ANGIOGRAPHIC COMPLICATIONS IN PATIENTS WITH CEREBROVASCULAR DISEASE

D. W. LINDNER, M.D., W. G. HARDY, M.D., L. M. THOMAS, M.D., AND E. S. GURDJIAN, M.D.*

Neurosurgical Service, Wayne State University School of Medicine and the Grace and Detroit Memorial Hospitals, Detroit, Michigan

(Received for publication June 26, 1961)

In 1958 we first reported on our experiences in the use of sodium diatrizoate (Hypaque) for cerebral angiography. At that time we were particularly interested in comparing morbidity and mortality among patients studied angiographically from the standpoint of the contrast material that was used in the examination. Of the various media available, we selected sodium diatrizoate for use because of results that were obtained in animal experimentation. All of the patients in the present study were investigated by Hypaque angiography. The purpose of this report is not only to summarize the effectiveness of sodium diatrizoate as a contrast medium, but to consider the effectiveness as well as the dangers of cerebral angiography in the presence of cerebrovascular disease.

We have noticed in the past few years a progressive increase in the number of angiographic studies done as well as in the completeness of these studies done in any given patient. The one great impetus in this respect has been the recent increased interest in patients presenting the stroke syndrome. Since July 1, 1956 we have done routinely bilateral carotid angiography in all patients seen with the stroke syndrome. More recently, we have included either 3-vessel or 4-vessel angiography, i.e. bilateral carotid and percutaneous cervical vertebral, or bilateral carotid and bilateral retrograde brachial-vertebral angiography. The brachial studies have been very helpful in evaluating the extent of occlusive vascular involvement in patients whose primary diagnosis was atherosclerosis involving either the cranial or extracranial vessels, and in determining those patients who may be amenable to surgical intervention.

METHODS AND MATERIAL

The present series consists of 1000 patients admitted consecutively to the Neurosurgical Services of the Grace and Detroit Memorial Hospitals between July 1, 1956 and April, 1961. These patients all had either an admitting diagnosis of "cerebrovascular accident" or were proven to have cerebrovascular disease during admission. Of these patients, 951 had a total of 1199 angiographic procedures performed. The extent of the procedures done at one sitting was as follows: Bilateral carotid angiography was performed 689 times. On 25 occasions bilateral carotid and percutaneous cervical vertebral angiography was done. In 289 instances the patient had only a single carotid study performed. On 33 occasions, percutaneous vertebral study only was done. Retrograde brachial angiography was done 155 times. In 15 instances other combinations of the various vessels were studied depending upon clinical symptoms.

One hundred forty-one of these patients had both bilateral carotid angiography and bilateral retrograde brachial angiography (4-vessel study). These were all done at separate sittings.

The distribution of age and sex in these 1000 cases is given in Table 1.

TECHNIQUE

Bilateral carotid angiography usually is done at one sitting. The patient is supine on the roentgen-
drawn and pressure is applied over the site of arterial puncture for 2 to 3 minutes to control bleeding. The procedure then is repeated on the opposite side.

In selected cases exposures are made with a Fairchild camera to determine the arterial and venous phases of vascular filling as well as collateral supply.

Percutaneous vertebral angiography is performed with the patient in the same position as described above. The direction of the needle is the same except that, in this instance, the carotid vessel is held laterally by the left hand as the spinal needle is inserted with the right hand. The needle is directed to enter the space between the vertebral transverse processes into the canal of the vertebral artery, and is usually advanced until bony obstruction is met. Then as the needle is withdrawn, a pulsating flow of blood is obtained similar to that described above. Much more care is required in the positioning of the head for the roentgen-ray views in vertebral studies because of the inability to thread the spinal needle into the lumen of the vertebral artery. Again, however, anteroposterior and lateral roentgenograms are taken following injection of 12 cc. of 40 per cent Hypaque.

Retrograde brachial angiography has been performed routinely under intratracheal general anesthesia in the operating room with a portable roentgen-ray unit. The patient is supine with the arms outstretched laterally. The antecubital fossae on both sides are prepared and draped, following which the brachial arteries are cannulated percutaneously by a 17 gauge thin-wall spinal needle. This is performed by puncturing the skin 1½ inches below the crease in the antecubital fossa and then advancing the needle subcutaneously to a point at the elbow where good pulsations are palpable. The needle then is directed to puncture the vessel as the other hand palpates just above the point of puncture. When a good pulsatile flow is obtained through the needle, the needle is advanced ½ inch to 1 inch in the lumen of the vessel, again making sure that a good pulsatile flow is maintained. The needle then is connected to a plastic extension tubing, connected with a two-way stopcock. Roentgenograms sized 14×17 inches are used in this examination which are large enough to include the entire head and upper third of the thoracic region. A total of 6 exposures and 6 injections of 50 cc. 50 per cent Hypaque are made including an anteroposterior, a right lateral and a left lateral view on each side. The lateral views are made by merely turning the patient's head to one side or the other. The injection is made manually as rapidly as possible and the exposure is made as the last 5 cc. are being injected. An interval of 2 to 3 minutes is allowed between injections and

### TABLE 1

**Age and sex of 1000 patients with cerebrovascular disease**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-30</td>
<td>15</td>
</tr>
<tr>
<td>31-40</td>
<td>37</td>
</tr>
<tr>
<td>41-50</td>
<td>129</td>
</tr>
<tr>
<td>51-60</td>
<td>310</td>
</tr>
<tr>
<td>61-70</td>
<td>376</td>
</tr>
<tr>
<td>71-80</td>
<td>126</td>
</tr>
<tr>
<td>81-90</td>
<td>7</td>
</tr>
<tr>
<td>Males=618</td>
<td>Females=382</td>
</tr>
</tbody>
</table>

Ray table with a soft roll placed beneath both scapulae, and the head hyperextended. Intravenous fluid is given slowly during the procedure to have a vein available for immediate use if necessary. An anesthetist is present at all times during the procedure. The carotid pulse is palpated on the side to be studied and a skin-wheal then is raised with 1 per cent xylocaine or novocain at a point just slightly above the clavicle and overlying the carotid artery pulsation on that side. The local infiltration then is carried into the deeper tissues including some injection into the carotid sheath. This is done with the needle angled superiorly. The arterial puncture then is performed with a standard 18 gauge spinal needle, again with the needle angled superiorly in order to avoid the apex of the lung on that side. When the tip of the needle is felt to go through the arterial wall, the stylet is removed and the needle is slowly withdrawn until a freely pulsating flow of blood is obtained. Following this, the needle is advanced into the lumen of the vessel making sure that a good pulsatile flow is maintained. The needle then is connected to a plastic extension tubing to which there is attached a two-way stopcock. The patency of the system is tested with saline solution at which time an easy to and fro flow of blood should be obtained. The head then is positioned by the roentgen-ray technician for an anteroposterior view. Twelve cc. of 40 per cent Hypaque solution are rapidly injected via the plastic extension tubing and the roentgen-ray exposure is made as the last cc. is being given. The lateral view is done in a similar manner with an interval of 2 to 3 minutes between injections and exposures. In cases of spontaneous subarachnoid bleeding an additional injection is made for an oblique view of the carotid complex intracranially. In this instance the patient's head is rotated so that the roentgen rays are directed through the orbit on the side being studied. The films are examined prior to removal of the needle in case further injections and roentgen-ray studies are required. The needle then is withdrawn.
the sides are alternated. Again, the films are examined prior to removal of the needles in case there is a necessity for further injections and studies. If the studies are satisfactory, the needles are removed; a small gauze pressure dressing is applied over the site of puncture and an ace bandage is applied to the arm for 2 hours following the procedure.\(^4\)

Originally the retrograde brachial studies were performed by operative exposure of the brachial artery just above the elbow. An arteriotomy was done, and a 2 inch metal cannula was ligated in situ. Following the injections and roentgen-ray exposures, the cannula was removed and the arteriotomy was repaired to re-establish blood flow in the vessel. Since the percutaneous method has been adopted, fewer than 8 per cent of the vessels have required operative exposure to complete the study (because of failure of percutaneous cannulation).

The first two-thirds of the patients in this series were tested routinely for sensitivity to Hypaque (skin test). The last one-third were not tested.

**RESULTS**

Table 2 summarizes the angiographic findings in 951 patients. It will be noted that in 204 instances a significant degree of stenosis was noted in the extracranial portion of the internal carotid artery on one or the other side. Bilateral stenoses were noted in 97. Complete occlusion of one or the other internal carotid artery was noted in 91 and bilateral occlusion in 10. Occlusion or non-filling of the proximal part of the anterior cerebral artery was noted in 118. When this finding is seen during the angiographic study injection is repeated with digital occlusion of the opposite carotid artery in the neck in an attempt to fill this portion of the vessel. Occlusion of the middle cerebral artery was noted in 38 and stenosis or occlusion involving the vertebral basilar system in 102. Unexpected aneurysms or arteriovenous malformations were noted in 37. Intracerebral hematoma of surgical proportion was found in 23. In these instances single carotid angiography was performed and this usually was done as an emergency procedure. Subdural hematoma was found in 12 and brain tumor in 50.

**COMPLICATIONS**

In patients with major angiographic abnormalities it is frequently quite difficult to interpret a worsening of the patient’s condition and ascribe it either to the pathology demonstrated or to the diagnostic procedure performed. For this reason, we have included in the list of complications all patients who had worsening following angiographic study and then have tried to interpret this worsening in view of both the existing pathology as well as the studies performed. There were 8 patients in this group who expired during their hospital stay in whom the angiographic study was felt to be a definite contributing factor. These cases are as follows:


7. W.S., white male aged 61, admitted Nov. 4, 1957. Patient had seizure during angiography on Nov. 8, 1957 and study was discontinued. The patient became decerebrate and expired 5 hours later. There was no autopsy. Clinical impression was that of basilar occlusion. The left carotid angiographic study performed was normal.


There were 5 patients in whom major angiographic findings made interpretation of the effects of angiography difficult. These cases are as follows:


There were 11 patients who had difficulties at the time of angiography felt to be related directly to the angiographic study. There was complete recovery in all but 3 cases. These cases are as follows:


18. M.M., white female aged 68, admitted April 2, 1959. Patient had embolus to retinal artery at the time of angiography on April 7, 1959. Residual quadranteric defect at time of discharge.


TABLE 3

<table>
<thead>
<tr>
<th>Summary of complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
</tr>
<tr>
<td>Occlusive cerebrovascular disease</td>
</tr>
<tr>
<td>Aneurysm/arteriovenous malformation</td>
</tr>
<tr>
<td>Tumor of pulmonary artery</td>
</tr>
<tr>
<td>Metastatic carcinoma to brain</td>
</tr>
<tr>
<td>Hemorrhage or hemorrhagic infarction</td>
</tr>
<tr>
<td>Cardiac arrest</td>
</tr>
<tr>
<td>Transient weakness</td>
</tr>
<tr>
<td>Persisting weakness</td>
</tr>
<tr>
<td>Embolus</td>
</tr>
<tr>
<td>Coronary spasm</td>
</tr>
<tr>
<td>Radiculitis</td>
</tr>
<tr>
<td>Heart block</td>
</tr>
<tr>
<td>Convulsion</td>
</tr>
</tbody>
</table>


Table 3 summarizes the complications in this total series.

DISCUSSION

Among the 24 patients considered as possibly having angiographic complications, there were 13 with fatal outcome. In this group, 5 patients had major cerebrovascular atherosclerosis as a primary diagnosis, 1 had cardiac arrest during angiography under general anesthesia, 1 had associated cerebral metastases, and another a primary tumor of the pulmonary artery. Two patients had intracranial aneurysms, 1 of which was associated with a massive hemorrhage, 2 others had surgical intracerebral hematomas which had been operated upon, and another patient died 3 weeks following angiography which had resulted in a hemiparesis. This last patient had been discharged on anticoagulant therapy and upon readmission was found to have a cerebellar and brain-stem hemorrhage. Of the 13 patients, then, with fatal outcome, 7 were found to have serious conditions of disease that undoubtedly contributed to that fatal outcome.

Among the 11 patients having nonfatal complications there were 4 examples of transient hemiparesis, 2 patients with persisting hemiparesis, 1 instance of presumed embolization to a retinal artery, 1 example of heart block, 1 example of a grand mal seizure during angiography, and 1 patient having coronary spasm during the procedure. In 1 patient cervical radiculitis developed as a result of percutaneous vertebral angiography.

As has been reported previously, the presence of marked atheromatous disease in the cerebrovasculature increases the expected morbidity and mortality from cerebral angiographic studies. Mechanical factors at the time of arterial puncture or injection seem to be of major significance in this respect. In Case 18 (Fig. 1) the patient complained of visual difficulty immediately following arterial injection. The angiographic study revealed atheromatous involvement at the point of arterial puncture in the neck. Because of the rapidity of development of her symptoms and the demonstration of arterial occlusion and retinal blanching by immediate ophthalmoscopic examination it was felt that embolization from the point of arterial puncture had occurred. In Case 22, however, the mechanism of assumed embolization is somewhat more obscure. The patient's weakness developed on the same side as the injection that was being made, i.e., weakness of the right leg developed immediately following injection of the right carotid artery. This is complicated further by the demonstration of complete occlusion of both internal carotid arteries in the neck (Fig. 2). In view of these findings, it also seems conceivable that the blood supply in the hemisphere contralateral to the injection was compromised to a point beyond which any minor insult could lead to a progressive thrombosis. We feel that this may be the situation encountered in many patients having difficulties following angiographic injections.

It is interesting to consider the relative rarity of complications from retrograde
Fig. 1. Note generalized atheromatous involvement of extracranial portions of carotid arteries. Quadrantic visual-field defect occurred immediately after injection into left common carotid artery (left).

Fig. 2. Note complete occlusion of internal carotid artery on both sides. Weakness of right leg developed after injection was made into right common carotid artery.
ANGIOGRAPHIC COMPLICATIONS IN CASES OF STROKE

185

brachial studies as compared with percutaneous carotid studies. In the present series we did not encounter any cerebral complications from retrograde brachial injections. We feel this may well be related to the actual distance between the site of injections and the atheromatous disease which may lead directly to difficulties. Furthermore, an atheromatous dislodgement in the limb would tend to travel peripherally in the vessel (with the flow of blood) toward the distal portions of the extremity, whereas with direct carotid or vertebral puncture any dislodged fragments would travel toward the brain. Also, dilution of the contrast material we feel is definitely a factor. Complications have occurred frequently enough following puncture directly at the site of demonstrable atheromatous disease to make us feel that direct manipulation into these atheromatous plaques is associated with a relatively higher degree of morbidity and mortality. It is for this reason that we have not made use of catheterization techniques for retrograde brachial studies. On one occasion injection by catheter at the aortic-subclavian junction resulted in aortic subintimal injection, presumably resulting from dissection beneath an atheromatous plaque by the catheter (Fig. 3).

SUMMARY

1. A review of angiographic complications in a large series of “stroke patients” has been presented.
2. Morbidity and mortality have occurred in 2.4 per cent of these patients.
3. The various mechanisms of these complications have been discussed.
4. The angiographic findings in this series have been tabulated.

REFERENCES