Polytetrafluoroethylene interposition grafts in vertebral to carotid artery transposition

A long-term follow-up study

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Eight patients undergoing an end-to-side vertebral artery (VA) to common carotid artery (CCA) transposition between August, 1979, and July, 1982, had a polytetrafluoroethylene (PTFE) interposition graft placed when a direct anastomosis was believed not to be satisfactory. Five of these patients are living; clinical and radiographic follow-up studies over periods ranging between 54 and 82 months show that their transpositions are patent. Two patients died perioperatively, one from an acute anterior myocardial infarction and the other from acute VA occlusion with a propagating thrombus. A third patient died of myocardial infarction 20 months after graft placement; the anastomosis had been found patent at 12 months. This report gives the clinical and radiographic follow-up results in a previously reported group of patients with PTFE interposition grafts. Some of these patients have been followed for over 6 years after surgery; the average radiographic follow-up period in the five survivors is 60 months, and all grafts are patent without evidence of progressive stenosis. Expanded PTFE appears to be an acceptable material for short interposition grafts in operations involving the VA; however, direct artery-to-artery anastomosis is preferred. The results of longer PTFE grafts in reconstructive cerebrovascular surgery have not been adequately studied.

KEY WORDS • polytetrafluoroethylene • anastomosis • vertebral artery • carotid artery • arterial interposition graft

Vertebral artery (VA) end-to-side transposition to the common carotid artery (CCA) in order to relieve symptoms of hindbrain ischemia due to proximal VA disease or subclavian steal syndrome has been reported by several authors with good results. It may be technically difficult to obtain adequate lengths of VA to transpose to the CCA, depending on anatomical variations and the extent of the diseased portion of the VA. This report discusses the long-term follow-up results in eight patients undergoing a VA-CCA transposition when an interposition graft of polytetrafluoroethylene (PTFE) 2 cm in length and 3 or 4 mm in diameter was used. Earlier results have been published previously.

Clinical Material and Methods

Twenty VA-CCA transpositions were performed by the neurosurgical service at the University of Texas Health Science Center, San Antonio, between January, 1978, and December, 1982. An interposition graft was deemed necessary in 11 patients: saphenous vein was used in three cases, and a PTFE graft in eight. The diameter of the PTFE graft was 3 or 4 mm, depending on the size of the VA. The purpose of this paper is to present the long-term follow-up findings in the eight patients with PTFE interposition grafts.

Follow-up results were obtained for all of the patients receiving PTFE interposition grafts. The characteristics of this group did not differ significantly from the remainder of the series. The average age at the time of operation was 58.9 years (range 46 to 71 years) for the PTFE group and 58.3 years (range 48 to 67 years) for the group with direct anastomosis or vein interposition grafting. The PTFE placement operation involved the left VA in five cases and the right VA in three cases.

Table 1 lists the procedures performed, the diameter of the interposition grafts, the clinical follow-up period, and the most recent angiographic findings. Figures 1, 2, and 3 present angiograms taken from patients having...
Polytetrafluoroethylene interposition grafts

**TABLE 1**

*Summary of course in eight patients with PTFE graft placement*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Date of Operation</th>
<th>Procedure</th>
<th>Diameter of PTFE Graft</th>
<th>Clinical Follow-Up Findings</th>
<th>Radiographic Follow-Up Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55</td>
<td>8/9/79</td>
<td>rt VA-CCA</td>
<td>4 mm</td>
<td>82 mos: asymptomatic</td>
<td>angio 31 mos: patent, ultrasound 82 mos: patent</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>5/12/80</td>
<td>lt CEA &amp; VA-CCA</td>
<td>4 mm</td>
<td>symptoms resolved; died of MI 20 mos postop</td>
<td>angio 12 mos: patent</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>8/5/80</td>
<td>rt VA-CCA</td>
<td>4 mm</td>
<td>died of MI 24 hrs postop</td>
<td>angio 12 mos: patent</td>
</tr>
<tr>
<td>4</td>
<td>58</td>
<td>12/8/80</td>
<td>lt VA-CCA; earlier bilat CEA's &amp; lt CCA-SCA Dacron graft</td>
<td>3 mm</td>
<td>orthostatic symptoms only at 78 mos postop</td>
<td>IV-DSA 75 mos: patent angio 26 mos: patent IV-DSA 54 mos: patent</td>
</tr>
<tr>
<td>5</td>
<td>46</td>
<td>5/12/81</td>
<td>rt VA-CCA</td>
<td>3 mm</td>
<td>54 mos: asymptomatic</td>
<td>angio 12 hrs: patent</td>
</tr>
<tr>
<td>6</td>
<td>52</td>
<td>5/26/81</td>
<td>lt CEA &amp; VA-CCA</td>
<td>4 mm</td>
<td>66 mos: lt cerebrovascular accident at 29 mos postop</td>
<td>angio 66 mos: nonprogressive anastomotic stenosis</td>
</tr>
<tr>
<td>7</td>
<td>59</td>
<td>6/22/81</td>
<td>lt CEA &amp; VA-CCA</td>
<td>4 mm</td>
<td>54 mos: asymptomatic</td>
<td>angio 18 mos: patent IV-DSA 54 mos: patent angio 2 days: occluded lt VA &amp; basilar artery thrombus</td>
</tr>
<tr>
<td>8</td>
<td>62</td>
<td>6/21/82</td>
<td>lt VA-CCA</td>
<td>4 mm</td>
<td>sudden coma &amp; died 2 days postop</td>
<td>IV-DSA 75 mos: patent</td>
</tr>
</tbody>
</table>

* Vascular procedures in treatment of simple and complex vertebrobasilar arterial insufficiency. Polytetrafluoroethylene (PTFE) interposition grafts were placed in all vertebral artery (VA) to common carotid artery (CCA) bypasses. CEA = carotid endarterectomy; MI = myocardial infarction; SCA = subclavian artery; IV-DSA = intravenous digital subtraction angiography.

undergone VA-CCA transposition employing PTFE interposition grafts.

Results

The clinical follow-up period ranged from 2 days to 6 years 10 months. All grafts except one (in Case 8) remained patent on follow-up vascular imaging (angiography or ultrasound studies). Two patients (Cases 3 and 8) died in the perioperative period: one from an anterior myocardial infarction and the other from neurological complications following acute postoperative occlusion of the VA with a propagating thrombus, demonstrated by angiography. One patient (Case 2) died 20 months postoperatively from a myocardial infarction. He was asymptomatic neurologically, and an angiogram at 12 months showed a patent anastomosis with good flow. Table 1 lists the procedure, diameter of interposition graft, and duration of the clinical follow-up period and follow-up vascular imaging, including arteriography, intravenous digital subtraction angiography (IV-DSA), and ultrasound evaluation.

![Fig. 1](image1.png)

**FIG. 1.** a: Preoperative arch angiogram showing bilateral internal carotid artery disease (arrows) with an occlusion on the right and stenosis on the left. High-grade stenosis is present at the left vertebral artery origin (open arrow). The right vertebral artery contributed little to the intracranial circulation. b: Arch angiogram after placement of a polytetrafluoroethylene interposition graft. The arrow shows the site of anastomosis.

![Fig. 2](image2.png)

**FIG. 2.** Intravenous digital subtraction study performed 54 months after operation in the same patient as depicted in Fig. 1. The arrow shows the anastomosis.
trophy did not appear. Patency rates in experimental microvascular anastomoses vary. Cuadros reported 100% patency in the carotid artery of rats at 2 weeks if sterile conditions were observed. Barry, et al., reported 50% patency in heparinized animals. Watanabe achieved a 90% patency at 7 months by using a telescoping technique of anastomosis, drawing the vessel inside the lumen of the graft to avoid exposing the cut surface of the PTFE.

There have been scattered reports of PTFE grafts 4 to 6 mm in diameter being used in aortocoronary bypass procedures. This material has only been used in extreme circumstances when saphenous veins or internal mammary arteries were not available for grafting. Molina, et al., Murtra, et al., von der Emde and Rein, and Islam, et al., have reported single cases with patency demonstrated between 3 and 53 months after PTFE graft placement. Yokoyama, et al., reported five patients with PTFE grafts, of which four were patent 3 to 6 months postoperatively. Sapsford, et al., reported a total of 27 grafts used in 16 patients. The angiographic follow-up monitoring varied, but six of nine grafts were patent 12 to 29 months postoperatively.

In our series of eight patients, five are alive and asymptomatic. One graft occlusion occurred acutely with a fatal outcome. The other two deaths were the result of myocardial infarctions, one early and one late. Both patients had patent grafts angiographically. The average duration of radiographic follow-up studies in the five survivors (angiograms or IV-DSA in all five and ultrasound study in one) is 60 months after graft placement, and all grafts are patent without evidence of progressive stenosis.

Discussion

When an adequate length of a VA is not available for transposition to the CCA, operative choices include further dissection of the artery from the transverse foramina or interposition of a graft. Further dissection increases the risk of arterial injury, bleeding from the venous plexus surrounding the artery, injury to radicular arteries, and injury to the sympathetic nerves resulting in a Horner's syndrome. It is important that tension at the anastomotic site be avoided. Anastomosis too near the carotid bifurcation is also undesirable. A saphenous vein graft requires another procedure to harvest the vein, and an adequate vein may not be obtainable for a variety of reasons. Expanded PTFE is a material readily available for grafting and is technically easy to work with. Clinical experience with PTFE derives from its use in peripheral vascular surgery and coronary bypass operations. Experimental work with microarterial anastomoses has also been performed.

Expanded PTFE is composed of PTFE nodes connected by thin fibers of the same material, producing a mesh with 30-μ diameter pores. The grafts are externally strengthened by a fine lattice of PTFE. Histological examination shows that the graft allows the ingrowth of platelets, capillary formation, and the establishment of a neointima. Soon after placement, the graft is covered by a fibrin network, which increases and is then joined by platelet cells. A continuous neointima from the host vessel is progressively formed over the fibrin layer. Formation of neointima in the graft is important for maintaining a physiological surface in contact with the blood. The possibility of hypertrophy of the intima and resultant stenosis or occlusion must be considered. Watanabe used grafts 20 mm in length with an inside diameter of 1.5 mm, and showed that a neointima was present at 14 days; however, it took 90 days for the entire graft to be covered. No thrombi formed during this period. Excessive endothelial hypertrophy did not appear. Patency rates in experimental microvascular anastomoses vary. Cuadros' reported 100% patency in the carotid artery of rats at 2 weeks if sterile conditions were observed. Barry, et al., reported 50% patency in heparinized animals. Watanabe achieved a 90% patency at 7 months by using a telescoping technique of anastomosis, drawing the vessel inside the lumen of the graft to avoid exposing the cut surface of the PTFE.

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References

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Manuscript received May 2, 1988.
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