PERCUTANEOUS BRACHIAL CEREBRAL ANGIOGRAPHY

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Cerebral angiography plays an important role in the diagnosis of intracranial disease. In some cases, clinical symptoms and physical findings may dictate the need to visualize only a single major artery. However, in many cases visualization of the carotid and vertebral-basilar systems bilaterally may be indicated. This problem has been discussed by Baker and others. To accomplish this ordinarily requires multiple arterial punctures and injections. This is true particularly if separate injections are required for the visualization of each carotid artery and the vertebral-basilar system. Visualization of the entire vascular system from thoracic origin to cranial termination, rather than the cranial circulation alone, also may be important. Visualization of the vertebral artery sometimes is fraught with considerable difficulty. The development of many approaches and complicated techniques attest to this difficulty.

This paper serves to describe a previously unreported, safe technique which has been used fairly extensively at this hospital with excellent results. The technique originally was suggested to one of the authors (E.B.S.) by Dr. E. S. Gurdjian and Dr. Francis Murphey. By means of a single, percutaneous peripheral arterial injection, without catheter or cutdown, serial visualization in two planes of the right internal carotid and vertebral-basilar systems are attained in nearly every case. Because of the ease and safety of this procedure it has replaced direct puncture of the right carotid and vertebral arteries in most patients.

TECHNIQUE

Most patients receive premedication consisting of 200 mg. Nembutal, 100 mg. Demerol and 0.4 mg. atropine. Under this sedation the patient is positioned for simultaneous anteroposterior and lateral views of the head and neck. The Elemen-Schönander biplane rapid film changer is used. The right antecubital region is prepared with an antiseptic solution and the course of the right brachial artery is determined by palpation. Following infiltration with a local anesthetic agent a 17-gauge, 3-in. needle is inserted into the artery near its most superficial portion. The needle is similar to one described by Smiley, who with Dr. Carl List first suggested its use to one of the authors (P.C.B.). The inset in Fig. 1 represents a diagrammatic section of this type of needle. This needle is thin-walled, with a sharp stilette or obturator. The obturator, which has a very fine point, is withdrawn after the needle, with the obturator in place, has pierced both walls of the artery. The needle then is withdrawn slowly until the blunt tip lies within the lumen of the artery. The blunt needle then is threaded up the artery a short dis-
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Fig. 2. Schematic drawing of an aberrant origin of right subclavian artery, showing the mechanism of failure of visualization of right common carotid artery.

tance (1–3 cm.). The final position of the needle in the artery is illustrated in Fig. 1. Thirty cc. of 50 per cent Hypaque then are injected under 7 to 8 kg./cm.² pressure using an automatic injector. Nine serial films are made in each projection simultaneously. These are started automatically after 10 to 20 cc. of the contrast medium have been injected. They usually are taken at a rate of 3 films each second for 2 sec. At 1.3, 2.6 and 4.6 sec. later the 7th, 8th, and 9th films are exposed. However, the speed, timing and number of films may vary, depending upon the known or suspected disease or upon the area in which there is chief interest.

RESULTS

After the adoption and routine use of this procedure for several months it was felt desirable to review the films in these cases and determine how often satisfactory visualization of various arteries was achieved (Figs. 3–14). At the time of this review the films on 53 patients were available for study. The figures that resulted are weighted favorably in that they include only the successful cases. During this period there was a small number of cases in which the procedure was attempted but was unsuccessful, and a right carotid puncture was then performed. Failures resulted from an unsatisfactory placement of the needle in the artery with resultant injection of the contrast medium in the tissues of the arm. Other than initial discomfort in the arm there were no sequelae to such injections. Although the number of these

Figs. 3 and 4. Normal anteroposterior and lateral views of skull during right brachial cerebral angiography. There is good visualization of the anterior, middle and posterior cerebral arteries. Arrow (a) points to superior cerebellar arteries and arrows (b) point to posterior inferior cerebellar artery.
Figs. 5 and 6. Normal anteroposterior and lateral views of skull and neck during right brachial cerebral angiography. There is good visualization of origin of common carotid and vertebral arteries. Later films in the series showed filling of the cerebral branches of these vessels.

Figs. 7 and 8. Anteroposterior and lateral films of skull during left brachial vertebral angiography. There is good visualization of vertebral and basilar arteries and posterior cerebral circulation.
failures was small the exact number is not known and consequently they could not be included in the statistics. Also excluded from the study were right and left brachial angiograms which were performed to visualize the vascular supply of structures other than the brain. These cases will be discussed in other papers.

The visualization of the different cranial vessels was classified as satisfactory only if the visualization was adequate enough to determine the course and caliber of that artery or arterial branch. If the vessel was only partially or incompletely seen, its visualization was classified as unsatisfactory. In cases in which a vascular block prevented visualization of the more distal vessels, the visualization of the distal vessels was classified as unsatisfactory. Mechanical failure of equipment accounts for additional partial failures of visualization. Another cause of failure of filling of the carotid system is an
aberrant origin of the subclavian artery. Fig. 2 illustrates one of the modalities of aberrant origin of this artery. This figure shows schematically why the carotid system would not be visualized in such a case. Daseler and Anson have discussed thoroughly the variation of origin of the subclavian and vertebral arteries.

Despite the above qualifications, the statistics reflect the high frequency of successful visualization of the vertebral-basilar and common carotid systems. The frequency with which these vessels as well as additional lesser arteries of the brain were visualized are given in Table 1.

**DISCUSSION**

The above technique provides an excellent means of visualization of the right subclavian artery, right common carotid artery, the carotid bifurcation, right internal carotid artery and its branches, and the right vertebral-basilar system and its branches. In our hospital it has replaced direct injection of the right carotid artery in most cases. No direct punctures of the vertebral artery have been performed since this procedure was introduced. This method of injection of the brachial artery has many advantages over other procedures used to visualize the vertebral arteries and their branches.

Direct vertebral puncture is difficult even in experienced hands. Anterior, posterior, and lateral approaches have been advocated. None of these methods is easy to perform nor is it successful routinely. None visualizes the proximal portion of the vertebral artery. Schechter has described a tech-

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**Fig. 14.** Lateral view of skull during right brachial cerebral angiography. There is stretching of posterior communicating artery (arrows a) and posterior displacement of basilar artery (arrow b). At operation a tumor of the pons was present.
TABLE 1
Frequency of satisfactory arterial visualization in 53 successful percutaneous right brachial angiograms*

<table>
<thead>
<tr>
<th>Artery</th>
<th>Satisfactory Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>Rt. int. carotid</td>
<td>51</td>
</tr>
<tr>
<td>Bifurcation of carotids</td>
<td>40</td>
</tr>
<tr>
<td>Rt. ant. cerebral</td>
<td>45</td>
</tr>
<tr>
<td>Rt. middle cerebral</td>
<td>48</td>
</tr>
<tr>
<td>Rt. vertebral</td>
<td>52</td>
</tr>
<tr>
<td>Basilar</td>
<td>27</td>
</tr>
<tr>
<td>Rt. post. cerebral</td>
<td>51</td>
</tr>
<tr>
<td>Lt. post. cerebral</td>
<td>37</td>
</tr>
<tr>
<td>Rt. post. communicating</td>
<td>29</td>
</tr>
<tr>
<td>Rt. sup. cerebellar</td>
<td>24</td>
</tr>
<tr>
<td>Post. inf. cerebellar</td>
<td>27</td>
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</tbody>
</table>

* Failures included 1 mechanical failure, 1 block of the internal carotid artery. 1 probable anomalous origin of the right vertebral artery, and 1 aberrant origin of the left subclavian artery. Excluded from the study are a small number of cases in which an unsuccessful injection of the brachial artery occurred.

The technique in which the entire vertebral artery is visualized but it requires two injections and appears to be very difficult. In some patients the small caliber of the vertebral artery nearly precludes direct puncture by any approach. Trauma to the neck and irritation of the brachial plexus are frequent occurrences.

Other methods for visualizing the vertebral-basilar system that have been described include open retrograde injection of the carotid artery after its surgical exposure.19 The insertion of a catheter from peripheral points has been advocated by numerous authors. Sites of origin of the catheter include the femoral artery,4,5 saphenous vein,6 right radial artery,7,8 and right brachial artery. Intravenous techniques9 have been used successfully in some medical centers. Percutaneous puncture of the subclavian artery by various techniques has been advocated.10,11 Several authors10,12,13 have used the right brachial artery to visualize the vertebral artery. All have used surgical exposure and cannulation. A #12-gauge arterial cannula and arterial suturing are required.

All of these techniques have serious disadvantages. Among these are the inherent dangers of thrombosis and embolism associated with catheterization, and the need for dissection and incision of the artery. Most are more time-consuming and more difficult to perform than direct percutaneous puncture of the brachial artery. Many require fluoroscopy and an entire "angiography team." Subclavian puncture is more difficult and entails the risk of pneumothorax. In most of these techniques the site of injection or placement of the tip of the catheter is near or at the site of major blood supply to the brain. Damage to the carotid and vertebral arteries is always a possibility.

Visualization of the internal carotid artery usually is accomplished by direct carotid puncture. Injection of the carotid sheath has occurred occasionally, and has given rise to complications. In some patients visualization of the carotid system should include the origin of the common carotid artery and its bifurcation and not just the intracranial portions. When the major vessels to the brain are the sites of suspected or unsuspected pathology (Figs. 9, 10 and 11), direct arterial puncture may result in further damage and/or failure of visualization of the vascular pathology.

Although we believe that cannulation after isolation and incision of the right brachial artery is an excellent method, the method described here is relatively simple and would seem to be less traumatic to the brachial artery. Surgical approaches14,15 to the brachial artery, contrary to the percutaneous technique described in this paper, necessitates dissection of the brachial artery out of its neurovascular bundle. Tapes are placed beneath the artery; it is lifted out of its normal location; it is occluded by the cannula; and it is sutured at the conclusion of the procedure.

The brachial artery lies quite close to the skin in the antecubital region in most patients. With some experience direct percutaneous puncture of this artery becomes quite easy and produces little trauma. The radial pulse is palpable during and after this procedure. The brachial artery is not oc-
cluded during the procedure.

In this series of 53 patients, 1 patient complained of persistent coldness of one finger. Physical examination revealed no circulatory or neurological abnormality except that the radial pulse on the injected side was not as strong as the radial pulse on the noninjected side. This is the only patient in this series who had any complaints referable to a sequela of the injection. A small number of patients have had a temporary reduction in the caliber of the radial pulse following brachial angiography. However, no subjective complaints indicative of a circulatory deficit have been elicited. In 4 patients, who had brachial angiography, although not of this series of 53 patients, complications developed that we feel worthy of mentioning. Two patients complained of paresthesias in the cutaneous distribution of the median nerve. These paresthesias persisted for more than 1 month in 1 of these patients. The possibility of injury of the median nerve can be understood easily if one considers the close relationship between the brachial artery and this nerve at the level of the elbow (Fig. 15). Injury to this nerve can be avoided by performing the puncture at the lowest possible point of the brachial artery, just before its bifurcation into radial and ulnar arteries. In the third patient there is an absent brachial and radial pulse, but no subjective complaints can be elicited. The fourth patient had left hemiplegia the day following the performance of a right brachial cerebral angiogram. He entered the hospital with symptoms and findings consistent with the diagnosis of cerebral vascular insufficiency. The angiogram was interpreted as normal. This patient made a partial recovery.

In no case has it appeared that a thrombosis of the internal carotid artery has been precipitated by this procedure as sometimes occurs with direct injection of the carotid artery. Although thrombosis of the vertebral artery and insufficiency of the basilar artery may be produced by direct vertebral injection,24 we have had no complications of this nature with brachial vertebral angiography.

The left brachial artery likewise may be injected to visualize the left vertebral-basilar system. This procedure has been used if interest centered upon the left vertebral artery or if the vertebral-basilar circulation was the only area of interest. Because of the vascular anatomy, the left carotid system cannot be visualized by this method. This fact does allow the vertebral-basilar angiogram to be made in the Towne projection as there is no overlap of the anterior circulation.

CONCLUSIONS

Advantages of percutaneous brachial cerebral angiography may be summarized as follows:

1. It is a safe and successful technique.

2. It is performed easily. Most of the injections have been performed by residents in neurosurgery. It is considered as easy as or easier than carotid puncture so that it has

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Fig. 15. Schematic drawing showing course of right brachial artery and its relationship to the median nerve. The site of puncture usually is in the antecubital region.
replaced right carotid puncture in most cases.
3. It is not a complicated, time-consuming procedure. One physician and one technician usually can perform the entire procedure in 30 minutes.
4. No surgical incision, catheter, fluoroscopy, electrocardiographic monitoring or angiography team is needed.
5. It is performed under local anesthesia.
6. Visualization of three-fourths of the cranial vessels occurs in most cases with only one arterial puncture and one injection.
7. The cervical vessels are visualized from their thoracic origin, and are free of puncture artifacts or subintimal injections.
8. The vertebral artery is visualized routinely even when its caliber is so small as to nearly preclude direct puncture.
9. This method markedly decreases the number of injections required to visualize the same vessels by other techniques.
10. No trauma is imposed upon the major arteries to the brain.
11. No irritation of the roots of the brachial plexus occurs.
12. The procedure is accepted by patients far more readily than carotid or vertebral puncture. The procedure inflicts far less discomfort upon the patient than the alternate procedures.

SUMMARY
A technique for cerebral angiography which we regard as a superior method has been described.

The results of over 50 right brachial angiograms were studied. Excellent visualization of the right internal carotid and vertebral-basilar systems occurred in nearly all cases. The left brachial artery likewise may be used to visualize the left vertebral-basilar system. The radiographs of several cases also have been presented. The advantages of the technique and the relatively few sequelae have been described.

REFERENCES
11. Gurujian, E. S. Personal communication.
16. Murphy, F. Personal communication.