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Use of gadolinium as an intraarterial contrast agent in digital subtraction angiography of the cervical carotid arteries and intracranial circulation

Technical note

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✓ Patients with renal insufficiency or other contraindications to iodine-based contrast agents present a significant management dilemma when conventional arteriography is required. The authors describe the use of gadolinium as an alternative contrast agent for arterial digital subtraction (DS) angiography of the cervical carotid arteries (CAs) and intracranial circulation.

Three patients with renal insufficiency presented with symptoms of ischemic cerebrovascular disease and inconclusive noninvasive imaging studies, which necessitated conventional angiography. Traditional transfemoral catheterization of the cervical CAs was performed and DS angiographic studies were obtained using gadolinium as an intraarterial contrast agent. In one case, selective arteriographic examination of the internal carotid arteries and vertebrobasilar system was performed as well. High-quality, diagnostic images essentially indistinguishable from routine angiographic studies were obtained in all cases. No patient suffered a complication related to the use of gadolinium, and no patient demonstrated worsened renal function after the procedure.

In the setting of a contraindication to iodine-based contrast agents, gadolinium represents an important alternative contrast material that allows for excellent visualization of the cervical CAs and intracranial circulation.

KEY WORDS • angiography • carotid artery • contrast medium • renal failure

ANGIOGRAPHIC evaluation of the CAs and cerebral vasculature is currently performed using iodine-based contrast media. This presents a significant problem for patients who require conventional angiography but have a major contraindication to the use of iodine-based contrast agents. It is estimated that 5 to 12% of individuals will have an allergic response to traditional contrast material.[2,5] In addition, those patients with borderline renal failure are at significant risk for worsening renal function following conventional angiography.[1,13]

In this report we describe our experience with three patients who underwent DS angiography of the CAs in which gadolinium was used as an intraarterial contrast agent. This important option should be considered in patients who require conventional angiography but who have a major contraindication to traditional contrast materials.

Cases and Methods

Three patients with mild renal failure (baseline serum creatinine levels of 2.8, 3.3, and 4.1 mg/dl) presented with hemispheric transient ischemic attacks and were initially evaluated using ultrasonography and MR angiography of the CAs. In two cases, there was a significant discrepancy between the ultrasound and MR angiography results. In the third case, MR angiography indicated the presence of a tandem stenosis of the petrous ICA, which was potentially more severe than the narrowing at the cervical CA bifurcation. In all cases, conventional angiography was deemed necessary to clarify the situation.

All patients underwent traditional transfemoral catheterization of the cervical CAs by using the Seldinger technique. A standard DS angiography technique with routine exposure parameters was used in all cases.[7] Contrast materials were injected by hand. Gadolinium-based contrast material (gadopentetate dimeglumine in two cases, gadodiamide in one case) was used as the sole intraarterial contrast agent in all cases.

Notably, the two patients being evaluated for atherosclerotic disease of the cervical CAs underwent bilateral common CA injections. The patient with the intracranial carotid stenosis underwent examination of both CAs and also the vertebrobasilar system to assess fully the collateral circulation.

Results

High-quality, diagnostic images were obtained in all cases. During contrast injection, it was noted that opacification was slightly less than that typically observed with standard contrast media, but the DS appeared to compen-

Abbreviations used in this paper: CA = carotid artery; DS = digital subtraction; ICA = internal CA; MR = magnetic resonance.

FIG. 1. Lateral right CA arteriogram *(left)* demonstrating occlusion of the ICA at the bifurcation. Comparable left common CA injection *(right)* demonstrating normal filling of the ICA.

sate for this. The radiographic results were comparable to those obtained during routine angiography in which traditional iodine-based contrast material was used (Figs. 1–4).

The total volume of contrast materials used in the three patients was 35 ml, 45 ml, and 65 ml, respectively. No patient suffered an adverse reaction to the gadolinium-based contrast agent, and no patient demonstrated worsened renal function after the procedure. One patient noted a sense of warmth during injection of the contrast agent.

Discussion

The limitations of iodine-based contrast agents in the

FIG. 2. Lateral view, selective injection of the right ICA, demonstrating an angiographic image comparable to that expected with traditional iodine-based contrast material.

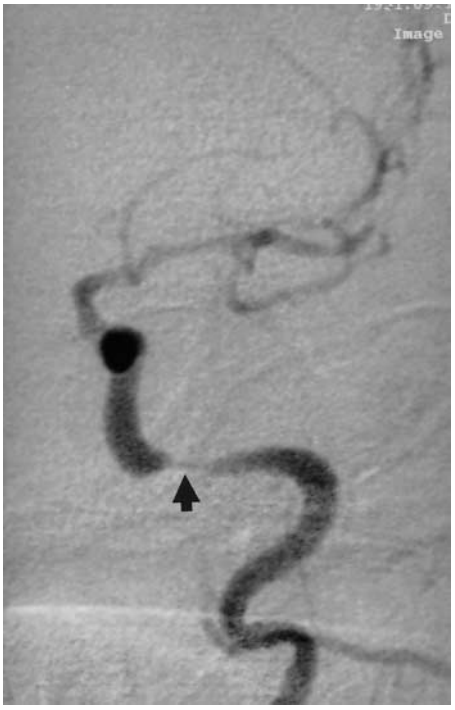

FIG. 3. Left CA arteriogram demonstrating a high-grade stenosis *(arrow)* of the petrous segment of the ICA.

arteriographic evaluation of the peripheral vascular system have been described previously.[1,4,6,9,12] In particular, a life-threatening allergic response may occur in up to 0.05% of the population, and the risk of a hypersensitivity reaction approaches 25% in those individuals with a history of contrast allergy.[1,5,6] Acute renal dysfunction following angiography has been reported to occur in 11% of patients with peripheral vascular disease and in 42% of patients with preexisting elevation of serum creatinine above 1.8 mg/dl.[1] The use of lower osmolar contrast agents and the avoidance of dehydration have decreased but not eliminated these risks, and for these reasons alternative contrast materials have been sought.[1,2,7]

Interestingly, carbon dioxide appears to be an excellent intraarterial contrast agent for the evaluation of the peripheral vasculature, particularly that of the lower extremities.[1] It is nonallergenic and lacks renal toxicity and therefore represents a nearly ideal contrast material. Unfortunately, the potential direct effects of carbon dioxide on the cerebral vasculature have restricted its use in the evaluation of the CAs.[1]

The use of gadolinium as an alternative to iodine-based contrast agents has also been described for angiographic examination of the peripheral vascular system.[3,4,8,9,13,14] Gadolinium has a higher atomic number than iodine, and its x-ray attenuation characteristics are such that good vascular opacification can be obtained when it is used with standard DS angiography techniques.[6] To our knowledge, there are only two reports of CA angiography with gadolinium contrast in the radiology literature, and most neurosurgeons have not yet become aware of this option.[4,7]

Safety of Gadolinium

The safety of gadolinium as an intravenous contrast

FIG. 4. Anteroposterior vertebral artery arteriogram demonstrating the incidental finding of an arteriovenous malformation *(arrow)*.

agent has been well established.[10–12] The rate of anaphylaxis following gadolinium administration reportedly ranges from 0.0003 to 0.01%, with the majority of adverse reactions being mild and consisting only of nausea, vomiting, or skin irritation.[10] In addition, gadolinium does not appear to cause contrast-induced renal failure even in patients with preexisting renal insufficiency.[6,7,13]

For comparison, during gadolinium-enhanced MR angiography, a total contrast dose of 0.1 to 0.3 mmol/kg is typically administered, and doses up to 0.4 mmol/kg (0.8 ml/kg) are safe and well tolerated in patients with normal or abnormal renal function.[6,7,13] Therefore, a total contrast volume of 40 to 70 ml is safe for most adults. Because of the relatively small amount of contrast material required for DS angiography of the CAs, 0.3 to 0.4 mmol/kg of gadolinium appears to be an adequate dose to properly evaluate the CAs in most adults. In all of our cases, the amount of contrast material used was within the reportedly safe range. It should be noted, however, that it may be difficult to perform a complete examination if multiple projections are required in particularly complex situations or if the anatomy is extremely complicated, which would necessitate multiple images to allow successful catheterization of the involved vasculature.

Limitations of the Study

In this study we describe our experience with three patients who underwent DS angiography of the cervical CAs or intracranial circulation with gadolinium as an intraarterial contrast agent. Our preliminary impression based on these cases and also from a review of the literature is that gadolinium is an important alternative to iodine-based contrast agents and deserves further evaluation. Obviously, this experience will have to be expanded before definitive conclusions regarding safety and efficacy can be established. Nevertheless, we believed it was important to alert others to what appears to be a very reasonable option for selected patients with contraindications to iodine-based contrast media who require CA or cerebral angiography. Finally, in this study we do not address the additional cost associated with the use of gadolinium, which ideally should not be a factor if gadolinium is a significantly safer option for the patient in this setting.

Conclusions

We describe the successful use of gadolinium as an alternative intraarterial contrast agent for DS angiography of the CAs and intracranial circulation. This represents an important option for patients with contraindications to traditional, iodine-based contrast agents who require angiography.

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