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Commentary

The Neuroradiologist Goes to the Operating Room

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The articles in this issue of the *AJNR* that describe a tabletop extension to facilitate intraoperative angiography [1] and a portable CT scanner [2] allude to important changes occurring within neuroradiology. As diagnostic neuroangiography evolves, it quickly is becoming apparent that the complexity of the angiograms we now do has increased dramatically. Intraoperative angiography represents the tip of the iceberg. In addition to this, we now do test occlusions of extra- and intracranial vessels, and with the advent of the variable-stiffness microcatheter, superselective diagnostic angiograms are performed routinely on intracranial vessels. In many cases, amobarbital (Amytal) is injected selectively into intracranial vessels to better define eloquent areas within the brain. These changes have occurred over the last 4 to 5 years, but they have received little publicity because they have been performed primarily by interventional neuroradiologists. Until now, interventionalists have focused primarily on advances in embolization and have considered these diagnostic advances to represent another facet of the embolization technique. However, as we are beginning to see, these complex diagnostic procedures are becoming essential to ensure the safety of neurosurgical procedures.

Hieshima et al. [3] described intraoperative digital subtraction neuroangiography in 1987. Since then, considerable interest has been generated within the neurosurgical community by Martin, who was quick to realize the value of this technique in the treatment of vascular lesions within the brain [4]. This technique has been made possible by the development of the portable digital angiographic C-arm (OEC-Diasonis, Salt Lake City, UT), the radiolucent operating room table (Skytron, Grand Rapids, MI), and the radiolucent neurosurgical head holder (Malcom-Rand Cranio-X-ray Frame, Storz, St. Louis, MO). The technique is simple. A sheath is placed in the patient's femoral artery in the operating room. This remains in place throughout the procedure. Once the vascular lesion is exposed, and angiography is desired, then routine transfemoral selective catherization of the appropriate vessel is performed. High-resolution digital angiograms are then obtained.

In the series of 105 intraoperative angiograms reported by Martin et al. [4], surgical technique was improved in 10 cases. In five of 57 aneurysms, the clip was repositioned after intraoperative angiography, and in five of 48 arteriovenous malformations (AVMs), the angiogram showed residual nidus that then was located and resected. In this series, complications included one small stroke due to a cerebral embolus that caused mild aphasia and hemiparesis and, in another patient, a femoral artery thrombosis caused lower-extremity ischemia. It remains to be seen if this technique decreases the morbidity and mortality associated with surgical treatment of aneurysms and AVMs.

Another technique that is used more and more is the temporary test occlusion of vessels. In such instances, a temporary occlusion balloon is placed in the vessel in question. The patient undergoes neurologic testing and receives heparin. The balloon then is inflated, and neurologic testing is repeated over the next 20–30 min. This technique long has been used by interventionalists before occlusion of major vessels, but now it is being requested by surgeons in situations in which they may have to sacrifice the artery at surgery. The surgeons obviously find it useful to know if it will be safe to resect the vessel. Head and neck surgeons find test

This article is a commentary on the preceding articles by Hecht et al. and Okudera et al.

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occlusions of the carotid particularly valuable. Test occlusions have become more selective. My colleagues and I recently performed one on a middle cerebral artery just proximal to a fusiform aneurysm in a case in which clipping of the parent middle cerebral artery was one alternative being considered during surgery. The patient tolerated temporary occlusion of the middle cerebral artery, and the artery was clipped safely at surgery. Intraoperative temporary carotid occlusion also is performed occasionally. This can be used to facilitate surgical clipping of large complex aneurysms and serves as a form of proximal control in case the aneurysm ruptures during surgical manipulation.

Superselective intracranial angiography is also useful in the evaluation of complex vascular lesions. Injections can be performed directly adjacent to the neck of an aneurysm to define the aneurysm better. Obscure lesions in the posterior fossa can be delineated better after selective angiography of the superior cerebellar and posterior inferior cerebellar arteries. Selective injections of amobarbital into normal vessels near AVMs and tumors can help define eloquent areas that pertain to speech and motor function [5]. Superselective injections of amobarbital are now used routinely at the University of Washington in the pretreatment diagnostic evaluation of AVMs.

In addition to these angiographic techniques, other intraoperative diagnostic techniques continue to be developed. In particular, intraoperative CT soon may become feasible because of the reduction in the size and price of these units [2]. Intraoperative CT promises to be a valuable adjunct in the surgical management of complex brain tumors.

The demand for more complex diagnostic techniques will continue to grow. Neuroradiologists who do not perform embolization procedures should become competent in some of the more challenging diagnostic techniques. These techniques are logical extensions of what neuroradiologists already do well, and they have great potential benefits for the patient and the surgeon.

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