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Neuroradiologic Applications of Intraarterial Digital Subtraction Angiography

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In the neuroradiologic evaluation of 118 patients using intraarterial digital subtraction angiography definite advantages and disadvantages were defined. Advantages include reduction of contrast medium volume, catheter time, and patient risk and discomfort. It also aids in angiographic planning. The paramount disadvantage is less spatial resolution compared with conventional film angiography.

Digital subtraction equipment has been developed independently and essentially simultaneously at several centers [1-4]. Early neuroradiologic application of digital subtraction angiography (DSA) equipment focused on intravenous injection of radiographic contrast medium to visualize the extracranial carotid arteries [5-7]. A large number of articles have since explored a variety of uses of intravenous DSA as it applies to neuroradiology as well as other areas of cardiovascular investigation.

However, the use of this same equipment to augment the visualization of small volumes of contrast medium delivered via an intraarterial catheter has been virtually ignored. The use of intraarterial DSA injection was first mentioned by Meaney et al. [6], who described the comparison of intraarterial DSA and conventional abdominal aortography and presented one intraarterial DSA of a selective internal mammary artery. Additional mention of the possible advantages of intraarterial DSA was made by Mistretta et al. [8], but no images were published. Comparisons of intraarterial DSA images, intravenous DSA images, and conventional angiograms of the carotid arteries in 50 patients were presented by Weinstein et al. [9]. Subsequently, Hawkins [10] published a single intraarterial DSA image of the abdominal aorta using iodinated contrast medium for comparison with digitally enhanced CO₂ arteriography.

Since the installation of digital subtraction equipment in the neuroangiographic suite at Vanderbilt University Hospital we have had the opportunity to explore various neuroradiologic applications of intraarterial DSA [11, 12]. In the first year of its availability (1981-1982) 302 patients underwent diagnostic neuroangiographic studies. Of these, 118 had a portion or all of their examination conducted using intraarterial DSA techniques.

Materials and Methods

The equipment used was a production model Technicare DR-960 digital subtraction unit coupled to a GE Fluoricon 300. The digital subtraction unit was operated in the pulsed mode at 600 mA, 65-80 kVp, and at appropriate time and *f* stop for the patient's size and image intensifier size (23 cm, 15 cm, or 11 cm).

The series consisted of 118 patients who had a portion or all (two cases) of their neuroangiographic examination conducted by intraarterial DSA. Some 246 injections were made with intraarterial DSA filming technique. No complications were encountered. The choice of conventional arteriography alone, intraarterial DSA alone, or both was arbitrary, dependent on the clinical question, ease of catheterization, catheter time, patient cooperation, and so forth.

Optimal contrast medium injection volume was found to be 2-5 ml of Conray 60 (iothalamate meglumine 60% injection, U.S.P., Mallinckrodt Pharmaceuticals, St. Louis) diluted 1:1 with heparinized normal saline, hand-injected in all cases except "arch" examinations, which required power injection of 15-18 ml of undiluted Conray 60 or Vascoray 76 (iothalamate meglumine 52% and iothalamate sodium 26% injection, U.S.P., Mallinckrodt) over 2-3 sec. The choice of contrast media for arch examinations was arbitrary in the belief that these small volumes would be equally well tolerated.

Representative Case Reports

Case 1

In a 55-year-old woman with subarachnoid hemorrhage (documented by computed tomography [CT] and lumbar puncture), conventional angiography revealed a left middle cerebral artery aneurysm. Intraarterial DSA of the left vertebral artery origin revealed a difficult and potentially dangerous catheterization. Intraarterial DSA of the posterior fossa obtained by subclavian artery injection showed absence of large aneurysms in the posterior fossa (fig. 1).

Case 2

In a 69-year-old woman with renovascular hypertension and asymptomatic bruits, intraarterial DSA with hand injection of 2 ml undiluted Conray 60 from the left common carotid artery origin showed stenosis of the carotid bifurcation (fig. 2).

Case 3

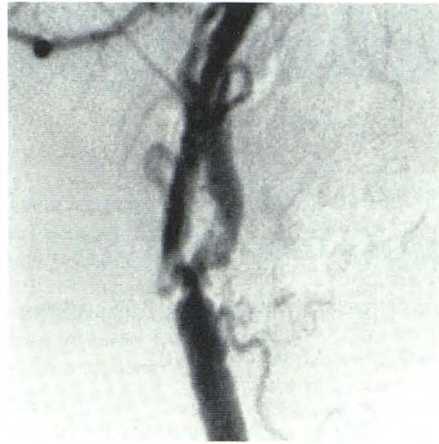
A 69-year-old woman presented with hypertension and intermittent left facial paresthesias, but had a normal neurologic examination. Bilateral conventional common carotid arteriograms were also normal. An intraarterial DSA arch using power injection of 16 ml of Vascoray over 3 sec revealed no significant stenosis of the common carotid arteries (fig. 3). (The catheter used in this case was a 6.5 French Simmons 2 cerebral [Cook, Bloomington, IN], but

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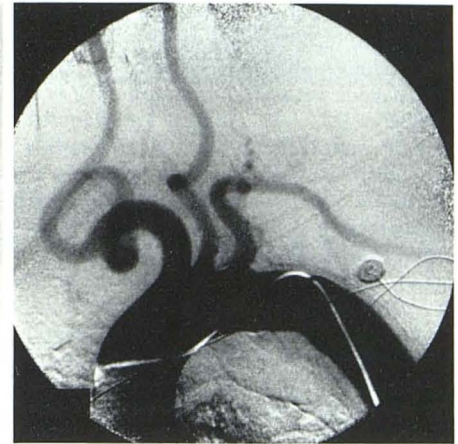
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Fig. 1.—Lateral view of posterior fossa by intraarterial DSA after hand injection of 5 ml diluted Conray 60 in origin of left subclavian artery.



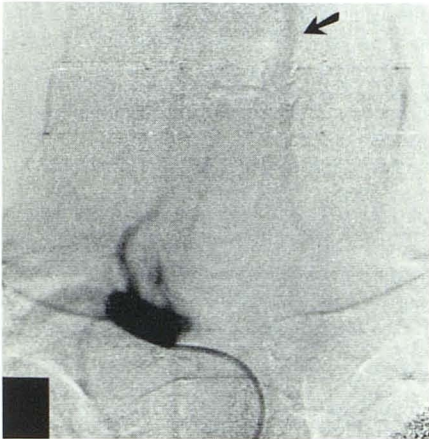
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Fig. 2.—Left carotid bifurcation by intraarterial DSA.



3

Fig. 3.—Intraarterial DSA arch arteriogram. Bilateral small vertebral arteries filled normally on later film.



A



B

Fig. 4.—A, Early frame from intraarterial DSA of upper thorax and neck during right subclavian injection of 6 ml diluted Conray 60 shows early retrograde flow in left vertebral artery (*arrow*). B, Later frame in same series shows reconstitution of left subclavian artery. (Reprinted from [11].)

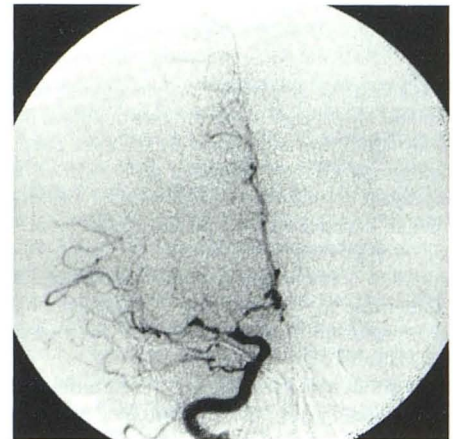


Fig. 5.—Intracranial intraarterial DSA after hand injection at origin of innominate artery. Other views (not shown) revealed right vertebral occlusion.

similar arch examinations were performed using a variety of 5–7 French cerebral catheters.)

Case 4

In a 52-year-old woman, peripheral vascular disease and asymptomatic left supraclavicular bruit were found on routine physical examination. Cerebral angiography was requested in anticipation of aortoiliac surgery. A right subclavian artery injection intraarterial DSA showed antegrade flow in the right vertebral artery with reconstitution of the left subclavian artery via retrograde flow in the left vertebral artery (fig. 4). Intracranial views showed that retrograde flow in the left vertebral artery occurred before opacification of the basilar artery.

Case 5

In a 71-year-old woman with long-standing hypertension, expressive aphasia and a right posterior frontal infarct were diagnosed by

CT. Attempts at transfemoral selective carotid catheterization were unsuccessful. Intraarterial DSA of carotid bifurcations bilaterally revealed no significant stenosis or irregularity. An intraarterial DSA of the left common carotid showed no obvious intracranial abnormality. An intraarterial DSA of the right common carotid with catheter tip at the innominate origin (patient also had right vertebral occlusion) revealed obvious intracranial disease of the proximal anterior and middle cerebral arteries, rendering further examination unnecessary (fig. 5).

Results

Evaluation of the vertebrobasilar circulation in patients with small, stenotic, tortuous, or single vertebral arteries was the most frequent indication for intraarterial DSA (68 cases). The second most common use for intraarterial DSA was as a real-time subtraction spot film device (62 cases). This application was used not only to document presence or lack of disease at vertebral origins, carotid bifurcations, and proximal carotid origins, but also to aid in planning

the actual angiographic approach for a procedure.

The third most frequent use of the intraarterial DSA technique was for aortic arch examination. Sixty intraarterial DSA "arch" examinations were performed during the first year.

Subclavian "steal" can be demonstrated without resorting to either an arch aortogram or selective vertebral artery catheterization, which is often difficult and/or dangerous in these patients. Injection of 2–5 ml of diluted contrast material in the subclavian artery proximal to the vertebral origin allows visualization not only of the reconstitution of the contralateral subclavian artery via retrograde flow in the analogous vertebral artery, but also of the intracranial flow sequence. In those instances when catheterization is prolonged and selective catheterization of a desired vessel difficult, injection of 2–5 ml of diluted contrast material at the carotid origin or in the subclavian or innominate arteries proximal to the vertebral origin will allow visualization of intracranial circulation adequate to exclude gross abnormalities of major branches.

Additional uses included evaluation of bypass patency in patients with superficial temporal artery–middle cerebral artery anastomoses and demonstration of the arterial spasm secondary to previous subarachnoid hemorrhage by contrast material injection in the proximal common carotid artery.

Discussion

Use of DSA equipment as an adjunct to standard intraarterial catheter angiography may provide definitive answers to many questions facing the angiographer. In other cases, it allows for rapid patient positioning for optimal projection or the choice of the best angiographic approach. This reduces catheter time, contrast volume, and consequently patient risks, whether used alone or in conjunction with conventional film angiography. There is also a reduction of patient discomfort. Spatial resolution is, of course, not comparable to standard cut film angiography, but it is often adequate; when coupled with the previously noted advantages, intraarterial DSA is often preferable.

An additional advantage of intraarterial DSA arch examinations is that they do not require a catheter exchange since the volumes and rates of injection are low enough to be safely performed through an end-hole catheter. Exceptions are patients who have had previous coronary artery bypass surgery. In these patients, the risk of inadvertent injection of the graft caused by catheter recoil is considered too great, and a multi-side-hole catheter is routinely employed.

Another use contemplated but not investigated in this series of patients is the measurement of intracranial blood flow using intraar-

terial DSA. Evaluation and treatment of cases amenable to interventional neuroradiologic procedures (e.g., embolizations, balloon detachments) would also benefit from the contrast material reduction and availability of real-time subtracted imaging.

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