Comparison Between B-Scan Ultrasound and MRI in the Detection of Diabetic Vitreous Hemorrhage

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ABSTRACT
The efficacy of proton magnetic resonance imaging (MRI) was evaluated and compared with that of B-scan ultrasound in the detection and differentiation of diabetic vitreous hemorrhage. Although conventional spin-echo MRI could not locate vitreous hemorrhages, gradient-recalled-echo (GRE) MRI readily did so. The aberrant signals appeared to originate from the interfacing between hemorrhages and the vitreous, and possibly also from the paramagnetic effect of the ferrous ion. The information provided by boundary/susceptibility detection, unique to the GRE sequence, is useful in delineating the extent of vitreous hemorrhage and hemolysis. However, for the diagnosis and follow up of diabetic vitreous hemorrhages, MRI appears no more informative than B-scan ultrasonography.

Magnetic resonance imaging (MRI) of the eye, performed with a judicious selection of MRI pulse sequences, can yield important diagnostic information.1-10 There are two sequences now clinically available: spin-echo and the faster gradient-recalled-echo (GRE). The principal difference between the two is that in spin-echo, the 90-degrees radio-frequency (rf) excitation pulse is followed by a 180-degrees refocusing pulse (to generate echo, i.e., rf signals); while in GRE, the excitation rf pulse is at low angles (< 90°), and the refocusing is achieved by reversing field gradients. GRE is used mostly for three-dimensional volume data acquisition, for example in MR angiography, to take advantage of its short image-acquisition time (in the order of a few seconds per image) and thin slices (currently, 0.75 mm per slice). A unique feature of GRE MRI is its extreme sensitivity to boundaries, e.g., the interface between intravitreous C3F8 gas bubble and the vitreous;11 and the presence of paramagnetics, e.g., the ferrous ion from hemoglobin. These aberrant MR signals are from the so-called "boundary-susceptibility" effect, which accentuates the lesions. Both spin-echo and GRE sequences were tested on diabetic vitreous hemorrhages of varying durations and the results compared with those of B-scan ultrasound.

MATERIALS AND METHODS
Three patients with different stages of vitreous...
hemorrhage secondary to proliferative diabetic retinopathy were selected. The time intervals between the vitreous hemorrhage and examination with MRI and B-scan ultrasound for the three patients were 3 weeks, 3 months, and 10 months, respectively. The last case was reexamined 1 month after pars plana vitrectomy. Informed consent was obtained from each patient before the MR scans.

A General Electric Signa 1.5 Tesla body imager was used, with a 3-inch surface coil positioned over the eye. Since ocular motion is often reduced in eyes with poor vision, the images were relatively free of motion artifacts. Imaging sequences included standard T1- and T2-weighted spin-echo and GRE pulse sequences. GRE MRI of the eye, specifically the anterior segment, is subject to degradation due to the boundary interaction between air and the precorneal fluid. If necessary, this problem can be partially avoided by asking patients to close their eyes during the MR scan. The in-plane image resolution in the present study was $0.47 \times 0.47$ mm, with a $256 \times 256$ matrix, and a slice thickness of 4 mm.

B-scan ultrasonography was performed using the Ophthascan-B (Biophysic Médical S.A., France).

**CASE REPORTS**

**Patient 1.** A 46-year-old woman was initially referred for treatment of diabetic retinopathy. Her visual acuity was 20/40 RE and 20/70 LE. Slit-lamp examination of the anterior segments revealed mild, cortical peripheral spokes in both lenses. Indirect ophthalmoscopy and fluorescein angiography of the left eye revealed macular edema and neovascularization along the superior and inferior temporal arcades. Argon laser panretinal photocoagulation of the left eye was performed in four different sessions within 1 year. This eye remained asymptomatic, with a visual acuity of 20/50 for the next 4 years. Then, however, the patient noticed a sudden decrease in vision to hand movement. Indirect ophthalmoscopy revealed blood obscuring fundus details. Three weeks later, B-scan ultrasound examination confirmed the presence of a homogeneous opacity in the entire vitreous cavity (Fig 1). Dense opacity was also seen in the inferior vitreous cavity.

On the same day, MRI was performed. T1- and T2-weighted images failed to detect any blood (Fig 2); however, GRE images revealed a hypointense area in the inferior vitreous cavity (Fig 3) which corresponded to the dense vitreous hemorrhage detected by B-scan ultrasound.

**Patient 2.** A 48-year-old woman with a 23-year history of insulin-dependent diabetes underwent multiple sessions, spanning 3 years, of argon laser panretinal photocoagulation of both eyes. Three years after the last session, she experienced vitreous hemorrhage in the right eye and her visual acuity decreased to hand movement. In 3 months, her acuity improved to 20/400. Indirect ophthalmoscopy revealed a hazy vitreous. B-scan ultrasonography detected diffuse vitreous opacities, mainly in the posterior vitreous cavity (Fig 4). Spin-echo T1- and T2-weighted MR images did not show
any vitreous abnormality; however, GRE images disclosed a susceptibility effect in the inferior vitreous cavity (Fig 5).

**Patient 3.** A 70-year-old woman with a 22-year history of insulin-dependent diabetes with preproliferative diabetic retinopathy underwent panretinal photocoagulation of both eyes. One year later, she had a dense vitreous hemorrhage in the right eye and her visual acuity decreased to hand movement. The vitreous hemorrhage failed to resorb after 10 months. B-scan ultrasound and MRI examinations were performed. B-scan ultrasound revealed diffuse vitreous opacities with increasing density near the posterior pole (Fig 6). Spin-echo images failed to show any abnormalities, but GRE images showed an extensive, diffused susceptibility effect (Fig 7A). She then underwent successful pars plana vitrectomy in the right eye. When the eye was examined 1 month later, neither ultrasound nor MRI revealed any vitreous abnormalities. The GRE image (Fig 7B) no longer showed a susceptibility effect.

**DISCUSSION**

The results from all three cases show that even though conventional T1- and T2-weighted spin-echo MRI could not identify vitreous hemorrhages (Fig 2), GRE MRI readily detected vitreous abnormalities that corresponded to vitreous hemorrhages, and the patterns of hemorrhages of various durations were distinctly different (Figs 3,5,7).

It is surprising that spin-echo MRI failed to show vitreous hemorrhages, especially since they can be readily discerned in experimental animal models. It is possible that the water-proton relaxation of long-standing hemorrhages is altered: The short T1 of fresh hemorrhages may have arisen from plasma-lipids, which are soon resorbed, leaving only the GRE-detectable boundaries between the blood products and the vitreous gel, and the paramagnetic susceptibility effect from ferrous ions released from hemoglobin.

In other words, MRI can detect vitreous hemorrhages...
and blood products. However, this information per se is no more useful than that obtained with B-scan ultrasound. Indeed, in the examination and follow up of diabetic vitreous hemorrhage, especially if total vitrectomy is contemplated, there is no compelling reason to choose MRI over ultrasonography. On the other hand, GRE MRI is quite sensitive in detecting vitreous hemorrhages. This may prove useful in situations where ultrasonographic differentiation between hemorrhages and other lesions is difficult, eg, in stage-5 retinopathy of prematurity, in which a precise definition of the extent of the hemorrhage may be crucial in determining the surgical prognosis.

REFERENCES