical CT appearance consisted of central areas of nonenhancing medium to low (but not negative) attenuation in the choroid plexus glomera with surrounding areas of peripheral irregular calcifications. The central areas of low attenuation were generally similar to or slightly higher than CSF in the attenuation characteristics.

Of the 167 consecutive MR examinations of the brain reviewed retrospectively, 56 had bright glomera bilaterally and 10 had unilaterally bright glomera, for a total of 66 (39.5%) with either bilaterally or unilaterally bright glomera. The remainder of the glomera were intermediate to low intensity. The size of the bright areas within the glomera varied from 3–22 mm in this group of patients. Eleven in this group of 66 patients had CT scans; seven of these showed the typical CT appearance described above and four showed uncalcified glomera.

Fifty-two glomera obtained at autopsy were sectioned retrospectively. Eight (15%) of these glomera had localized

masses within, which showed combinations of lipid deposits, neuroepithelial microcysts, and peripheral psammoma body calcifications. One of the patients imaged with MR who had positive choroid plexus findings later died, and the lateral ventricular choroid plexus glomera were sectioned at autopsy. The same findings—including lipid deposits, neuroepithelial microcysts, and peripheral psammoma bodies—were again identified. The MR and pathologic findings were more prominent on the right.

## Discussion

The highly variable appearance of the choroid plexus glomera in the atria of the lateral ventricles when viewed on T2-weighted MR images of the brain has provoked some discussion. Typically, the choroid plexus glomera and, for that matter, other portions of the choroid plexus, show relatively low signal intensity on T1-weighted images and varying relatively low to intermediate signal intensity on T2-weighted images. The degree of calcification of choroid plexus would appear to be significantly related to the degree of low signal intensity. However, we have noted in the past that many choroid plexus silhouettes show quite bright signals of varying size with T2 weighting. These same choroid plexus silhouettes show low signal intensity with T1 weighting in the regions where brightness was most pronounced on T2 weighting.

Our 167 cases examined retrospectively yielded a total of 66 patients with either bilaterally or unilaterally bright choroid plexus glomera with T2 weighting. The size of these foci of bright signal measured from 3–22 mm. (Figs. 1 and 2). Eleven of the 66 patients had CT scans. In four, the glomera were not calcified and presented intermediate attenuation. In seven, there were irregular flecks of calcium surrounding the margins

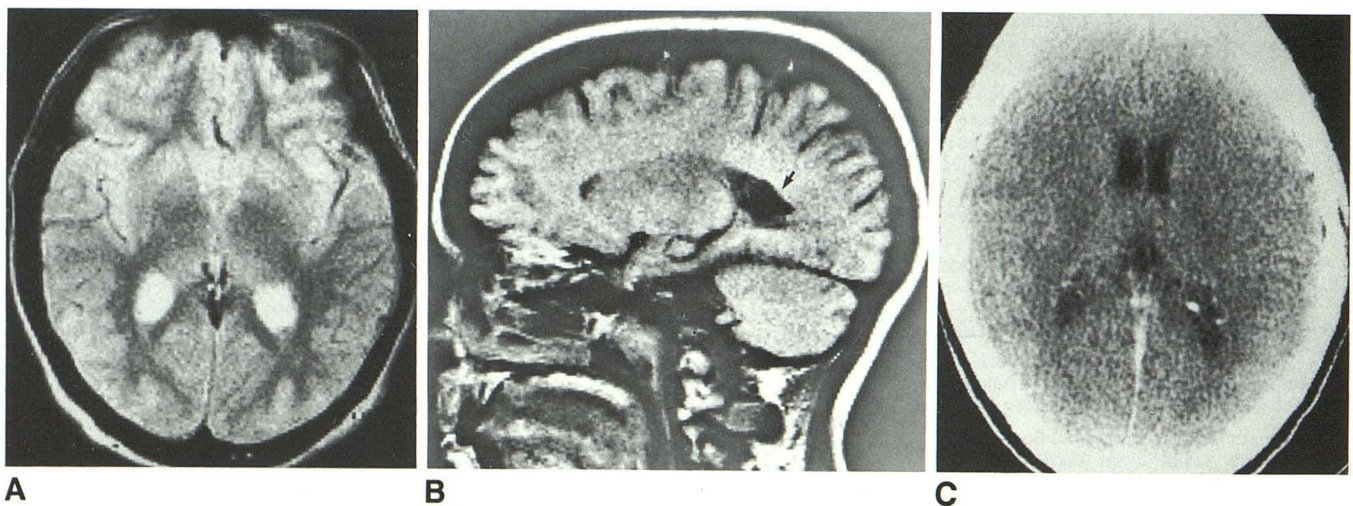


Fig. 1.—39-year-old woman.  
 A, T2-weighted MR image (1800/70) shows large bright bilateral choroid plexus glomera in lateral ventricles. Glomus on left measures 15 × 10 mm, while that on right measures 15 × 12 mm.  
 B, T1-weighted MR image (500/30) identifies area of low signal in atrium (arrow), consistent with enlarged glomus.  
 C, CT scan with contrast demonstrates typical CT appearance with irregular flecks of calcification around nonenhancing central region of low attenuation.



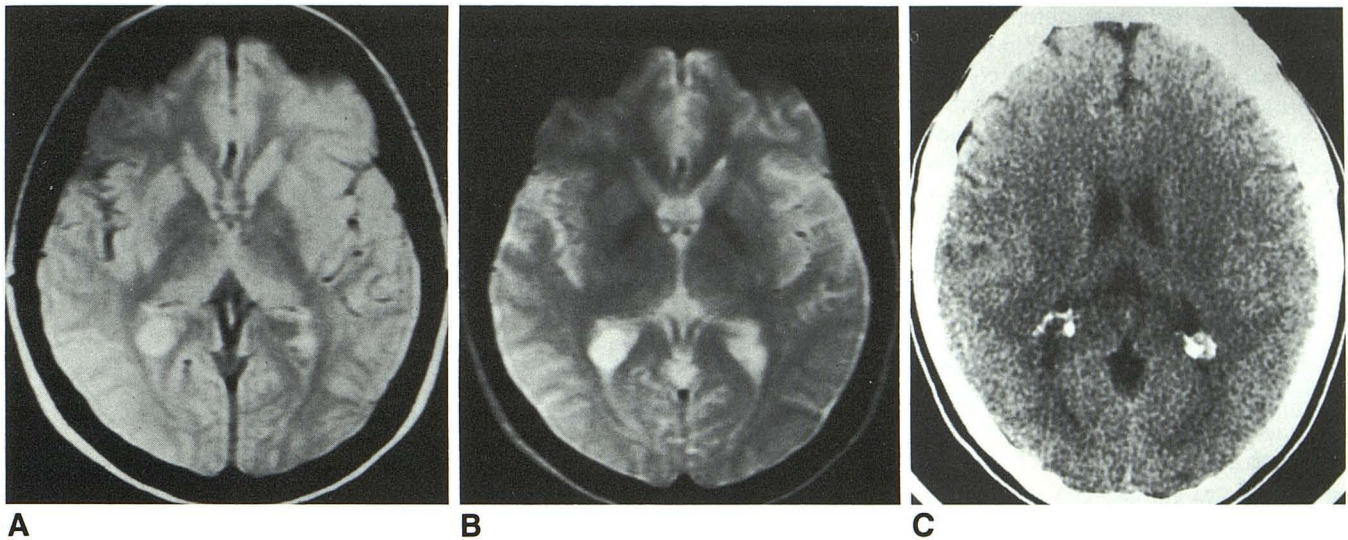


Fig. 2.—48-year-old woman.

A, Proton-density-weighted MR image (2000/35) shows 12 × 12 mm bright choroid plexus glomus filling right atrium and 7 × 5 mm bright focus of glomus in left.

B, On T2-weighted MR image (2000/70), hyperintense glomera can become indistinguishable from adjacent CSF.

C, CT scan without contrast reveals low attenuation and peripheral calcification of choroid plexus on right. Left choroid plexus glomus is highly calcified. This is not well seen on MR image except for a thin rim of low signal on right. A small area of low intensity at medial margin of left bright glomus probably represents calcium also.

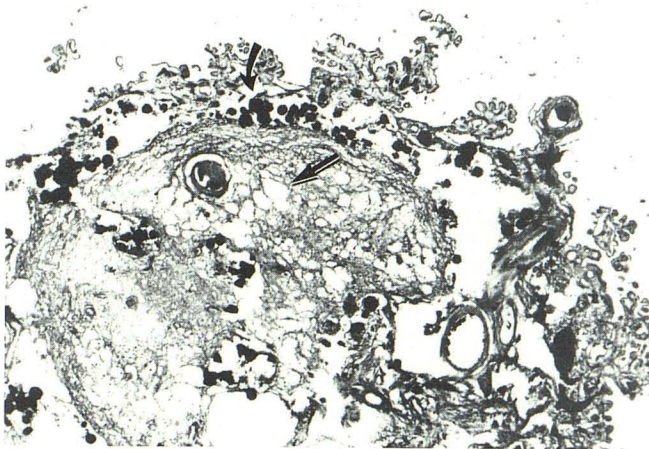


Fig. 3.—48 year-old man. Cytoplasm of the choroid plexus neuroepithelial stromal cells is enlarged by foamy material and shows microcystic changes. These microcysts coalesce and form larger cystic areas (straight arrow). Only minimal lipid deposits were found. Round foci of mineralization tend to accumulate near periphery of such areas (curved arrow). (Magnification ×37.)

of masslike areas of intermediate to low attenuation. These areas did not enhance and were the same bright areas seen on T2-weighted MR images (Figs. 1 and 2). These findings are similar to the typical CT appearance of xanthogranuloma described by Terao et al. [1] and Pear [2]. These researchers found punctate calcification, central areas of low attenuation, and no enhancement, as reported by Pear, or only marginal enhancement, as reported by Terao et al. In our cases, these

central areas of choroid plexus showed low attenuation but no evidence of negative attenuation values at CT and they showed no evidence of brightness on T1-weighted MR images, indicating an absence of significant concentrations of lipid.

Eight (15%) of the 52 glomera sectioned at autopsy and the glomera of the patient imaged with MR who died showed varying size, small localized masses made up of combined minimal lipid deposits, neuroepithelial microcysts, and peripheral psammoma calcifications (Fig. 3). The neuroepithelial microcysts typically were empty after fixation; however, the neuropathologist believed they had contained proteinaceous material. These combined findings were thought to be typical for early xanthogranulomatous degeneration. The formation of xanthogranulomata has been described by Netsky and Shuangshoti [3] and by Shuangshoti et al. [4]. They found that epithelial cells of the choroid plexus proliferate and accumulate lipid that, when released into the stroma, causes a granulomatous reaction. According to them, the neuroepithelial cells form proteinaceous cysts. The extent of neuroepithelial microcysts, which apparently contain proteinaceous material with only minimal lipid, should be compatible with the long T1, long T2 characteristics of these choroid plexus masses at MR, on which they appear bright with T2 weighting and dark with T1 weighting [5]. There does not appear to be sufficient lipid present to visibly shorten the T1 characteristics.

In no case was there any evidence of ventricular obstruction or significant ventricular dilatation, distal or proximal to these choroid plexus glomerular changes. Two of our patients with particularly large bright glomera were reexamined with MR after a 6-month interval. No change whatsoever could be seen in the appearance or size of the choroid plexus. None



of the patients had any symptoms that could be clearly related to these changes in the choroid plexus. Other abnormalities of the choroid plexus should be considered in the differential diagnosis. Intraventricular meningioma can certainly present as a masslike lesion having prolonged T1 and T2 characteristics. The MR appearance of intracranial meningiomas has been described by Spagnoli et al. [6] as typically showing overall hypointensity on T1-weighted images and hyperintensity on T2-weighted images. They also generally show a clear enhancement pattern with iodinated contrast on CT scans, and in the one intraventricular case that we have seen with MR and CT, where a trigonal meningioma reached 20 mm in size, there was associated obstruction of the temporal horn. The early xanthogranulomatous microcystic changes of the choroid plexus do not, in our experience, enhance with iodinated contrast and do not produce ventricular obstructive changes.

Choroid plexus papillomas present as mass lesions within the ventricle, are often calcified, and may be hypersecretory, expanding the ventricular and subarachnoid CSF spaces. These lesions are often quite vascular. At MR the vascular channels can often be seen as flow-void, low-signal-intensity areas within the choroid plexus mass. In our experience these lesions have more intermediate T1 and T2 relaxation characteristics and do not have extreme brightness on T2-weighted images. However, Wagle et al. [7] reported a case of fourth ventricular papilloma that had high intensity with T2 weighting.

Angiomatous abnormalities of the choroid plexus have been associated with Sturge-Weber syndrome, and the CT and MR findings have been described by Stimac et al. [8]. In these patients the choroid plexus can be focally expanded and bright with T2 weighting; however, when these angioma changes are associated with Sturge-Weber syndrome the choroid plexus enhances brightly with IV iodinated contrast material at CT. Stimac et al. [8] found that five of seven patients with Sturge-Weber syndrome who were scanned with CT showed enlargement and enhancement of the choroid plexus on the same side as the intracranial and facial abnormalities. These findings corresponded to the location of a bright choroid plexus appearance on T2-weighted MR images.

Czervionke et al. [9] described the MR appearance of intraventricular neuroepithelial cysts. The signal characteristics of these lesions are very similar to those of xanthogranulomatous choroid plexus with both T1 and T2 weighting. However, the typical thin wall margin of their cysts were not typically visualized with our xanthogranulomas, and the peripheral clusters of calcium were not a frequent feature of the cysts. A displaced calcified glomus was noted in one of their cases. There is probably some overlap in the MR appearance of xanthogranulomatous changes and neuroepithelial cysts.

Neuroepithelial cysts could, in fact, represent coalescence or dilatation of the xanthogranulomatous microcysts seen in our pathologic material.

In our experience ependymomas present as intraventricular masses that generally have long to intermediate T1 and long T2 relaxation characteristics. Scotti et al. [10] reported 10 cases of spinal ependymomas that had highly variable T1 and T2 relaxation characteristics. Areas of low signal may be associated with calcium. Ependymomas typically enhance with iodinated contrast on CT scans, and large lesions may produce ventricular obstruction.

## Conclusions

Up to 40% of MR imaged choroid plexus glomera show areas of prominent T2 lengthening measuring 3–22 mm. These tend to show a typical CT appearance in which there is central intermediate to low attenuation (but not negative attenuation) with peripheral flecks or clumps of calcification and no central postcontrast enhancement. Pathologically, these areas appear to be regions of early xanthogranuloma formation. No clinical significance can be attached to them but it is necessary to differentiate them from pathologic conditions.

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