Transvenous copper wire insertion for dural arteriovenous malformations of cavernous sinus

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Therapeutic embolization by means of transvenous copper wire insertion was performed in five patients with dural arteriovenous malformations (AVM's) of the cavernous sinus. In each case, angiograms had shown that the AVM's were supplied from both internal and external carotid arteries, which was thought to render complete transarterial embolization difficult. A No. 2.5 French Teflon catheter was introduced into the affected cavernous sinus through the superior ophthalmic or internal jugular vein with the aid of a flexible mini guide wire. Copper wires were pushed by the guide wire into the cavernous sinus until the disappearance or a sufficient decrease in the arteriovenous shunt was noted. The patients' symptoms resolved or improved without any severe complications. Angiography revealed complete disappearance of the lesion immediately after treatment in three cases and follow-up angiography taken within 8 months showed no arteriovenous shunt in any patient. This method is a promising treatment for dural AVM's when conventional transarterial embolization is thought to be difficult.

KEY WORDS: dura mater, arteriovenous malformation, cavernous sinus, embolization, copper wire

Various methods have been advocated for the treatment of dural arteriovenous malformations (AVM's) of the cavernous sinus. These include conservative therapy such as intermittent carotid compression, direct surgical intervention, focal irradiation, and transarterial and transvenous embolization. Among these methods, transarterial embolization is accepted as the treatment of choice; however, in some cases (especially those in which the lesions are supplied exclusively from the internal carotid arterial system), the AVM's are difficult to embolize completely. Direct surgical intervention aimed at obliterating the cavernous sinus with various materials is an alternative therapy in such cases. Because of the risk and the invasiveness of open surgery, it seems better to obliterate the cavernous sinus without craniotomy.

Encouraged by pioneering work using transvenous embolization for the treatment of traumatic carotid cavernous fistulas, we have developed an application of this technique for dural AVM's of the cavernous sinus. This report presents five cases of dural AVM of the cavernous sinus treated by embolization using transvenous copper wire insertion.

Summary of Cases

Patient Population

During the past year, five patients with dural AVM's of the cavernous sinus were treated with transvenous copper wire insertion through the superior ophthalmic or internal jugular vein. The patients included four women and one man, aged 40 to 63 years (Table 1). Clinical symptoms and signs on admission were as follows: exophthalmos in four cases, chemosis in four, bruit in three, diplopia in two, disturbances of ocular movement in three, and headache and ocular pain in three. Although visual acuity was not disturbed, raised intraocular pressure was noted in four cases. None of the patients had a history of head trauma.

Preoperative Studies

Angiographic examination included studies of both external and both internal carotid arteries and at least one vertebral artery. In three cases (Cases 1, 4, and 5), bilateral external and internal carotid branches fed a unilateral dural AVM of the cavernous sinus. Branches from both external arteries and from one internal ca-
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Fig. 1. Case 4. This 40-year-old man with high-flow dural arteriovenous malformation of the left cavernous sinus was treated by the anterior approach. Selective injection of the left ascending pharyngeal (A) and more distal external carotid artery (B) showed an abnormal arteriovenous shunt within the dura around the posterior inferior aspect of the left cavernous sinus which drained into the superior and inferior ophthalmic veins, superficial middle cerebral vein, and basal vein of Rosenthal. Right external carotid and bilateral internal carotid angiography revealed accessory feeding arteries to the same lesion (not shown). A small catheter was placed into the cavernous sinus (C). At the end of embolization, the abnormal arteriovenous shunt had disappeared (D).

Operative Procedure

The therapeutic embolization was performed in an operating room where a DSA unit was available under modified neuroleptanalgesia and local anesthesia. All procedures were monitored by high-quality fluoroscopy and DSA. A No. 5 French sheath introducer was placed into the femoral artery and left for arteriographic control during the operation.

For the anterior approach via the superior ophthalmic vein, a 5- to 10-mm long incision was made at the

Table 1

Summary of cases treated by transvenous copper wire insertion

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Symptoms</th>
<th>Feeding Arteries</th>
<th>Draining System</th>
<th>Operative Approach</th>
<th>Degree of Thrombosis</th>
<th>Follow-Up Symptoms</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51, F</td>
<td>It exoph, lt chemosis,</td>
<td>bilat ECA (ltt),</td>
<td>lt SOV (35 cm)</td>
<td>complete</td>
<td>none at 10 mos</td>
<td>slight V dysesthesia</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lt VI palsy</td>
<td>bilat ICA</td>
<td></td>
<td>incomplete at 1 mo</td>
<td>complete at 6 mos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>55, F</td>
<td>rt exoph, rt chemosis,</td>
<td>bilat ECA (rtt),</td>
<td>rt SOV (106 cm)</td>
<td>incomplete at 8 mos</td>
<td></td>
<td></td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rt bruit, rt V pain</td>
<td>rt ICA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>63, F</td>
<td>It III palsy, bruit,</td>
<td>bilat ECA (ltt),</td>
<td>bilat IPS</td>
<td>complete</td>
<td>none at 8 mos</td>
<td>aggravation of lt III palsy, improved within 2 wks</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pul-sating headache</td>
<td>lt ICA</td>
<td></td>
<td>complete at 8 mos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>40, M</td>
<td>lt exoph, lt chemosis,</td>
<td>bilat ECA (ltt),</td>
<td>lt SOV (269 cm)</td>
<td>complete</td>
<td>none at 6 mos</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>lt V miosis,</td>
<td>bilat ICA</td>
<td></td>
<td>complete at 6 mos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50, F</td>
<td>rt exoph, rt chemosis,</td>
<td>bilat ECA (rtt),</td>
<td>rt SOV (53 cm)</td>
<td>incomplete</td>
<td>none at 5 mos</td>
<td>aggravation of rt VI palsy, improved within 1 wk</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rt V pain, rt VI palsy</td>
<td>bilat ICA</td>
<td></td>
<td>at 5 mos</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Abbreviations: exoph = exophthalmos; III = oculomotor nerve; V = trigeminal nerve; VI = abductens nerve; ECA = external carotid artery; ICA = internal carotid artery; SOV = superior ophthalmic vein; IOV = inferior ophthalmic vein; SMCV = superficial middle cerebral vein; IJV = internal jugular vein; IPS = inferior petrosal sinus.
† Main feeding vessel.
‡ Total length of copper wire used is shown in parentheses.
Transvenous treatment of dural AVM’s

medial corner of the upper eyelid. A Doppler ultrasound detector was used to identify the exact outlet of the arterialized blood flow. It was useful to decline the head of the patient when the superior ophthalmic vein was not hypertrophied. With the aid of torque-controlled floppy guide wires (0.014 to 0.018 in. in outer diameter), a No. 2.5 French Teflon catheter was introduced into the site of the arteriovenous shunt in the affected cavernous sinus (Fig. 1C). In the last four cases, guide wires with a platinum tip designed for percutaneous transluminal angioplasty were used because of the excellent maneuverability in selective placement of the Teflon catheter and superior radiopacity for intraoperative fluoroscopy. The site could also be detected by intracavernous venography. For the posterior approach via the internal jugular vein, a No. 4 French catheter was introduced percutaneously via the cervical jugular vein into the orifice of the inferior petrosal sinus. The Teflon catheter was then introduced coaxially into the cavernous sinus.

A flexible small-caliber copper wire (0.05 mm in outer diameter) was used as an embolic material. Double-twisted copper wire (5 to 15 cm in length) was pushed either by the same guide wire that was used for the introduction of the Teflon catheter or by a slightly stiffer 0.018-in. guide wire. The end of the wire was folded several times to a diameter a little smaller than the inner diameter of the Teflon catheter so that it would be detectable fluoroscopically and in order to introduce it more easily (Fig. 2). During embolization, intracavernous thrombosis was monitored carefully by intracavernous venography and arteriography, especially near completion of the procedure (Fig. 1D). To avoid overembolization, it was necessary to wait several minutes after the procedure to observe the progress of the thrombosis.

After embolization, selective bilateral internal and external carotid and vertebral angiography was performed to obtain a baseline for follow-up monitoring. In the four cases in which the anterior approach was used, the puncture site in the superior ophthalmic vein was ligated and coagulated, and the upper eyelid was sutured with plastic surgical technique. In the one patient undergoing a jugular puncture (Case 3), hemostasis was achieved by compression. Follow-up angiography was performed within 8 months.

Postembolization Results

Clinical improvement in the bruit, chemosis, and exophthalmos occurred after embolization in all cases. Immediate angiographic studies showed disappearance of the dural AVM in three cases and faint filling of the cavernous sinus in two cases. However, in Case 1 (the first case in which this technique was used) follow-up angiography 1 month later showed faint filling of the dural AVM with opacification of the superior ophthalmic vein. Because intraocular pressure did not decrease sufficiently, this patient received conventional radiotherapy amounting to 40 Gy. In the postembolization course, transient cavernous sinus syndromes were observed but all symptoms cleared within a few days to a month. Except for this, there were no neurological or systemic complications. Follow-up angiography ranged from 5 to 8 months postembolization, and showed no evidence of persistence of the dural AVM. Clinical follow-up examination ranging from 5 to 10 months revealed that there was no recurrence and that the patients were doing well (Table 1).

Discussion

Recent developments in intravascular neurosurgery offer the opportunity to treat dural AVM’s without open surgery. Transarterial embolization using various embolic materials has now been accepted as the treatment of choice. The use of liquid material such as isobutyl 2-cyanoacrylate (IBCA) requires special techniques with superselective catheterization to avoid the complications of catheter gluing, cranial-nerve palsies, and even unwanted embolization of pial arteries via tiny collateral vessels. For the embolization of external carotid artery branches, often bilaterally, several embolization sessions may be necessary. We have developed a chemical embolization method using estrogen without fear of such complications; however, in some patients, especially those whose lesion is supplied exclusively from tiny internal carotid artery feeders, complete embolization is difficult to achieve. Because of the relatively benign clinical course, aggressive therapy such as detachable-balloon occlusion of the cavernous internal carotid artery should be avoided. It seemed reasonable for us to treat such cases by transvenous embolization.

Transvenous embolization was first used in cases of bilateral low-flow dural AVM’s in 1987 by Courtheoux, et al., who introduced steel coils and sclerosing liquid via the superior ophthalmic vein. To our knowledge, this technique was first reported in 1969 by Peterson, et al., who used it to treat a traumatic carotid-cavernous fistula (CCF) with copper wire and electrical current. After that, it was used for traumatic CCF’s by various investigators. In 1988, Debrun, et al.,
reported two cases of dural AVM treated by a detachable balloon introduced through the superior ophthalmic vein. There has been no report of transvenous embolization using copper wire through a retrogradely introduced catheter for dural AVM, and the method described here might thus be considered a new application.

Transvenous embolization has many advantages compared with transarterial embolization. In spite of the complex feeding arteries, dural AVM’s of the cavernous sinus simply drain into the sinus with intervening vascular networks within the adjacent dura. This situation makes it feasible to occlude the cavernous sinus in order to obliterate the abnormal arteriovenous communication without fear of rupturing vascular networks. This is therefore a curable approach, with little risk of complications such as thromboembolic events or arterial injury that sometimes occurs in transarterial embolization.

Transvenous embolization is also associated with some complications and limitations, such as spasm or occlusion of the parent artery, rupture of the superior ophthalmic vein, difficulty in entering the cavernous sinus, postembolization cavernous sinus syndrome, and incomplete obliteration of the shunt. To decrease these complications, two modifications have been adopted which have not previously been reported. First, a No. 2.5 French Teflon catheter was used to negotiate the relatively small-caliber and tortuous superior ophthalmic and internal jugular veins. With the aid of a flexible platinum-tipped guide wire, it is not difficult to introduce the catheter exactly into a desired portion of an abnormal shunt. Uflacker et al., warned about the possibility of venous rupture during the use of No. 5 French catheters in cases of recent traumatic CCF with nonarterialized veins. Gentle maneuvering of a soft-tipped catheter should avoid such a serious complication. Moreover, this catheter and guide wire combination has the advantage of more precise placement for complete occlusion of the lesion. Recent development of more supple catheter materials may fulfill the requirement for precise embolization.

Second, very thin thread-like copper wires were utilized as embolic material. These wires easily transform their shapes on entering the lesion to obliterate the abnormal shunt more completely as compared with the Gianturco type of steel coils. Electrical irritation of the vessel can be avoided by use of copper wires without electrical current. Introduction of liquid materials such as a sclerosing agent or tissue adhesives seems to be a more aggressive treatment, but the risk of embolization of the draining venous outflow which might result in serious complication seems to be higher. Because embolization is against the blood flow in these cases, it is difficult to introduce a detachable balloon. The only complication observed in our series was a transient postembolization cavernous sinus syndrome. We think this is caused by too much wire compressing the sinus wall. Therefore, it is important to determine an adequate amount of wire; this plus precise intraoperative DSA monitoring and focal obliteration of the abnormal shunt should be useful in avoiding this complication.

References


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