Subclavian steal syndrome

Part 2: Intraoperative vertebral artery blood flow measurement

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Intraoperative vertebral artery blood flow was measured in two patients with symptomatic subclavian steal syndrome, before and after proximal end-to-side vertebral to common carotid artery transposition. This confirmed retrograde flow in the vertebral artery before transposition, and antegrade flow after transposition. The measured flow rates were compared to values in other series involving different operative procedures for correction of symptomatic subclavian steal. The greatest mean antegrade flow rates in the vertebral artery were restored by proximal end-to-side vertebral to common carotid artery transposition.

Key Words: blood flow velocity · cerebral vascular disorder · collateral circulation · subclavian steal syndrome · vascular surgery · vertebral artery

The subclavian steal syndrome is a well known cerebrovascular disorder in which blood is siphoned from the circle of Willis, and flows retrograde down a vertebral artery, as collateral to a proximally occluded subclavian artery. A discussion of surgical approaches to treatment of the symptomatic syndrome and a description of an operation, proximal end-to-side vertebral to common carotid artery transposition, used recently in three patients, were the subjects of another paper. Intraoperative vertebral artery blood flow was measured in two of those patients before and after vertebral artery transposition. The results suggest that this procedure may restore higher mean rates of antegrade vertebral artery flow than do other available procedures.

Summary of Cases

Procedure

The three patients had incapacitating neurological symptoms of subclavian steal syndrome due to complete atherosclerotic occlusion of the left subclavian artery in two and stenosis of the left subclavian artery in the third. All three underwent left proximal end-to-side vertebral to common carotid artery transposition. Collateral circulation to the distal subclavian artery was demonstrated angiographically from the thyrocervical trunk and small vessels off the aortic arch, in addition to collateral flow through the vertebral artery. Clinical details of these three patients are reported elsewhere.

Under general anesthesia the proximal left vertebral artery was exposed from its origin off the subclavian artery up to its entrance into the C-6 transverse foramen. In the two patients with subclavian artery occlusion, blood flow rates in the proximal vertebral artery were measured with an electromagnetic flowmeter before and after end-to-side anastomosis to the common carotid artery. A 4-mm handle-type probe was used.

Results

Both patients initially had retrograde flow in the vertebral artery of 90 and 115 ml/min, respectively. This flow reversed after anastomosis, to 150 and 160 ml/min antegrade (Table 1). In one patient, temporary occlusion of either the vertebral artery or the large ascending branch of the thyrocervical trunk before transposition lowered the ipsilateral brachial blood pressure, measured by cuff, from its resting systolic level of 62 torr, to 50 torr. Simultaneous temper...
TABLE 1

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Systemic Blood Pressure</th>
<th>Preop</th>
<th>Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120/80†</td>
<td>-115</td>
<td>+160</td>
</tr>
<tr>
<td>2</td>
<td>110/60‡</td>
<td>-90</td>
<td>+150</td>
</tr>
<tr>
<td>mean</td>
<td>-130</td>
<td>+155</td>
<td></td>
</tr>
</tbody>
</table>

* = retrograde flow (brachial), and + = antegrade flow (cephalad).
†Dorsalis pedis intra-arterial pressure.
‡Contralateral radial intra-arterial pressure.

subclavian artery occlusion, on the order of 100 ml/min, than in those with stenosis, in whom flow is usually around 15 to 30 ml/min retrograde.1,10 Interesting extreme cases, with vertebral artery flow as high as 500 ml/min, have been recorded.8 Also, some patients in whom antegrade vertebral artery flow was restored by subclavian endarterectomy still developed retrograde flow upon simulated arm exercise.6 Exercise was simulated in those experiments by inflating and releasing a blood pressure cuff to produce reactive arm hyperemia, and by intra-arterial injection of a vasodilator into the subclavian artery.

Surgical treatment of the neurological manifestations of subclavian steal syndrome is predicated upon improving cerebral circulation. This may be accomplished by increasing flow through other vessels, as in treatment of associated, hemodynamically significant, carotid artery stenosis.11,12 Another method is arresting the steal, most simply by vertebral artery ligation.10,16 A preferable approach is not merely arresting the steal, but restoring antegrade flow through the vertebral artery. A number of surgical procedures are available that usually accomplish this, but not all consistently restore flow to the physiological range (Table 2).

Anatomically the purest reconstruction, subclavian endarterectomy, generally results in satisfactory flow rates in the vertebral artery, but the range is very wide, and failure to maintain antegrade flow during exercise has occurred. Carotid to subclavian bypass, which is currently the most popular operation for subclavian steal syndrome, produced the lowest mean flow rates in the vertebral artery. This procedure is popular because of ease of performance and success in restoring flow in the extremity. However, experimental models of subclavian steal syndrome have demonstrated failure of this procedure to restore antegrade flow in the vertebral artery.1,8 Furthermore, in one patient a carotid to subclavian steal was documented that reduced distal common carotid artery flow from 190 ml/min to 50 ml/min.6

TABLE 2

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>No. of Patients</th>
<th>Status of Artery</th>
<th>Initial Flow</th>
<th>Procedure</th>
<th>Postop Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berger, et al., 1967</td>
<td>1</td>
<td>occlusion</td>
<td>-29</td>
<td>SCE</td>
<td>+97</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>stenosis</td>
<td>-26</td>
<td>SCE</td>
<td>+85</td>
</tr>
<tr>
<td>Ekeström &amp; Retamal, 1967</td>
<td>8</td>
<td>occlusion</td>
<td>-128</td>
<td>SCE</td>
<td>+128</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>stenosis</td>
<td>-15</td>
<td>SCE</td>
<td>+61</td>
</tr>
<tr>
<td>Barner, et al., 1971</td>
<td>2</td>
<td>occlusion</td>
<td>-49</td>
<td>C-SCB</td>
<td>+15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>stenosis</td>
<td>-26</td>
<td>C-SCB</td>
<td>+38</td>
</tr>
<tr>
<td>Magaard &amp; Ekeström, 1976</td>
<td>20</td>
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<td>-97</td>
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<td>+108</td>
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<td>-15</td>
<td>SCE</td>
<td>+88</td>
</tr>
<tr>
<td>Mehigan, et al., 1978</td>
<td>8</td>
<td>occlusion</td>
<td>-62</td>
<td>SC-CT</td>
<td>+82</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>occlusion</td>
<td>-103</td>
<td>V-CCT</td>
<td>+155</td>
</tr>
</tbody>
</table>

* = retrograde (brachial), + = antegrade (cephalad). SCE = subclavian endarterectomy; SC-CT = subclavian to carotid transposition; C-SCB = carotid to subclavian bypass; V-CCT = vertebral to common carotid transposition.
Vertebral artery blood flow

These blood flow data suggest that the greatest mean antegrade flow rates in the vertebral artery may be restored by proximal end-to-side vertebral to common carotid artery transposition. When subclavian steal syndrome is treated with this procedure or by vertebral artery ligation alone, a principal consideration is whether flow to the extremity will remain adequate. Measurement of distal subclavian artery flow after temporary occlusion of a reverse-flowing vertebral artery would suggest whether elimination of the retrograde flow would critically diminish extremity perfusion. Unfortunately, there are no reports of such flow measurements. However, in our second case, temporary occlusion of both the vertebral artery and the large branch of the thyrocervical trunk had only a modest effect on the brachial blood pressure. Furthermore, in 20 cases of vertebral artery ligation for this syndrome, the worst result has been claudication of a notable degree induced by exercise in only one patient. In our three cases, after proximal end-to-side vertebral to common carotid artery transposition, the blood pressure and pulse amplitude in the ipsilateral upper extremity were not diminished. It appears that, over a period of time, the numerous collateral channels to the subclavian artery, other than the vertebral artery, assume the volume of flow previously carried retrograde through the vertebral artery.

In summary, intraoperative flow measurement clarifies direction and rate of flow in the vertebral artery before and after surgical procedures performed to correct the symptomatic subclavian steal. The effectiveness of various operative procedures may thus be critically evaluated and compared. The mean antegrade flow rate restored in the vertebral artery by proximal end-to-side vertebral to common carotid artery transposition in two patients was greater than the mean flow rates produced by subclavian endarterectomy, subclavian to carotid artery transposition, and carotid subclavian bypass in other series. Statistical comparison of these results would not be significant, due to small numbers of cases and wide ranges of postoperative flow rates in some categories. However, the advantages of an extrathoracic vascular reconstruction that emphasizes direct blood flow to the brain rather than to the extremity, and the measured high volume of antegrade vertebral artery flow after proximal end-to-side vertebral to common carotid artery transposition, suggest that this procedure may be preferable for the treatment of most patients with neurological symptoms of subclavian steal syndrome.

Acknowledgments

The authors acknowledge the generous contributions of the Science Unlimited Research Foundation and Mr. Milton B. Clapp in their support of the University of Texas Health Science Center Neurosurgical Research Laboratories.

References


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