Editorial

Intraoperative angiography

ROBERTO C. HEROS, M.D.

Department of Neurological Surgery, University of Miami, Florida

In these two excellent articles the authors report prospectively accumulated data that they have used to evaluate the impact of routine intraoperative angiography in aneurysm surgery. It should be emphasized that both studies were conducted at institutions that have excellent reputations for aneurysm surgery and that all the operations were performed by experienced neurovascular surgeons. In this context, the finding that a high proportion (12.4% in the Emory study and 11% in the one from Johns Hopkins) of all initial intraoperative angiograms revealed a less than perfect technical result is striking. Incidentally, these rates of imperfect immediate results on the initial intraoperative angiograms are very similar to those reported in smaller series from other centers of excellence in aneurysm surgery. The imperfect result was due to residual aneurysm and/or compromise of either the parent artery or one of its branches in the majority of cases.

Not surprisingly, aneurysm size was the most important factor associated with unsatisfactory clipping. Also not surprisingly, aneurysms in the paraclinoidal region were more frequently associated with imperfect initial results. In the Emory series, there was an important breakdown of these aneurysms into those originating from the clinoidal segment, the origin of the superior hypophyseal artery (SHA), and the origin of the ophthalmic artery (OphA). The OphA aneurysms had a rate of unsatisfactory clipping that was not very different from aneurysms located elsewhere; however, the clinoidal and SHA aneurysms had a much higher rate of imperfect initial clipping. Any experienced neurosurgeon will readily appreciate the difficulty in clipping these aneurysms of the clinoidal segment and the superior hypophyseal region, where, in contrast with aneurysms in the origin of the OphA, the neck of the lesion frequently arises in close relationship to the fibrous external ring and the aneurysm can project partially into the cavernous sinus and partially above it, making complete clipping very difficult. It should be noted, however, that in contrast with the findings of the Emory group, the Johns Hopkins group identified a significant number of problems with OphA aneurysms. It is possible that some of the aneurysms listed as ophthalmic may have actually originated from the clinoidal segment or the superior hypophyseal region, because there is considerable overlap in these locations, particularly with regard to aneurysms with a relatively broad base (in the Johns Hopkins series, there was only one aneurysm listed as arising from the SHA, and none arose from the clinoidal segment).

These two groups of investigators have truly perfected the use of intraoperative angiography to such a degree that they had only a 0.3 to 0.4% incidence of serious neurological complications directly attributable to the use of the procedure, and intraoperative angiography added only approximately 20 minutes to the operative time. In addition, their technique was obviously very accurate: in the group of patients who underwent both intraoperative and postoperative angiography there were only a few discrepancies between the two studies. Clearly, at institutions where intraoperative angiography can be performed with this degree of efficiency and effectiveness, it would be hard to argue against its routine use. Unquestionably, however, there is a learning curve, and it is unlikely that this degree of efficiency can be achieved rapidly, particularly at institutions where there is a lower volume of aneurysm surgery. It is clear that at both institutions, intraoperative angiography was performed frequently before the technique became routine, and in these two reports the authors describe the experience at both institutions only from the time when they began to use intraoperative angiography routinely in all cases of aneurysm surgery. I suspect that they began to use the procedure routinely only after they had gone through their learning curve.

The important challenge that these articles present to the neurosurgical community is that, although it is not explicitly stated, they may support the conclusion that routine use of intraoperative angiography should be the standard of care in aneurysm surgery. This has certainly happened, as the authors clearly state, at their institutions. Also, as I suggested earlier, given the results presented, it would be hard to argue against the use of routine intraoperative angiography for aneurysm surgery at institutions where the technique has been perfected to the degree that it has at these two. One could argue that intraoperative angiography is not necessary for straightforward aneurysms such as small lesions of the supraclinoidal segment of the internal carotid artery, the middle cerebral artery, and the anterior communicating artery complex. In both series, however, there was still a significant percentage of problems, even with small aneurysms in those locations.

I have argued before, as is discussed and referenced in the paper from the Emory group, that it is likely, although impossible to prove, that when a surgeon is not planning, for whatever reason, to obtain an intraoperative angiogram, he or she is likely to devote extra effort to ensuring that the clipping is as perfect as it can possibly be, and that therefore, the rate of imperfect clipping may be lower in such
cases. I still believe that this is a valid argument, although in both papers the authors make a good point in their rebuttals by quoting from other series published by experienced groups, in which intraoperative angiography was not used and routine postoperative angiography revealed an incidence of imperfect clipping very similar to that found at Emory and Johns Hopkins after intraoperative angiography. Still, I cannot help but be struck by my own experience with arteriovenous malformation (AVM) surgery, in which I now routinely use intraoperative angiography in all but the most straightforward, superficial AVMs. Before intraoperative angiography was available, I would spend a significant amount of time ensuring that there was no residual AVM by methods such as rubbing the resection bed with a cottonoid to try to create new bleeding, raising the patient’s blood pressure significantly and observing the field for a long period of time, and so forth. In my initial report on 153 AVMs treated before intraoperative angiography was available, there was only one patient in whom a residual nidus was found on postoperative angiography. In the last several years, since I have begun to use intraoperative angiography, I have found a significant number of patients in whom residual AVMs were observed on the initial intraoperative angiogram. I can only conclude from this experience that I am being less compulsive in ensuring that there is no residual nidus before obtaining the intraoperative angiogram, trusting that the latter will reveal a problem if there is one. I would be surprised if this attitude did not also apply to aneurysm surgery and to other surgeons.

In summary, the authors of these two studies have demonstrated that intraoperative angiography is a very valuable technique that should be used routinely for aneurysm surgery in institutions where it can be used as efficiently and effectively as in their own. With these reports, they have also encouraged those of us who only use intraoperative angiography selectively to use it more and more frequently, which is the only way to approximate the degree of efficiency with this technique that these authors have achieved. Unquestionably, to be used routinely the technique requires major logistical support, which can be very expensive. Clearly, the additional operating time will be considerably longer than 20 minutes in most hospitals, and it is a rare institution in which there is the technical support and a neuroradiologist available to come to the operating room immediately whenever the neurosurgeon is ready. Given these logistical impediments, which surely cannot be disregarded, it would be absurd to demand the routine use of intraoperative angiography as a standard of care at all centers and by all surgeons who treat aneurysms. Likewise, in my opinion, it would be very wrong to hold neurosurgeons liable for not having used intraoperative angiography in cases in which, despite doing their best to treat an aneurysm operatively, there were adverse outcomes. I am sure that the authors of these two excellent papers will strongly agree with me in this respect.

Reference

RESPONSE: We thank Dr. Heros for his thoughtful comments on our publication. Like him, we were somewhat surprised that imperfect results were identified on routine intraoperative angiography in 12.4% of our cases. We do not disagree with Dr. Heros’ hypothesis that the routine use of this modality may artificially elevate the incidence of imperfect findings because the surgeon may rely on the intraoperative angiogram instead of devoting extra efforts to ensure that the clipping is as ideal as it can be. As pointed out by Dr. Heros, this phenomenon may be more applicable to surgery for AVMs, in which more aggressive resection of perinidal tissue may be performed in the absence of intraoperative angiography, whereas the surgeon who routinely uses this modality may limit the dissection and resection at an earlier stage to avoid potential injury to normal vasculature or normal perinidal tissue.

Ultimately, our primary objective is to accomplish the goals of the neurovascular procedure and to minimize risks to the patient. If intraoperative angiography assists in the clinical decision-making process and prevents some complications that might have resulted from additional manipulation and/or dissection, the rate of imperfect results identified on these images is irrelevant. This study was not designed to demonstrate improved outcomes with the use of intraoperative angiography, and it is impossible to determine if the 12.4% of patients in whom the images demonstrated less than perfect results fared better as a result of the use of this modality. We believe they did.

Dr. Heros has raised the very important issue of the standard of care for aneurysm surgery. We are by no means advancing a position that intraoperative angiography must be used to meet the standard of care for aneurysm surgery. We do believe, however, that with the development of new technology and a better understanding of the disease process, the bar has been raised for the management of patients with intracranial aneurysms. All neurosurgeons caring for patients with these lesions should use, to the best of their ability, the technological advances in neurosurgery, interventional neuroradiology, and neurological critical care to lower the morbidity and mortality rates associated with the management of patients with intracranial aneurysms.

RESPONSE: We appreciate Dr. Heros’ thoughtful comments on our publication. Like him, we were somewhat surprised that imperfect results were identified on routine intraoperative angiography in 12.4% of our cases. We do not disagree with Dr. Heros’ hypothesis that the routine use of this modality may artificially elevate the incidence of imperfect findings because the surgeon may rely on the intraoperative angiogram instead of devoting extra efforts to ensure that the clipping is as ideal as it can be. As pointed out by Dr. Heros, this phenomenon may be more applicable to surgery for AVMs, in which more aggressive resection of perinidal tissue may be performed in the absence of intraoperative angiography, whereas the surgeon who routinely uses this modality may limit the dissection and resection at an earlier stage to avoid potential injury to normal vasculature or normal perinidal tissue.

Ultimately, our primary objective is to accomplish the goals of the neurovascular procedure and to minimize risks to the patient. If intraoperative angiography assists in the clinical decision-making process and prevents some complications that might have resulted from additional manipulation and/or dissection, the rate of imperfect results identified on these images is irrelevant. This study was not designed to demonstrate improved outcomes with the use of intraoperative angiography, and it is impossible to determine if the 12.4% of patients in whom the images demonstrated less than perfect results fared better as a result of the use of this modality. We believe they did.

Dr. Heros has raised the very important issue of the standard of care for aneurysm surgery. We are by no means advancing a position that intraoperative angiography must be used to meet the standard of care for aneurysm surgery. We do believe, however, that with the development of new technology and a better understanding of the disease process, the bar has been raised for the management of patients with intracranial aneurysms. All neurosurgeons caring for patients with these lesions should use, to the best of their ability, the technological advances in neurosurgery, interventional neuroradiology, and neurological critical care to lower the morbidity and mortality rates associated with the management of patients with intracranial aneurysms.