Investigation of Extracranial Cerebral Arteries by Intravenous Angiography: Report of 1,000 Cases

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Intravenous angiography is a safe, rapid, simple examination, which, with sonography, is complementary in selecting patients for conventional angiography. This examination is not designed to replace conventional angiography, but, rather, to study high-risk stroke patients, patients with asymptomatic cervical bruit, or postoperative patients. Improvements in contrast media, film subtraction, the use of oral anesthesia with viscous lidocaine, and the technique of cooling the contrast medium have made the procedure more successful. A review of 1,000 examinations was undertaken to determine the accuracy of the technique and to emphasize technical points. Excellent results, comparable to conventional angiography, were obtained in 50.3% patients and good results in 32%. Poor or uninterpretable results were obtained in 17.7%. These were secondary to either patient movement or the presence of venous reflux or stasis of contrast medium.

Despite the dynamic information provided by indirect or direct noninvasive techniques such as periorbital directional Doppler sonography, supraorbital plethysmography, ocular plethysmography, and carotid Doppler spectral analysis [1–4], accurate morphologic information is essential to evaluate and guide the treatment of patients with carotid artery atheromatous disease. Long-term follow-up examination of these patients using noninvasive technique will help us understand the natural history of carotid atheromatous lesions. These noninvasive techniques should not replace angiography, but rather should help us select those patients that should be studied by angiography. However, the risks of conventional angiography of the great vessels of the neck frequently prevent the radiologist from using this examination in the investigation of high-risk patients or patients with asymptomatic cervical bruit.

Intravenous angiography was first used for imaging the pulmonary vessels, the chambers of the heart, and the aortic arch [5, 6]. However, the poor contrast medium opacification obtained at the level of the main supraaortic vessels and the rapid development of catheter techniques rapidly supplanted this method [7].

Improvements in contrast media and in radiologic imaging (subtraction) allowed us to reactivate intravenous angiography in our institution in 1977. Preliminary reports have emphasized the usefulness of this method in the evaluation of atherosclerotic lesions of the supraaortic vessels [8–10]. Our experience is based on 1,000 examinations to date. The purpose of this study is to present the current status of this technique and to emphasize some technical details.

Materials and Methods

Between June 1977 and February 1980, 1,000 patients (680 men and 320 women) were examined by intravenous angiography. They were 26–93 years old (mean, 62 years).
The examination was performed in patients with clinical symptoms of a stenotic or occlusive lesion of the great vessels. These included permanent or regressive stroke, transient ischemic attack, vertebrobasilar insufficiency, and cervical bruit. High-risk patients and postoperative controls were also included in this series. About 25% of the patients were ambulatory.

No patients required general anesthesia or premedication. The only preprocedure orders were: (1) the patient should be fasting for at least 4-6 hr before examination and (2) adequate hydration should be maintained.

Percutaneous catheterization of the brachial or antecubital vein is performed with a Teflon needle (14 or 16 gauge Cathlon catheter). The femoral vein can also be used when the arm veins cannot be catheterized or when there is a marked jugular venous reflux. Arm to tongue circulation time is measured by injecting 3-5 ml of sodium dehydrocholate (Dycholium, Laboratoire Theraplix, Paris, France) through the needle in 1 sec. Circulation time (time between the injection and the first manifestation of a bitter taste at the base of the tongue) usually is 10-20 sec and tends to increase with age and in patients with mitral disease. Dycholium should not be used in patients with hepatobiliary disease. Next, 5 ml of 1% viscous Xylocain (Laboratoire Roger Bellon, Neuilly, France) is administered orally to the patient. Xylocain induces local anesthesia at the base of the tongue and prevents the burning sensation produced by the contrast medium; local anesthesia lasts 1-3 hr and does not preclude oral feeding afterward since the gag reflex is preserved.

An automatic pneumatic injector with two syringes (Caillon 602 V.D., Medical France, Mérignac, France) is used to inject 1 ml/kg body weight loxatalamate (Laboratoire Guerbet, Aulnay Sous Bois, France) (38 g iodine/100 ml; 2,100 mosmol/kg at 37°C) in 3-4 sec. The contrast medium is cooled and injected at a temperature of 10°-15°C.

Injection of the contrast medium begins at time 0 (fig. 1). A 50 ml macromolecular solution, or Dextran, is injected immediately after the contrast medium via the second syringe of the pneumatic injector. Saline or 5% dextrose can be used but it is less adequate.

Two radiographic series are then performed: one in the anteroposterior (AP) projection and the other in the right posterior oblique. A third projection, left posterior oblique, may also be necessary if the two previous projections are inadequate. The x-ray beam is centered on the thyroid cartilage and the focus-film distance is 1 m as in conventional angiography. The patient is instructed to suspend his respiration 2-3 sec before the beginning of the radiographic series. A first film (mask) is exposed for subtraction at this time. A series consisting of eight films at a rate of one film/sec begins at

![Fig. 1. — Contrast injection begins at time 0. Radiographic series begins at one-half the measured circulation time at a rate of one film/sec during 8 sec.](image)

![Fig. 2. — Intravenous angiogram. Anteroposterior (A) and right posterior oblique (B) projections. Supraaortic vessels well demonstrated from origin to polygon of Willis. Internal carotid arteries and siphons (closed arrows). Vertebral and basilar arteries (open arrows).](image)
Results

We classified the results into four groups: (1) excellent, (2) good, (3) poor, and (4) uninterpretable.

Excellent results were obtained in 503 patients (50.3%) demonstrating the upper part of the aortic arch, both proximal subclavian arteries, the brachiocephalic artery, the common, internal, and external carotid arteries, and the vertebral arteries from their origin to the base of the skull (fig. 2). The intracranial part of the internal carotid arteries and vertebrobasilar system up to the polygon of Willis were demonstrated in 25% of these cases (Fig. 3). These images are nearly comparable with those obtained by arch aortography (Fig. 4).

Good results were obtained in 320 patients (32%). The origin of the vertebral artery on the ipsilateral side of the injection was usually partially masked by venous stasis of the contrast medium. (fig. 5).

Poor results were seen in 125 cases (12.5%). The reasons for these results included reflux into or stasis of contrast medium in the external or internal jugular vein obscuring part of the origin of the arteries of interest and patient movement (swallowing) preventing adequate subtraction.

Uninterpretable results were noted in 52 cases (5.2%). These results were secondary to severe venous reflux and stasis in the neck that subsequently obscured the main arteries.

Discussion

Intravenous angiography is a safe, simple, rapid method for screening vascular lesions of the supracaecor vessels. Lesions such as arterial stenosis, occlusion, or subclavian steal syndrome can be diagnosed with an accuracy comparable to arch aortography (Figs. 4, 6, and 7).

Intravenous angiography represents the bridge between the noninvasive techniques (direct and/or indirect) [1–4] and conventional angiography. There are advantages and disadvantages of the noninvasive sonographic techniques, conventional angiography, and intravenous angiography in the evaluation of vascular lesions of the supracaecor vessels.

The distinct advantages of intravenous angiography over...
conventional angiography include: (1) the risks of arch aortography are reduced; (2) patients can be examined on an outpatient basis (25% of patients in our series were ambulatory); (3) the examination is simpler, time-saving, less costly, and can be easily repeated if necessary; (4) the number of conventional angiographic procedures performed as a "first order" diagnostic tool is reduced; and (5) intravenous angiography can be combined with computed tomography (CT) to carry out a complete evaluation of patients with cerebrovascular disease (i.e., examination of the brain parenchyma).

The primary advantage of intravenous angiography over sonography is that it provides more accurate morphologic information of the great vessels from their origin to their penetration into the skull. This is particularly the case for the vertebral arteries, which are poorly investigated with sonography. When extensive atheromatous disease is suspected, intravenous angiography can provide in the same session screening of the lesions not only of the major cerebral arteries but also of the aorta (fig. 8). In our institution, intravenous angiography and sonography are considered to be complementary and aid us in the selection of patients for conventional angiography.

The main indications for intravenous angiography are similar to those proposed by Ackerman [2] for noninvasive diagnostic procedures: (1) high-risk patients presenting with transient ischemic attacks, minor deficit from a recent stroke, or good neurologic recovery from a completed stroke; (2) patients with asymptomatic cervical bruit; (3) patients with asymptomatic cervical bruits who will be undergoing extensive surgery with possible intraoperative hypotension; (4) patients with signs or symptoms that are equivocal for carotid or vertebral arterial disease; (5) postoperative controls after supraaortic vascular surgery (carotid, subclavian, vertebral), even if the patients are anticoagulated (fig. 7); and (6) follow-up of patients presenting with early hemodynamic changes or with scan evidence of atherosoma.

Our successful examinations (82.3%) resulted from good techniques, including film subtraction. Cooperation of the patient (i.e., apnea and immobility during filming) is essential. Two technical details aid the patient in remaining mobile during serigraphy. These are: (1) use of oral anesthesia with viscous lidocaine and (2) cooling of the contrast medium. The use of local anesthesia at the base of the tongue prevents the burning sensation caused by the rapid intravenous injection of contrast medium, and it will also inhibit coughing. The anesthesia lasts 1–3 hr and does not preclude oral feeding afterward since the gag reflex is preserved. The coughing and burning sensations are also suppressed, or decreased, by cooling the contrast medium to 10°–15°C. Cooling increases the viscosity of the contrast medium and, thus, improves the bolus effect. At 30°C, the viscosity of the contrast medium (sodium meglumine ioxitrate) is 15.4 centipoises; at 20°C, it is 17 centipoises; and at 10°C, it is 17.7 centipoises. As the temperature of the contrast material decreases, ionic dissociation of sodium salts diminishes. This, in turn, decreases the osmolality, thereby improving the patient’s tolerance of the contrast medium [11]. Dilution of contrast medium is decreased when macromolecular solution is used to flush the contrast instead of saline or dextrose. Dextran solution has a higher viscosity (6 centipoises); this provides a better bolus effect and reduces the time of contact between the hyperosmolar contrast and the venous wall, thereby improving patient tolerance.

Poor or uninterpretable results in 17.7% of patients were secondary to the two main disadvantages of intravenous angiography. These are: (1) stasis or reflux of contrast medium in the cervical veins on the ipsilateral side of injection and (2) the necessity of using film subtraction in patients who may be moving. Venous stasis may mask part of the cervical arteries, primarily near the origin of the right vertebral artery. The stasis, usually in the jugular or, less frequently, the innominate or subclavian vein, may be transient. It may be present on one series and absent on the next; this is probably related to the rotation of the head (fig. 9). Injection of the contrast medium either by the femoral vein route or by catheterization of the superior vena cava by the
Fig. 6.—Atheromatous carotid lesions on intravenous angiography. A, Ulcerated plaque on left internal carotid artery (arrow). B, Carotid stenosis (arrow). C, Carotid occlusion (solid arrow). Ulcerated plaques on left carotid bifurcation (open arrows).

Fig. 7.—42-year-old woman with vertebrobasilar insufficiency. A, Preoperative intravenous angiogram. Severe annular stenosis of proximal left subclavian artery (arrow). B, Postoperative intravenous angiogram 1 year after endarterectomy. Normal filling of left vertebral artery (arrow).

Brachial vein [12, 13] is indicated if the venous stasis is severe on the ipsilateral side of the injection on the first series. Slight compression of the external jugular vein with an adhesive tape transversely across the neck is used when reflux or stasis is present there.

Fifty examinations were also performed with Hexabrix (Laboratoire Guerbet, Aulnay Sous Bois, France) (32 g iodine/100 ml), a new hexaoidized contrast medium. There was no, or decreased, burning sensation, coughing, and nausea with Hexabrix, probably related to the lower osmo-
Fig. 8.—85-year-old woman with right regressive hemiparesis, abdominal bruit, and severe arteriopathy of the inferior limbs. A, Intravenous angiogram, right posterior oblique projection. Calcified atheromatous plaque on left internal carotid artery (solid arrow) and severe stenosis near carotid bifurcation (open arrows). No visualization of left vertebral artery. B, Abdominal aorta in same session. Severe atheromatous lesions of infrarenal aorta.

Fig. 9.—65-year-old man with left asymptomatic cervical bruit. Origin of right vertebral artery masked by venous reflux into jugular vein (solid arrows) on anteroposterior (A) and right posterior oblique (B) views, but absent on left posterior oblique view (C). Stenosis at origin of left external carotid artery in A and B (open arrows).
Intravenous angiography provides more accurate morphologic assessment of the great vessels than sonography and it is better tolerated than conventional angiography in high-risk patients. Neither intravenous angiography nor sonography can replace conventional angiography, but, with the development of newer techniques of digital subtraction angiography, there may be fewer indications for performing conventional angiography. Our technique of intravenous angiography should be considered as an intermediary technique between conventional and digital angiography. However, the techniques of contrast injection and computer subtraction still have to be mastered.

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