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Limited Usefulness of Aortic Arch Angiography in the Evaluation of Carotid Occlusive Disease

Steven J. Goldstein[1]
Andrew M. Fried[1]
Byron Young[2]
Phillip A. Tibbs[2]

The role of aortic arch angiography in the evaluation of cerebral ischemic disease is not well defined. In an attempt to develop guidelines for its optimal use, a prospective study of 100 patients with carotid distribution ischemic events was undertaken. Each patient underwent bilateral selective carotid angiography followed by arch aortography. In only two of the cases did the arch examination affect patient management. In the other individuals, the arch study either added no clinically useful information (69), or demonstrated abnormalities that did not affect patient care (29). The findings of this study support the use of arch aortography only in those patients who have surgical lesions demonstrated by the selective carotid examinations.

Cerebrovascular disease is a major cause of disability and the third leading cause of death in the United States today [1]. Rational therapy for the patient with cerebral ischemia is predicated on the accurate evaluation of the underlying pathologic vascular anatomy. Although the various noninvasive procedures available such as opththalmodynamometry, Doppler sonography, and high resolution real-time scanning provide useful screening techniques, cerebral angiography remains the procedure of choice to delineate most accurately the vascular anatomy in most patients with cerebrovascular disease [2].

Unfortunately, the angiographic evaluation of the individual with symptomatic cerebrovascular disease carries a small but definite risk of permanent neurologic injury [3–5]. Consequently, there is considerable controversy regarding the safest and most efficient method of performing cervicocranial angiography in this group of high risk patients. While the necessity for selective bilateral carotid angiography is well established [3, 5, 6], the role of arch aortography remains unsettled. Some radiologists advocate the use of aortography on a routine basis [7–10] while others use it only in certain well defined circumstances [5, 6, 11, 12]. To the best of our knowledge, there has been no prospective study designed to examine the role and value of arch aortography in the patient with symptomatic carotid territory cerebral ischemia. In an attempt to develop guidelines for the optimal use of aortography, we prospectively examined its role in the mangement of 100 patients clinically suspected of having cerebrovascular disease who were referred to our service for cervicocranial angiography.

Subjects and Methods

Between April 25, 1980 and January 13, 1981, 100 patients underwent cerebral angiography because of clinically suspected carotid territory cerebral ischemia: 88 had neurologic deficit (hemiparesis, hemisensory deficit, aphasia, amaurosis fugax) resolving within 24 hr; 10 had mild or improving neurologic deficit lasting more than 24 hr; and two were candidates for major surgical procedures who had asymptomatic bruit. All patients with any symptoms referable to the vertebrobasilar system were excluded from the study. The population consisted of 62 men and 38 women aged 18–83 years (mean, 60.8). (Three patients were under 40 years of age. In each of these individuals, arteriography was

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[1]Department of Diagnostic Radiology, University of Kentucky School of Medicine, 800 Rose St., Lexington, KY 40536. Address reprint requests to S. J. Goldstein.

[2]Department of Surgery, Division of Neurosurgery, University of Kentucky School of Medicine, Lexington, KY 40536.

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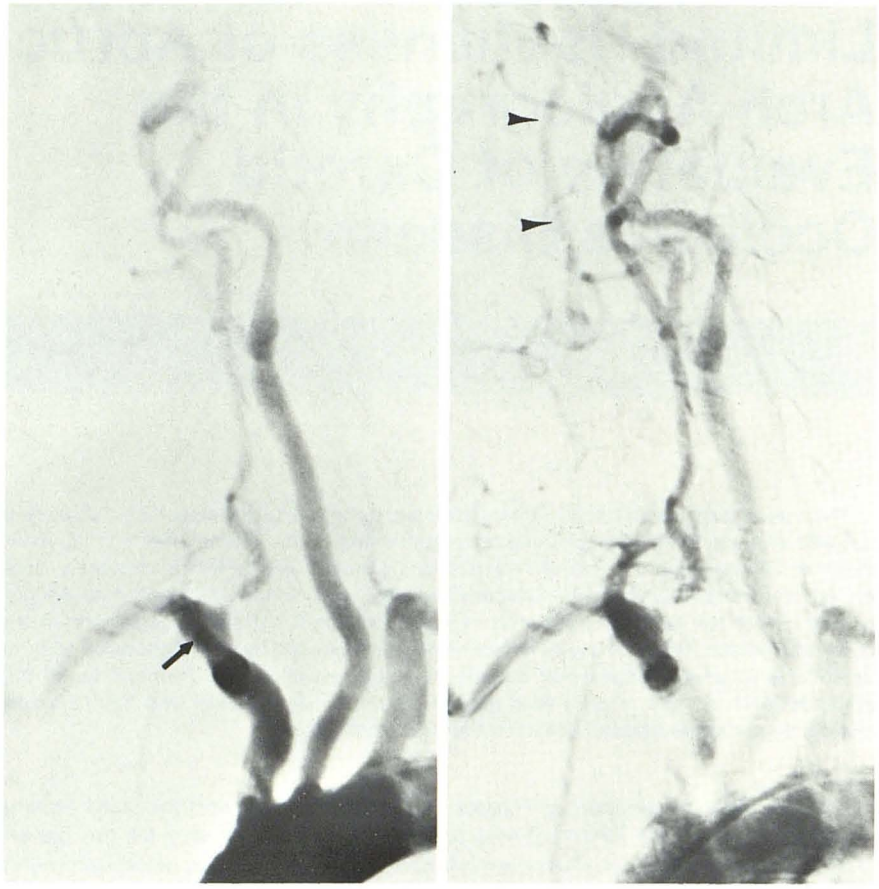


Fig. 1.—Common carotid occlusion. **A**, Early phase of arch study. Filling of only most proximal part of the occluded right common carotid artery (*arrow*). **B**, 2 sec later. Opacification of right internal carotid artery (*arrowheads*) via collateral branches from both right vertebral artery and thyrocervical trunk.

performed to rule out nonathrerosclerotic causes of cerebral ischemia such as vasculitis or fibromuscular dysplasia). Before angiography, cranial computed tomography was performed to rule out an unsuspected intracranial mass lesion as the etiology of the patients' symptoms.

In each patient a sequence of five angiographic injections was performed using biplane × 1.5 magnification technique. The symptomatic carotid artery was selectively catheterized and the patient fluoroscopically positioned for optimal demonstration of the common carotid bifurcations. An injection was then performed with filming of the neck followed by a second injection with filming of the intracranial circulation in the standard anteroposterior and lateral views. The same procedure was repeated on the contralateral side. To complete the examination biplane, nonmagnified arch aortography was performed with the patient in the 45° right posterior oblique position.

Number 5 French polyethylene catheters were used whenever possible for selective studies performed via the femoral route. In 19 patients 6.5 French catheters were required for the selective catheterizations because of excessive tortuosity of the brachiocephalic vessels. In seven individuals a right axillary artery approach was necessary because of severe aortofemoral artery disease. These studies were also performed with 6.5 French catheters. A 6.4 French Teflon pigtail catheter was used for the aortic injections of the first four patients in the study. Because of technical difficulties described below, this catheter was replaced with a 7.1 French polyethylene catheter in the remaining 96 examinations. In most patients 8, 12, and 70 ml of contrast material was used for the cervical, intracranial, and aortic examinations, respectively. All studies were performed by radiology residents in their third or forth year of training under the direct supervision of a staff radiologist.

After completion of the angiographic procedures, the films were independently reviewed by two radiologists (S. J. G., A. M. F.) who assigned the arch studies to one of three categories:

Category 1. The arch study demonstrates radiographic abnormalities, not revealed by the selective carotid injections, that directly influence patient management.

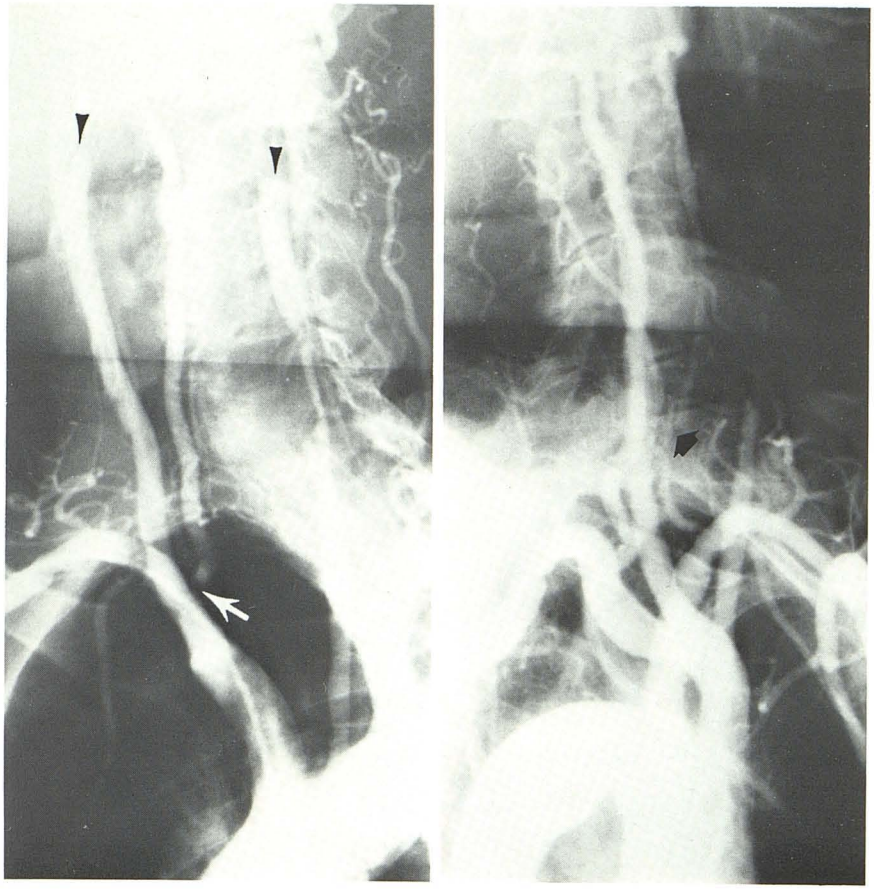
Category 2. The arch study reveals radiographic abnormalities that do not alter patient management.

Category 3. The arch study adds no clinically pertinent information.

Results

Total catheterization time in these 100 patients averaged 72 min per procedure (range, 53–125 min). The arch aortogram prolonged catheterization time by an average of 23 min (range, 13–35 min). In all cases both common carotid arteries were successfully catheterized.

Treatment was influenced by the additional information provided by the arch aortogram in only two patients (category 1 studies). In one of these cases, the arch examination revealed patency of the right internal carotid artery in a 66-year-old woman whose selective study demonstrated occlu-



A B

Fig. 2.—Bilateral common carotid occlusion. **A**, Right posterior oblique projection. High grade stenosis of right vertebral artery origin (*arrow*). Since both internal carotid arteries are occluded (*arrowheads*), intracaranial blood supply solely depends on vertebrobasilar system. **B**, Left posterior oblique projection. Occlusion of proximal left vertebral artery (*arrow*) with reconstitution distally via muscular branches of occipital and posterior auricular arteries.

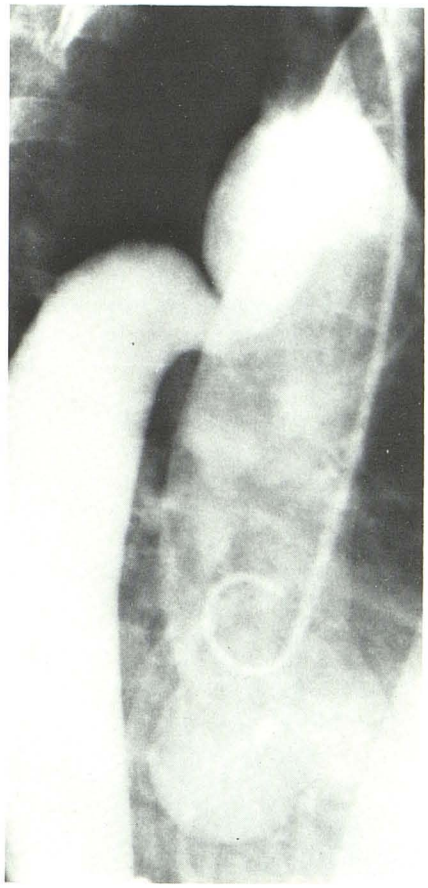


Fig. 3.—Coarctation of aorta. Arch study reveals asymptomatic and previously unsuspected coarctation of aorta in patient with right hemisphere ischemic episodes.

sion of the right carotid artery about 2 cm proximal to its bifurcation (fig. 1). As a consequence of this finding, she underwent carotid endarterectomy with the reestablishment of normal flow. The second patient with a category 1 study, a 69-year-old man, had bilateral internal carotid artery occlusions demonstrated by selective studies. His entire intracranial blood flow was supplied by the vertebrobasilar system. Arch angiography revealed occlusion of the left vertebral artery and a 95% stenosis involving the right vertebral artery at its origin (fig. 2). Consequently, the patient underwent a subclavian to right vertebral artery, saphenous vein graft bypass procedure. Both of these patients with category 1 arch studies required transaxillary artery approaches because of associated severe aortofemoral artery occlusive disease.

In 29 patients, the arch aortogram revealed abnormalities involving the proximal brachiocephalic vessels which did not alter subsequent therapy (category 2). In most of these cases, the arch study demonstrated nonsurgical disease involving the proximal common carotid arteries. In each case the selective studies showed distal disease which necessitated either anticoagulation or surgery. Consequently, in 29 patients the proximal lesions demonstrated by the aortogram required no specific therapy beyond that which was instituted on the basis of the abnormalities revealed by the selective carotid angiograms.

Asymptomatic subclavian steal was demonstrated by the arch study in two of the patients in category 2. Each of these patients had had carotid artery distribution transient ischemic attacks and underwent unilateral carotid endarterectomies with good clinical results. Since these patients had no evidence of arm claudication or posterior fossa ischemic disease, no specific therapy was instituted despite the left subclavian disease demonstrated by the arch study. Another patient in this group, a 51-year-old hypertensive woman with neurologic symtoms referable to the right cerebral hemisphere, was found to have a very tight coarctation of the aorta beyond the origin of the left subclavian artery (fig. 3). Her selective carotid studies, which demonstrated minor smooth plaques involving both bifurcations, had to be performed from the right axillary approach because the coarctation would not permit retrograde passage of a 5 French

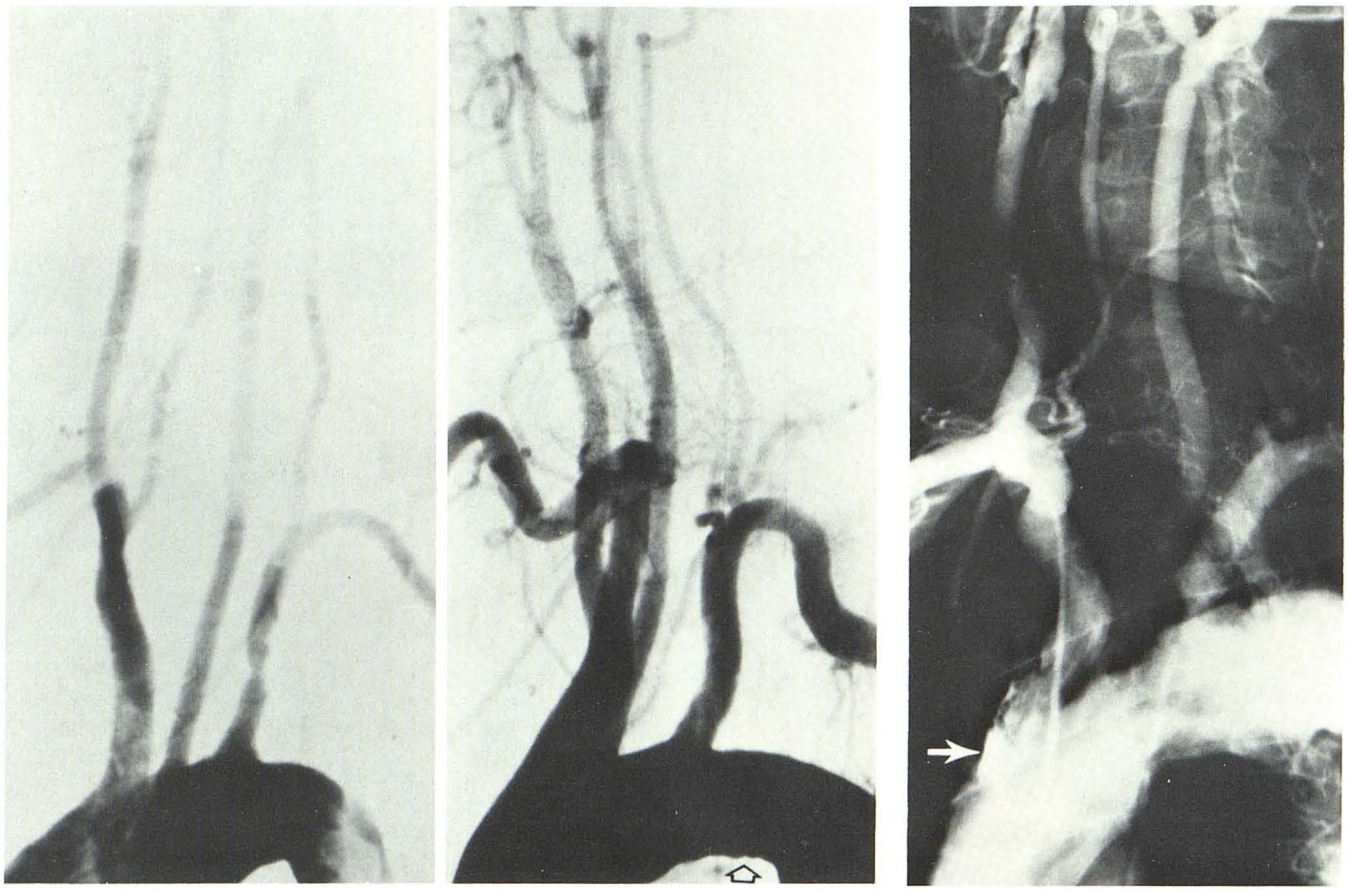


Fig. 4.—Angiographic abnormalities of no clinical signifiance in two symptomatic patients with normal selective carotid injections. **A**, Hemodynamically insignificant stenosis of left subclavian artery. **B**, Small plaques involve inferior aspect of distal aortic arch (*arrow*). Neither of these lesions demonstrated by arch study represents likely sites of distal embolization.

Fig. 5.—Subintimal injection (arrow) results in right middle cerebral artery embolization afer uncoiling of soft Teflon catheter tip during arch injection.

selective catheter. She was discharged on oral anticoagulants and did not require any specific therapy for the coarctation of the aorta demonstrated by the arch study.

Of the 100 patients, 69 had category 3 arch angiograms. Of those 69 patients, 41 had entirely normal aortic arch anatomy. The other 28 arch examinations were normal except for nonulcerated, hemodynamically insignificant, stenotic lesions involving the origin of one vertebral artery; in none of these cases was the stenosis greater than 50% of the cross-sectional diameter of the vessel.

Twenty-two patients in the study population, including the three patients less than 40 years old, had entirely normal selective carotid arteriography. In 20 of these patients the aortogram was normal, and in the other two the arch examinations demonstrated minor lesions which were not thought to be responsible for the patients' symptoms. The arch study demonstrated a focal stenosis of the proximal left subclavian artery in one patient and small plaques involving the inferior aspect of the descending aorta distal to the origins of the brachiocephalic vessels in the other (fig. 4). Therefore, in no patient with clinically documented transient ischemic attacks and negative selective carotid arteriography did the arch study reveal a possible source of distal embolization.

The only neurologic complication encountered in this series occurred with an aortic injection using a 6.4 French Teflon catheter. The terminal part of the catheter recoiled and the pigtail tip of the catheter uncoiled, resulting in a partially subintimal injection adjacent to the origin of the innominate artery (fig. 5). The patient, a 69-year-old man, who had had right hemisphere transient ischemic attacks, immediately developed a left hemiparesis which resolved within 72 hr. No major nonneurologic or neurologic complications were encountered as a result of the selective carotid catheterizations.

Twenty-two patients had operative procedures after the angiographic evaluations. Twenty-one underwent carotid endarterectomy after the angiographic procedures, and the 69-year-old man in category 1 had a right subclavian artery to right vertebral artery bypass operation. The indications for carotid surgery were the presence of a hemodynamically significant stenosis (65% or greater reduction in cross-sectional diameter) involving the artery supplying the symptomatic hemisphere or the demonstration of a large ulcer

deemed unlikely to heal with medical therapy alone. The number of patients requiring surgical therapy in each of the three groups was as follows: two patients from category 1, 10 patients from category 2, and 10 patients from category 3.

Discussion

The most reliable indicator of an impending cerebral infarction is the transient ischemic neurologic event. The causes of transient ischemic attacks are multiple and varied. The two most important factors are thought to be embolization of cerebral end arterioles by platelets, fibrin, and atheromatous debris originating predominantly in extracranial locations, and reduction in regional cerebral blood flow secondary to stenotic lesions involving the extracranial and intracranial arteries [1]. A stenosis of 63% in cross-sectional diameter is required to produce a consistently significant fall in the arterial pressure distally [13]. Ulcerated or irregular common carotid artery bifurcation plaques are the most frequent source of arterial emboli and are demonstrated in almost 65% of patients with symptomatic cerebrovascular disease [14]. Current surgical techniques to relieve cerebral ischemia, such as carotid endarterectomy and external-internal carotid bypass operations make precise delineation of the pathologic anatomy essential. Since patients with cerebrovascular disease are usually elderly and often have associated cardiac and renal disease, they are a high risk group for any invasive procedure such as cerebral arteriography [3, 5, 6]. Consequently, there is considerable controversy regarding the safest approach to the diagnostic workup of these patients whose clinical status is often precarious at best.

Although there are those who use arch arteriography alone for examination of the intracranial and extracranial vessels [9, 15], there is convincing evidence to support the need for selective carotid catherization [2, 6, 8, 10]. Even with the use of subtraction techniques, small but clinically significant lesions are commonly not well demonstrated by aortic arteriograms. The common carotid artery bifurcations, the most frequent site of atheromatous disease, and the proximal parts of the anterior and middle cerebral arteries are not consistently well visualized with arch angiography because of the superimposition of adjacent vessels [10]. Cronqvist [8] has shown that without the use of selective studies, up to 35% of significant cervical carotid lesions will be missed. Visualization of the distal intracranial vessels is also suboptimal as well, especially if there is a proximal stenosis. Thus it seems clear that all patients with transient ischemic attacks should undergo selective common carotid studies with high quality magnification views of the cervical and intracranial vessels.

The arch examination is the only study that provides information regarding the status of the origins of the great vessels. In the cooperative study [16], stenotic lesions involving the proximal left common carotid and innominate arteries occurred in only 4.8% and 4.2% of patients, respectively. Occlusions at the origins of these arteries occurred even less often. In a more recent study of 400 patients using current transfemoral catheter techniques, Palmer et al. [11] demonstrated significant proximal stenotic disease in only six patients (1.5%). Since proximal disease that involves the origins of the brachiocephalic vessels occurs with only one-fifthteenth the frequency of common carotid bifurcation lesions [14, 16], it is not surprising that the arch aortogram is not helpful in the large majority of patients requiring angiography because of cerebrovascular disease.

The aortogram influenced patient management in only 2 of the 100 patients in this study. In each of these cases, the patients had advanced carotid bifurcation disease that was well demonstrated by the selective injections. In both cases, the information provided by the arch arteriograms was critical in determining optimal surgical management. In 29 of the 100 patients, the aortogram demonstrated nonsurgical lesions involving the proximal brachiocephalic vessels. In each of these instances the selective studies demonstrated distal disease that required endarterectomy or oral anticoagulation. Thus the abnormalities demonstrated by the arch study did not require specific therapy, that is, the patient would have been managed in an identical fashion on the basis of the carotid studies alone. In the other 69 patients, the arch examination added no significant information. The arch study was entirely normal in 41 of these patients, and in the other 28, the study demonstrated minor abnormalities that were not related to the patient's ischemic episodes.

Various investigators advocate performing the arch study before selective catheterization [7], contending that the aortogram provides a "roadmap" for the selective catheterizations and also demonstrates proximal stenoses or irregular atherosclerotic plaques that may be dislodged by selective catheterization. Performing the arch studies first with a 7.1 French pigtail catheter, however, precludes the use of the 5 French catheters for the selective carotid studies during the same procedure unless the arch catheter is removed, hemostasis is achieved, and a second arterial puncture is performed [5]. Whenever possible, 5 French catheters should be used for selective studies as these are safer than the larger catheters and associated with fewer central nervous system complications [3, 7, 17]. Consequently, our angiographic routine in the patient with cerebral ischemia begins with selective catheterizations using 5 French catheters. Since we successfully and safely catheterized both common carotid arteries in all 100 patients without the need of a "vascular roadmap," and since no complications were encountered as a result of the selective studies, we do not agree that performing arch angiography routinely before selective catheterizations is either necessary or desirable.

Arch angiography has been used in the search for proximal disease in those patients with transient ischemic attacks who have negative selective arteriograms [5, 6]. In the group of 22 patients in this series with normal distal anatomy as determined by the selective studies, the arch angiogram uniformly failed to demonstrate a proximal source for distal embolization. Thus, we do not advocate the use of arch angiography in the patient whose selective carotid catheter-

izations are normal. It is more appropriate to perform aortography in the patient in whom a surgically correctable lesion is demonstrated by the selective studies in the distal circulation in order to rule out the possibility of a proximal stenosis that might jeopardize the surgical results. Since only 22%–59% of patients requiring angiography will have surgical lesions [18–20], this approach will eliminate the need for an arch study in most patients requring cerebral angiography for transient ischemic attacks. The consequent reduction in patient morbidity and savings in terms of time and expense are enormous.

What then is the optimal role of arch angiography in the patient with symptomatic cerebral ischemic disease? It is certainly indicated in all patients requiring angiography because of suspected vertebrobasilar disease, as it demonstrates the status of the vertebral artery origins—the only site in the posterior circulation that is readily amenable to surgical therapy. Arch aortography is warranted in those patients with carotid territory ischemia who have surgical lesions demonstrated by selective angiography. (Rarely, a patient will have minor disease involving the common carotid bifurcations and a significant lesion at the origin of the great vessels. This situation is usually apparent at fluoroscopy, and these patients also deserve an arch angiogram.) Aortography is the only examination that documents the presence and extent of significant proximal disease while also revealing collateral flow patterns which may potentially influence patient management.

On the basis the findings of this prospective study of 100 patients with symptomatic cerebrovascular disease, we do not believe that the information provided by the arch angiogram justifies its routine use in every patient. It does not play a significant role in demonstrating likely sites of distal embolization in the patient with normal selective studies, nor is it needed to provide a "roadmap" for the selective catheterizations. The primary role of arch angiography seems to be in the patient with demonstrated surgical disease who is a candidate for endarterectomy or bypass surgery. In these individuals, the arch study not only adds important information regarding collateral blood supply to the compromised cerebral hemisphere, but also demonstrates the presence of any stenotic disease at the origin of the brachiocephalic vessels which might compromise the surgical results.

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