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LETTERS

MR Lesion Enhancement: Spin-Echo versus Gradient-Echo

We read with interest the two recent articles (1, 2) concerning the comparison of lesion enhancement between spin-echo and gradient-echo magnetic resonance scans. Although they both conclude that minimally enhancing lesions may be missed by a gradient-echo technique, one paper (1) seems to overstate dramatically the theoretical reasons for the clinically observed difference. The authors demonstrate an apparent theoretical superiority of a 600-millisecond repetition time (TR) scan over a 35-millisecond TR scan without allowing any consideration for the additional signal averaging that occurs in a three-dimensional short-TR scan. In fact, for equal scan times, a short TR provides optimal T1-weighted contrast-to-noise ratio, as shown by Buxton et al (3). Given this fact, the theoretical reason for the superiority of the spin-echo over a 3-D gradient-echo technique with similar scan time, as observed by the authors of the second paper (2), remains open to debate.

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Reply

Drs Crawley and Wallace raise a very important issue. Signal-to-noise ratio and contrast-to-noise ratio can differ considerably when one evaluates sequences of varying TR using either the constraint of a fixed number of excitations or a fixed total acquisition time. In our study, our intent was to explore the possible basis of a well-observed clinical phenomenon: less apparent gadolinium enhancement in some cases with T1-weighted spoiled gradient-echo than with T1 weighted spin-echo. We chose to perform our study using a fixed number of excitations for two reasons: First, it is more relevant to the clinical situation in which rapid 2-D gradient-echo imaging is substituted for conventional spin-echo and, second, the measured signal-to-noise ratio was found to be adequate for quantitating the contrast differences being evaluated.

The report by Buxton et al documents the fact that images of excellent T1 contrast can be obtained at short TR using an appropriate flip angle. However, it has also been shown that the enhancement response with gadolinium in the brain can vary with different magnetic resonance parameters. This has been demonstrated, for example, with changes in magnetic field strength and with application of magnetization transfer saturation pulses. Therefore, our study was designed to determine whether the dose-response curves for gadolinium varied for different spoiled gradient-echo sequence parameters when compared with T1-weighted spin-echo. Our results indicated that the slope of the signal change with increasing gadolinium concentration varied with spoiled gradient-echo parameters with a very short TR but was nearly identical with T1-weighted spin-echo when the TR and echo time parameters for both sequences were equal. We postulate that this may, in part, explain the observed decrease in enhancement that occurs with rapid clinical spoiled gradient-echo imaging. We do not feel that the results of our phantom experiments would be affected by comparing these same sequences with normalized acquisition times.

Chappell and colleagues looked at the same question using a different method. They concluded that part of the explanation for apparent decreased enhancement may be related to comparison of the enhancing lesion with surrounding background. They postulate that in the absence of edema, a pathologic lesion with long T1 may become nearly isointense to adjacent high-signal white matter, although no precontrast and postcontrast spoiled gradient-echo measurements were available. This is, however, partly supported by the graph in Figure 6B of our paper, which shows that enhancement (precontrast and postcontrast signal difference) of the lesion is nearly identical for spin-echo and spoiled gradient-echo in this particular patient, whereas the degree of contrast (signal difference between lesion and surrounding background tissue) is measurably reduced for the spoiled gradient-echo image.

In summary, decreased enhancement with rapid spoiled gradient-echo imaging is a documented clinical phenomenon. The studies by ourselves and Chappell et al have suggested some potential explanations. It is likely that more than one mechanism is occurring that accounts for this phenomenon. The results from these studies and the questions raised by Crawley and Wallace indicate that additional work is needed to characterize further the paramagnatic effects occurring with rapid spoiled gradient-

echo imaging. We thank Drs Crawley and Wallace for their comments, because such debate serves to focus the issues more clearly and stimulates further research.

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Guglielmi Coils in Ruptured Aneurysms

We read with interest and amusement the letter from Drs Scotti and Righi, "The Hypoteloric Happy Face Sign: A Misleading Indicator of Complete Aneurysm Closure with Guglielmi Detachable Coils," and the reply of Dr Guglielmi (1).

We strongly endorse the point made by Dr Guglielmi that the first and second coils are of critical importance in achieving a happy smiling face of the completely occluded aneurysm. In our experience the best occlusion is achieved when the first coils cover the neck of the aneurysm satisfactorily and the radius of the helix is well matched to the size of the aneurysm. The implication in Dr Guglielmi's letter is that only the small-gauge coils (0.010-in Tracker 10) should be used in previously ruptured aneurysms even if they exceed 8 mm in diameter, the maximum available size of the small gauge coils. Helix diameters of up to 14 mm are available in the Tracker 18 coils (0.015 in).

To date we have treated 74 patients within 6 weeks of subarachnoid hemorrhage with the Guglielmi detachable-coil device. Thirty patients were treated with Tracker 10 coils, and 44 were treated with Tracker 18 coils or a combination of the two.

We have seen two aneurysm perforations, and both of these occurred with Tracker 10 coils. In both cases, with continued treatment the leak stopped.

We have seen no perforations in the larger aneurysms treated with Tracker 18 coils. In aneurysms with a lumen diameter greater than 8 mm we prefer to use larger coils and therefore the Tracker 18 system, especially when there is a wide neck, to reduce the frequency of neck remnant (2).

We believe the use of Tracker 18 coils is safe in large ruptured aneurysms when they are carefully delivered and can produce a smile not only on the face of the aneurysm but also on that of the patient and the neuroradiologist.

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Reply

The letter from Drs Molyneux, Byrne, and Renowden is a valuable one in that it allows us to clarify several technical points of the Guglielmi detachable-coil technique.

(*a*) The Guglielmi detachable coils are soft enough not to rupture the fragile aneurysmal wall and stiff enough not to be taken by the flow and migrate out of the aneurysm. They are effective and safe if their physical properties remain within these two borders. Softness and stiffness have to be balanced in a delicate equilibrium. Every inclination toward excessive softness leads to coil migration (it is possible to see this phenomenon when using the first Guglielmi detachable coil number 10 in a wide-necked aneurysm; the tip of the Guglielmi detachable coil tends to exit the sac) and every inclination toward stiffness leads to possible aneurysm perforation. If we want the technique to be effective and safe, we must remain in this narrow path, lined by coil migration and aneurysm perforation. Balloons are too stiff and rupture aneurysms; plastics are too soft and migrate out of the aneurysm, at least before they harden.

(*b*) It is necessary to keep in mind that in a 4-mm aneurysm, for instance, a Guglielmi detachable coil number 10 with a 3-mm circular memory can exert more force and stress on the aneurysmal wall than a Guglielmi detachable coil number 10 or 18 with an 8-mm circular memory in a 9-mm aneurysm. This is because the area of physical contact between coil loop and aneurysm is larger in the large aneurysm, and therefore the force exerted per unit of surface is less. It is therefore not surprising that in the experience of Molyneux et al the two perforations occurred with the Guglielmi detachable coil number 10.

(*c*) It needs to be remembered that there are two kinds of number 18 Guglielmi detachable coils: those with a large circular memory (10, 12, and 14 mm) and those with a smaller circular memory (8 mm or less). The former are constructed with a platinum wire that is 0.004 in in diameter and are less soft. The latter are constructed with a 0.003-in platinum wire and are softer. Number 10 Guglielmi detachable coils, of course, are the softest; they are constructed with a 0.002-in platinum wire.

(*d*) It is in our plan to have a softer version of the Guglielmi detachable coil number 10, 2 and 3 mm in circular memory. All cases of perforation we are aware of occurred with number 10 Guglielmi detachable coils, 2 and 3 mm in circular memory. For these particular Guglielmi detachable coil we have probably leaned toward excessive stiffness, and we might have to construct these

particular number 10 Guglielmi detachable coils with platinum wires that have a diameter of 0.0015 in.

(*e*) In light of what has been pointed out, the letter from Molyneux et al seems perfectly logical. It is probably safe to use number 18 Guglielmi detachable coils (those with a circular memory of 8 mm or less) in previously ruptured large aneurysms, 15 or more days after subarachnoid hemorrhage. We consider that the acute phase of subarachnoid hemorrhage goes from day 0 to day 15. We do not know whether their 44 cases treated with number 18 Guglielmi detachable coils within 6 weeks of subarachnoid hemorrhage were treated before or after day 15.

(*f*) In acute aneurysms it is often possible to identify the "bleeding site" or "rupture point" or "bleb" on the diagnostic angiogram. In these cases, while delivering the Guglielmi detachable coils, it may happen that one or two or more loops "want" to enter the bleeding site. Under these circumstances, we prefer to withdraw part of the coil and reposition it in hope that it will not touch the "bleb" anymore. Unfortunately, this is not always the case, and then we feel much safer knowing that we are depositing in the bleeding site a Guglielmi detachable coil 10 rather than a Guglielmi detachable coil 18.

(*g*) In any event, it seems imperative to use only Guglielmi detachable coil 10 in small aneurysms, ruptured or unruptured.

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Stereoscopic MR Angiography

I read the letter from Drs Healy and Wong, "Application of Stereoscopic Viewing to Maximum Intensity Projection Images Obtained in MR Angiography" (1). I agree completely with their observations and conclusions. For those who are interested in more information on this topic, I would direct them to an article by Wentz et al (2) on the same subject, which was published in 1991.

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Subthalamus versus Substantia Nigra

I have read with interest the "Radiologic-Clinical Correlation" by Provenzale and Schwarzschild (1), which appeared in the August 1994 *AJNR*. The patient had right-sided hemiballism, and the magnetic resonance images shown in the figures indicated a toxoplasma abscess "in the left subthalamic region." Although I agree that the lesion was situated near the subthalamus and presumably involved the subthalamus itself, most of the lesion should be located in the substantia nigra. My argument is supported by their Figure 1, in which the lesion is in the midbrain level, too caudal for the subthalamus. The schemes in Figure 1B, D, and F are misleading, in that the subthalamus is incorrectly placed.

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Reply

We thank Dr Yamamoto for his interest in our article. The regions of normal anatomy, which have been marked as the subthalamic nucleus, are correct, judging from a number of standard neuroanatomic references used in preparation of the manuscript. Specifically, Figures 1A and B conform closely to Figure 154 in Duvernoy's *The Human Brain* (1) and Figure 11-14 in Carpenter's *Core Text of Neuroanatomy* (2), Figure 1C and D to the figure on page 111 in Schnitzlein and Murtagh's *Imaging Anatomy of the Head and Spine* (3), and Figures 1E and F to Figures 9-5 and 9-6 in Carpenter's textbook, which demonstrate that the subthalamic nucleus can be seen on the same axial image as the red nucleus, a midbrain structure. Based on these references, it is clear that the lesion encompasses the subthalamic nucleus. We agree with Dr Yamamoto that the lesion also involves adjacent structures such as the substantia nigra, as we have explicitly stated in the caption for Figures 1E and F.

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