Gd-DTPA-enhanced MR images: accentuation of vascular pulsation artifacts and correction by using gradient-moment nulling (MAST).

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Abbreviated Reports

Gd-DTPA–Enhanced MR Images: Accentuation of Vascular Pulsation Artifacts and Correction by Using Gradient-Moment Nulling (MAST)

A long-recognized advantage of MR over CT is the absence on MR images of bone-related artifacts within the posterior fossa. With the recent introduction of Gd-DTPA, however, a troublesome increase in the number of flow-related artifacts superimposed on MR images of the cerebellum and brainstem has been noted. This report quantifies these iatrogenically created artifacts and describes the effectiveness of a gradient-moment nulling technique for reducing them.

Methods and Results

Three sets of T1-weighted axial images centered on the transverse sinuses were obtained in 25 consecutive patients referred for gadolinium-enhanced cranial MR examinations. All studies were performed with a 1.5-T Picker Vista superconducting system (Picker International, Highland Heights, OH). The TR, TE, and number of excitations were the same, 500/30/2, for all studies. The first sequence was performed before Gd-DTPA enhancement (Fig. 1), the second sequence was performed after injection of contrast material, and the third was performed after enhancement in conjunction with MAST, a previously described technique for gradient-moment nulling [1, 2]. Flow in the sinuses parallel to the image plane produced curvilinear artifacts, whereas flow perpendicular to the imaging plane produced less well-defined artifacts that tended to be rounded. Highly consistent and reproducible measurements of cerebellar signal and noise at the level of the transverse sinuses were obtained with commercially available software as previously described [1]. Quantitative analysis showed a 21% decline in mean signal-to-noise ratio on the images obtained with Gd-DTPA compared with images obtained without Gd-DTPA ($p < .001$, two-tailed paired Student's t test with 19 degrees of freedom). The original signal-to-noise ratio was restored completely on subsequent enhanced images when gradient-moment nulling was used.

Discussion

If vascular or CSF pulsations occur during the time that the gradient coils are operating, either with spin-echo or gradient-echo sequences, the flowing protons acquire phase-shift inconsistencies [1–8]. Two-dimensional Fourier reconstruction of these phase-shift errors produces multiple sidebands or phase-shift modulations that are displaced from the baseband along the phase-encoding axis [4–7]. The spacing of these sidebands is determined by TR and the heart rate. These sidebands are superimposed on the image and may be additive (high signal) or subtractive (low signal) with respect to the background

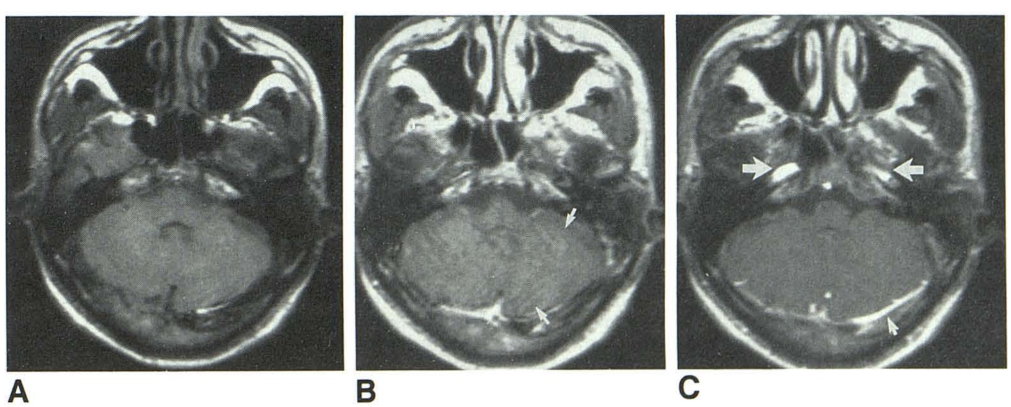

Fig. 1.—Representative example of three prospective axial MR images (500/30) from one patient.
***A*, Without Gd-DTPA.**
***B*, With Gd-DTPA. Accentuated curvilinear artifacts in posterior fossa can be seen along phase-encoding axis (*arrows*).**
***C*, With Gd-DTPA and gradient-moment nulling. Artifacts have been eliminated from cerebellum, and signal from blood in left transverse sinus (*small arrow*) and carotid arteries (*large arrows*) has been refocused, giving a uniform bright appearance.**

image. Phase-shift artifacts become more prominent with increasing TR and with decreasing slice thickness [6]. They may obscure anatomic detail, hinder detection of lesions, or even mimic lesions. Just as bright artifacts simulate high-signal lesions on T2-weighted images, bright artifacts simulate areas of Gd-DTPA enhancement on T1-weighted images.

It follows directly from the analysis by Perman et al. [7] that the intensity of the sidebands is directly related to the intensity of the baseband. Therefore, if the intensity of pulsating blood is increased by administration of Gd-DTPA, the associated phase-shift artifacts will be more intense. Moreover, the magnitude of these artifacts will be proportional to the amplitude of pulsation and the quantity of blood [6].

MAST is one of several commercially available software programs for gradient-moment nulling. A modification of read and slice-select gradient waveforms during the evolutionary phase of the MR signal is used to reduce phase-shift errors associated with velocity and higher derivatives of motion [1, 2]. In our study, as in previous investigations [1, 3], application of gradient-moment nulling significantly improved signal-to-noise ratios. Although gradient-moment nulling can be used in conjunction with physiologic gating, it is superior to both cardiac gating alone [1] and even-echo rephasing [3] for reduction of pulsation artifacts intracranially. Disadvantages are related to increases in gradient currents necessitated by the sequence modifications, which limit the available TE, field of view, and number of slices.

In summary, venous pulsation artifacts in the posterior fossa are accentuated on T1-weighted images by the presence of IV Gd-DTPA, but use of gradient-movement nulling restores the signal-to-noise ratio to its precontrast level and helps eliminate potentially confusing pulsation artifacts.

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