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Neurologic Complications of Cerebral Angiography

Trygve O. Gabrielsen

One might dismiss the article in this issue by Heiserman et al (1) on neurologic complications of cerebral angiography by arguing that it brings nothing new to the medical literature. Especially those of us who are quite senior neuroradiologists are familiar with the kinds of findings reported in this paper. The article reports a number of positive and negative correlations of neurologic complications with certain variables, agreeing with some and also disagreeing with some previously reported correlations, again consistent with the lack of complete agreement between earlier publications.

However, I am pleased to see this article published in *AJNR* for a combination of reasons: (a) The subject matter is very important. (b) Scientific knowledge needs to be reevaluated by different investigators and under different circumstances, especially if previous results have been at variance. (c) This is a prospective study involving an unusually large number of studies performed during a relatively short period, considering current patterns of practice. Most previous, similar articles are retrospective studies, and most are from a different era. (d) These are "new times," with a different mix of patients and generally higher degrees of risk factors among patients referred for cerebral angiography. This article should serve as a timely reminder of some of the problems involved in performing cerebral angiography at present.

By coincidence, I was given the opportunity to read the manuscript for this article about 2 weeks after faculty members and fellows in our Division of Neuroradiology had reviewed the complications of cerebral angiographies done by us during the previous year. This was part of a quality control program, which forced us to look more closely, collectively, and more formally at our results than we have done in the past. Having grown to a much larger section

gradually, it now is much more difficult to keep track of how and what our colleagues are doing and how we are performing as a whole in the section. It was not a pleasant experience for me, remembering a different era that predates the experience of most colleagues. I can easily imagine similar reviews going on in other departments, especially given the present medical "climate" of quality control.

I am impressed that the authors of the present article performed 1000 cerebral angiographies in only 15 months, no doubt a rather infrequent situation in the United States today. I wonder what the complication rate might be in departments performing only about 100 such examinations yearly, especially if distributed among the same number of neuroradiologists and fellows. Most of all, I wonder what the complication rates may be in departments not reporting and/or unwilling to publish their complication rates, perhaps for fear of scrutiny and criticism by colleagues. *I suspect that the present neurologic complication rate of cerebral angiography in many institutions may be significantly higher than most published studies indicate.*

I promptly reviewed the articles by Mani et al (2) and Mani and Eisenberg (3, 4), with their analyses of 5000 angiographies from the early computed tomography (CT) era. Without undertaking any formal tabulation of our results and patient demographics some 25 years ago, it was my impression that our experience was similar. At that time, we had two neuroradiology faculty members and two neuroradiology fellows, one in the first and another in the second year of training. The year before we obtained our first CT unit, we performed cerebral angiographies on about 850 patients. Lately, we have had two to three times as many fellows who *usually* have been closely supervised by three to four times as many faculty members, but

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performing only (almost exactly) half as many diagnostic cerebral angiographies yearly (not including nearly 100 interventional neuroangiographic procedures and about 150 additional, diagnostic angiographies at our affiliated Veterans Administration Medical Center).

I have been very concerned that we now have a more basic "training hospital situation" throughout virtually the entire year, junior faculty members with less angiographic experience than prevailed 15 to 20 years ago, and even senior, experienced neuroangiographers becoming rusty. Different angiographic techniques and practices by our different faculty members also may be confusing to the neuroradiology fellows, especially during their early months of training. Even so, I am convinced that we perform more cerebral angiographies and offer far more such experience to our neuroradiology fellows than do most academic institutions. However, I wonder whether we ought to establish and enforce greater adherence to certain locally agreed-on, written guidelines for neuroangiographic procedures, including techniques such as volumes and rates of contrast injections.

Although most previous authors, as well as Heiserman et al, have not noted any correlation between neurologic complications and level of angiographic experience, McIvor et al (5) did find this to be the case. I suspect that level of experience may not be such an important issue in departments with a large volume of cerebral angiographies, where all persons performing such examinations are likely both to be quite experienced and to have the opportunity to maintain their expertise. I also suspect that the opposite situation may prevail in some departments with a low volume of cerebral angiographies, although such a situation may cause an overall low level of experience and quality of performance, so that *individual* differences in performance may not be readily apparent if neurologic complications are analyzed with respect to either level of angiographic experience or individual angiographers within such a department.

Although quite a few reports have included correlations between neurologic complications and level of angiographic experience, reports of correlations between neurologic complications and *individual* angiographers are remarkably scarce. Is this considered information too "sensitive" to publish, and are we too protective of each other, even to the detriment of our patients? I urge that such potentially painful anal-

yses be made and preferably also published provided that the identity of individual angiographers could be kept confidential. I suspect that sometimes improved quality neuroangiography would result, provided proper corrective actions were taken based on such analyses.

Mani and Eisenberg (3) found a nearly four-fold greater complication rate in training hospitals compared with nontraining hospitals, which they attributed to (and statistically correctly correlated with) level of angiographic experience. However, 2112 (50%) of their 4224 angiographies done in nontraining hospitals and 195 (23%) of their 827 angiographies done in training hospitals were reported as normal. As suggested by Earnest et al (6), this may have affected the complication rate. We now certainly have a much smaller percentage of normal angiographies, even compared with their training hospital cohort. This is no doubt largely attributable to the subsequent impact of magnetic resonance (MR) as well as interim increased influence of CT.

When Heiserman et al analyzed the group of patients who suffered complications, comparing the stroke/transient ischemic attack subgroup to the complete sample, the difference in average age was statistically significant ($P = .02$), with a higher age for the stroke/transient ischemic attack group. All neurologic complications occurred in patients older than 50 years. Occurrence of neurologic complications also was significantly correlated with complete occlusion or greater than 70% stenosis by North American Symptomatic Carotid Endarterectomy Trial criteria (7).

I found it interesting that all the neurologic complications reported by Heiserman et al occurred in the subgroup of patients referred for transient ischemic attack/stroke and related problems. Likewise, all but one of the permanent as well as transient neurologic complications in our own institution during the last year involved exactly the same subgroup, with the addition of patients referred because of recent, spontaneous intracranial (three subarachnoid, one intraparenchymal) hemorrhages. I am somewhat embarrassed to admit that, unfortunately, *our less formal study showed a neurologic complication rate approximately twice as great as that reported in the present manuscript*. However, I believe that there is a very important difference between their patients and ours. There was a subgroup of 322 cerebral angiog-

raphies done on patients examined for transient ischemic attack/stroke in their total of 1000 examinations, whereas that subgroup in our own institution is almost certainly more than twice as large when expressed as a percentage of our total cerebral angiographies. We have the impression that *at least 70% of our patients examined by cerebral angiography belong to their high-risk group*, if cases of recent spontaneous intracranial hemorrhage also are included. Our higher rates of neurologic complications probably can be explained, and probably even can be expected, on this basis. Nevertheless, complications always disturb me, especially if they are serious and permanent, even if their incidence is low.

I also have the definite impression that many of the transient ischemic attack/stroke patients undergoing cerebral angiographies in our hospital now are demonstrating more severe cerebrovascular and other vascular disease than we encountered 15 to 20 years ago. Disease states always have reflected the referral nature of our institution, but I believe that greater sophistication by referring physicians outside our institution has enabled them to care for patients with increasingly difficult cases. I suspect that our complication rate probably would be even higher now if we did not have the benefit of improved catheterization techniques and advantages of technical advances that have given us better catheters, guidewires, contrast agents, digital subtraction angiography, etc.

Heiserman et al state that there was a temporal association of their neurologic complications with a selective contrast injection in four cases, three of them involving either the left vertebral or left subclavian artery. Because the number of such complications was small, this was only marginally significant statistically. Most of their vertebral angiographies were selective vertebral angiographies, even in the stroke/transient ischemic attack subgroup.

I almost always have found it adequate to perform subclavian, as opposed to selective vertebral, artery injections for angiographic evaluation of stroke/transient ischemic attack. I always have believed, admittedly without any documented personal proof, that selective vertebral artery injections in elderly and/or stroke/transient ischemic attack patients are associated with increased risk. If there is some vertebral artery stenosis already not always readily recognized during angiography, catheterization of such an

artery may compromise flow in an artery that may have had preexisting reduced flow and prolong further, perhaps critically, the duration of brain/contrast exposure. Furthermore, I generally have used (and found sufficient) significantly smaller contrast injections than those used by Heiserman et al for all selective injections, again for fear of increasing the brain/contrast exposure. Several of my local colleagues do use volumes similar to those used by Heiserman et al, and I must confess that I have no definite proof that there is any increased risk in doing so, although the concept (and finding) of increased risk with increased contrast volume certainly is not new. Satisfactory subclavian artery injections may require slightly larger catheters than selective vertebral angiography, but I am happy to trade the possible risk of getting a few more small groin hematomas (usually avoided with proper and somewhat longer local compression after catheter removal) for a possible decrease in neurologic complications.

Four of the five persistent neurologic deficits and two of the five transient deficits reported by Heiserman et al occurred *after* the completion of the angiographies. Hypovolemia related to the contrast agent was postulated as a possible cause. I also wonder whether relative hypotension with decreased cerebral perfusion in patients with cerebrovascular disease may have played a role. *Close monitoring of blood pressure is warranted not only during but also after angiography.* However, I suspect that often this is done in a lax manner after the patient is returned to the ward. It is even more worrisome to me that this is not done at all after a patient is allowed to go home on the day of angiography.

As pointed out by Heiserman et al and quoting Dion et al (8), it is likely that at least some of the delayed neurologic complications ascribed to cerebral angiography represent part of the natural history of the underlying disease. I often have pondered the indisputable fact that patients tend to present for cerebral angiography because of new symptoms and/or aggravation of symptoms and/or increased frequency of symptoms. What is the statistical probability that 100 such patients would suffer neurologic deterioration during any 24-hour period, given such circumstances, if cerebral angiography were *not* done? It seems to me that this is a situation statistically "programmed" for a certain number of neurologic "complications" of angiography (ie, a "set-up"). *The neurologic complication rate would not be zero even if*

"perfectly safe" angiography could be performed (1, 9).

Some of the patients at greatest risk may have the most to gain diagnostically by undergoing cerebral angiography (10). On the other hand, as Huckman et al (11) pointed out in 1979, the complication rate of cerebral angiography may be influenced (decreased) by the use of CT as an *alternative study* in gravely ill patients. Now we have the additional capabilities and influences of MR, MR angiography, and better ultrasound studies to consider (12). *I am convinced that the net result is an increasingly select group of patients undergoing conventional and/or digital subtraction angiography cerebral angiography, undoubtedly representing an increasingly high-risk group.*

Yes, I do think that these are "new times." Some of the complications we undoubtedly will not be able to avoid, but others we almost certainly ought to be able to avoid, at least part of the time. I am willing to say without fear of contradiction that the "human factor," with its multiple ramifications, is an extremely important issue, although difficult to measure. I feel strongly that we should be consciously vigilant to exercise great care and caution during cerebral angiographies and keep reminding ourselves and our colleagues and trainees of this frequently. Such zealotry should include careful *preangiographic* problem analysis and planning (which may be difficult with outpatient angiography) and attention to detail as well as avoidance of distraction such as a noisy, cavalier atmosphere in the adjacent control booth *during* the examination. These may be significant factors that cannot be readily assessed. Nevertheless, *I suspect that our attitudes toward cerebral angiography and its performance may be as important as anything else in preventing complications.* A healthy respect, even a somewhat fearful state of mind, will tend to foster attentiveness to every aspect of the angiographic procedure, regardless of individual differences of opinion regarding techniques, and will encourage critical reviews of our habits and practices.

I believe that periodic, close reexaminations of our practices are useful reminders of what is at stake, and they may disclose correctable problems. An awareness (and acknowledgment) of an existing problem usually is a prerequisite for its solution. If we acknowledge that these are new times and that at least some of the problems I have discussed are real, we prob-

ably should make more certain than ever that: (a) *performance of cerebral angiography has a reasonable prospect of significantly influencing the course of clinical management, as determined by an appropriately expert clinician, sometimes only after personal consultation with an experienced neuroangiographer in a spirit of mutual respect,* and (b) *the angiography is performed in as safe a way as possible by, or under the direct and close supervision of, a highly experienced neuroangiographer.* As the number of conventional cerebral angiographies is decreasing, I believe that it is becoming increasingly important to limit the number of physicians performing such examinations to only a few, well-qualified neuroangiographers. Would we ourselves want anything less, if we were patients in need of cerebral angiography?

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