Surgical Treatment of Vertebral Artery Insufficiency Caused by Cervical Spondylosis*

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Symptoms that can be attributed to vertebral-basilar insufficiency are being diagnosed more commonly because of the increasing use of angiographic visualization of the vertebral arteries. Congenital or acquired stenosis of the vertebral artery at its origin from the subclavian artery, or kinking, especially of the first portion of the artery, can critically reduce the blood flow to the brain stem.5–8 Atherosclerotic narrowing of the vertebral-basilar system with involvement of long stretches of the vessels has a similar effect on the circulation. On rare occasions, the formation of cicatrices after thyroidec-tomy has caused vertebral insufficiency;13 compression of the vertebral artery against the lateral mass of the atlas has also been reported.3 It has been suggested that compression and displacement of one or both vertebral arteries, by spondylotic cervical vertebrae, may interfere with circulation. The frequency of this lesion and its exact clinical significance is not well known and few attempts have been made to correct this condition by surgical measures.

The surgical procedure presented here evolved from observations of patients after removal of spondylotic spurs by an anterior approach. A number of such patients have been operated upon for spondylosis with associated pyramidal tract signs. Postoperative x-rays and myelograms not only demonstrated that the big bony spurs have been effectively removed; they also showed an even more interesting development, namely, the disappearance of the remnants of these spurs following interbody fusion. Even those lateral osteophytes that were not completely removed at the operation subsequently disappeared.1 This prompted one of the authors (L.B.) to perform this operation in patients with vertebral insufficiency produced by cervical spondylosis.

Radiological and Operative Technique

The operation was performed in 3 patients whose chief complaint was severe and disabling dizziness brought about by positional change in the cervical spine. The detailed description will be limited to 2 of these patients, who were adequately evaluated several months after operation.

All patients had initial and follow-up plain films of the cervical spine. Myelography was used to determine the degree of encroachment upon the neural canal by the spurs. Pre- and postoperative three-positional pancervical angiography was carried out. Using the Seldinger technique, a #8 Teflon catheter was introduced into the ascending aorta via the femoral artery. Three sets of serial films were taken with the neck in extension, rotated to the right and then to the left. The patient was asked if any given position had exacerbated the symptoms; an attempt was made to simulate this position. A 40–45 cc. bolus of 90 per cent Hypaque was injected for each series. The procedure was well tolerated.

The operation was carried out in a routine fashion as described by Cloward.6 The cervical canal was entered not in the midline but centered toward the side where the vertebral artery is larger and more compressed (Fig. 1). The bulk of the spondylotic spur was removed in this process. From a cleav-
age plane between the posterior aspect of the vertebral bodies and the posterior longitudinal ligament, as much of the lateral osteophytes as possible was removed by curettes directed toward the intervertebral foramina. This usually resulted in the removal of the bulk of the lateral spur. However, we deliberately refrained from entering the intervertebral foramen so as to avoid any possible direct or indirect injury to the artery or nerve. Particular attention was paid to the disruption of the osteophytic bridges between the two adjacent vertebrae. A routine interbody fusion was then performed with bone taken from the iliac crest.

Case Reports

Case 1. R. G., a 47-year-old white man, was admitted on September 18, 1962, with the chief complaints of dizziness and fainting spells. These symptoms had started 4 years earlier, but had become more frequent in the last year, occurring almost daily during the last few months. These spells were associated with bending over or looking up. Beyond this observation, the patient, whose intelligence was limited, could not associate symptoms with any particular motion of the cervical spine. Every vertiginous episode was characterized by a feeling that the room was spinning around. This was immediately followed by a feeling of faintness. Occasionally the patient had to hold on to objects to steady himself; sometimes he dropped to his knees, and on about 24 occasions, he actually lost consciousness for a brief but undetermined period of time. The patient also complained of intermittent numbness of the 3rd, 4th and 5th fingers of both hands. He was a chronic alcoholic and had been treated for diabetes over the last 6 years.

Examination. Physical examination revealed a blood pressure of 160/90. His neck was supple, with only slight limitation of movement in flexion, extension, and lateral rotation of the cervical spine. Tests of labyrinthine function revealed no abnormality that could have accounted for his vertigo. Muscle weakness was limited to the left triceps. There was no spasticity and no ataxia. Sensory examination showed no abnormality. Both triceps and biceps reflexes were absent on the left. Knee jerks were very lively bilaterally but both ankle jerks were depressed. A positive Babinski response was present bilaterally. An electroencephalogram showed slight and diffuse slow wave activity. There were no epileptiform discharges and no focal abnormality.
X-ray studies of the cervical spine showed minor narrowing of the C4-5 disc space and notable narrowing of the C5-6 space with associated retrolisthesis of C-5 on C-6. Posterior spurring was present at C5-6. Vertebral spurring was noted at C3-4, C4-5, and C5-6 on the right and at C5-6 on the left.

Preoperative myelography revealed marked anteroposterior narrowing at the C5-6 disc level with posterior compression due to the posterior arch of C-6 and anterior compression by the spurring and posterior displacement of C-5. The root sheaths were obliterated and a partial myelographic block was present.

The pan-cervical angiogram (Fig. 2) showed a normal aortic arch and carotid arteries. The right vertebral artery was indented and displaced laterally by a vertebral spur at C4-5. More importantly, it was compressed by a similar spur at C5-6 with some diminution in the size of the lumen. The smaller left vertebral artery was also slightly narrowed by a spur at C5-6. On turning the head to the right, the indentation of the left vertebral artery disappeared. On the right, there was little change at C4-5, but the lumen size at C5-6 was notably diminished. On turning the head to the left, the left vertebral artery was virtually occluded by the spur; while on the right the indentation at C4-5 was essentially unchanged, but that at C5-6 had disappeared.

Operation (October 4, 1962). By a right anterior approach, the C5-6 interspace was explored. Our efforts were directed to an eventual decompression of the right vertebral artery since the left was so rudimentary that it did not seem to offer a worthwhile surgical target. The continuity of any spurs bridging the interspace laterally was broken by forcefully spreading the vertebral bodies apart until free motion between C-5 and C-6 was established. After careful curettage, interbody fusion was effected. Postoperative recovery was uneventful and the patient was discharged on October 12, 1962. Follow-up x-rays of the cervical spine revealed good bony fusion 5 months later, no motion at C5-6, but still some retrolisthesis of C-5 on C-6. The vertebral spurs at C5-6 had regressed.

Follow up. The patient was admitted for evaluation on March 7, 1963. By this time, his condition had improved greatly. He no longer complained of fainting spells and occasional episodes of vertigo were rare and mild. Motion of the cervical spine, particularly upward turning of the head which previously had always been associated with dizziness and faintness, produced no symptoms. The left triceps jerk was still absent but the biceps reflex had returned and the Babinski response had become normal bilaterally.

A myelogram done at this time revealed no block at C5-6, and a smooth anterior contour of the Pantopaque column. Repeat pan-cervical angiography (Fig. 3) demonstrated virtual absence of displacement or compression of the vertebral arteries at C5-6 and, of course, no change at C4-5 on the right. Right and left rotation failed to produce any compromise of either vertebral artery in notable contrast to the preoperative response to this maneuver.

Case 2: S.W., a 42-year-old colored man, was admitted on June 5, 1963, with a chief complaint of dizziness. This had started about 4 months earlier and was associated with occipital headache, worse on the left. Dizziness was brought about by changes in position of the head, particularly noticeable when he extended his neck and turned his head to the right; the latter also aggravated the occipital headache.

Examination. There was marked limitation of neck movements in all directions, particularly to the right, with subjective pain over the cervical region. The blood pressure was 130/65. His neurological status was within normal limits. An electroencephalogram showed moderately well-organized and well-developed waves of 10/sec., slightly depressed on the left side. There was no definite abnormality.

Plain films of the cervical spine showed slight narrowing of the disc spaces at C3-4, C4-5, and C5-6. There was only minor encroachment on the intervertebral foramina by spurs present at C4-5, C5-6, and C6-7 on the right, and C3-4, C4-5, and C5-6 on the left. Myelography demonstrated transverse bars at C3-4, C4-5, C5-6, and C6-7. Pancerebral angiography (Fig. 4) revealed normal carotid arteries. The right vertebral artery was displaced slightly laterally by spurs at C3-4 and C5-6. The left vertebral artery was somewhat tortuous in the canal and was displaced laterally at C3-4 and C4-5. Rotation to the right caused notable narrowing of the right vertebral artery at C5-6.

Operation (June 24, 1963). By the anterior approach, a hole was drilled into the spinal canal between C-5 and C-6 directed somewhat to the right of the midline. This was followed by fusion. The patient made a satisfactory recovery and was discharged 5 days later.

Follow up. He was admitted for evaluation on February 25, 1964. He considered himself cured. Dizziness was not present and could not be elicited by any motion of the cervical spine. On bending over forward to a maximum extent with his head at or below the level of the knees, he experienced mild dizziness. Neurological examination was normal. The pan-cerebral angiogram (Fig. 5) showed no change at the C3-4 and C4-5 levels on the left and no change at C3-4 on the right. However, rotation to the right no longer produced any compression of the right vertebral artery at C5-6.
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Fig. 2A. Preoperative anteroposterior study with neck extended. Right vertebral artery displaced by spurs at C4–5, and displaced and compressed by spurs at C5–6 (arrow). Small left vertebral artery also displaced by spurs at C5–6.

Fig. 3A. Postoperative anteroposterior study. Note virtual absence of displacement or compression of vertebral arteries at C5–6 (arrows).

Fig. 2B. Head turned to right. Little change at C4–5, but considerable further compression of right vertebral artery occurs at C5–6 (arrow).

Fig. 3B. Head turned to right. Now no compromise of right vertebral artery at C5–6 (arrow).

Fig. 2C. Head turned to the left. Small left vertebral artery is virtually occluded by the spurs (arrow).

Fig. 3C. Head turned to left. Left vertebral artery no longer occluded by this movement (arrow).
FIG. 4A. Preoperative anteroposterior study. Right vertebral artery displaced laterally by spurs at C5–6 (arrow).

FIG. 5A. Postoperative anteroposterior study. Less displacement of right vertebral artery at C5–6 (arrow).

FIG. 4B. Head turned to right. Notable narrowing of right vertebral artery occurs at C5–6 (arrow).

FIG. 5B. Head turned to right. No compromise of the right vertebral artery occurs now (arrow).

Discussion

It is well known that spondylotic exostoses occasionally interfere with the course taken normally by the vertebral artery. The anatomical studies of Hutchinson and Yates\(^1\) and radiological investigations by Kovacs\(^2\) revealed that in the so-called osteoarthritic affections of the neurocentral joint of the cervical vertebrae, the bony prominence displaces the artery laterally and in more severe cases in an anterior direction also. The subject was dealt with from a clinical point of view and in great detail by Bauer et al.\(^3,4,14\). There was good correlation in many of their patients between the angiographic demonstration of vertebral displacement and compression by spondylotic spurs and the clinical symptoms of ischemia in the vertebral-basilar distribution; these included vertigo, dizziness, ataxia and episodic collapse. However, they noted that kinking and tortuosity of the vessels, per se, rarely gave rise to symptoms of cerebral ischemia. This was corroborated by Faris et al.\(^9\) who studied the neck vessels in healthy men.

The most important factors that determine whether a patient who has one or both vertebral arteries displaced by spondylotic spurs will develop signs of vertebral-basilar insufficiency are the effect of cervical motion on the arterial lumen and the relative size of the 2 vertebral arteries. Tissington Tatlow and Bammer\(^17\) showed experimentally that the vertebral artery can be markedly nar-
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rowed by neck turning. Meyer et al.\textsuperscript{14,16} demonstrated \textit{in vivo} the same thing using positional angiography. They found that the compression of the vertebral artery due to bony spurs is most common at the C4–5 and C5–6 level, a singularly mobile portion of the cervical spine. During rotation of the head, stenosis may become more severe or converted into complete obstruction. They noticed that compression of the vertebral arteries by osteophytes may increase on the side opposite to which the head is turned by stretching; however, compression is usually more severe on the side to which the head is turned, due to the pressure of the osteophytes against the artery. Similar observations were reported recently by Chr\textacute{a}st and Korbička.\textsuperscript{8} Neither flexion nor extension of the neck reduced the blood flow in the vertebral arteries to any great extent; however, a considerable reduction in blood flow leading to almost complete obliteration occurred on rotation. Changes in the blood flow of the 2 vertebral arteries were most serious when extension was combined with rotation of the head.

Another important factor is the relative size of the 2 vertebral arteries. It is obvious that cerebral ischemia due to compression of 1 vertebral artery is more likely to occur when its mate is functionally inadequate, since displacement or even compression of a single vertebral artery rarely causes ischemia of the mid-brain under ordinary circumstances. Bakay and Sweet\textsuperscript{3} studied the vertebral arterial pressure during operative exposure of the posterior fossa in man. There was no measurable drop in pressure in the vertebral or cerebellar arteries distal to occlusion of 1 vertebral trunk at the atlas.

The additional factors that determine whether a given individual will have a reduced flow in the basilar artery are the anatomical variations in size between the 2 vertebral arteries and the effect of motion in the cervical spine on the patency of the artery. One of the vertebral arteries is frequently underdeveloped and occasionally does not appear on the angiogram. When one considers that compression by osteophytes of the vertebral arteries increases with motion, it becomes apparent that this may lead to critical reduction of the already compromised vertebral flow when the contralateral artery is functionally inadequate. Narrowing, occlusion, or absence of one vertebral artery was seen in 17 out of 40 patients in Meyer’s series.\textsuperscript{14} Only 16 of 90 patients studied by Ostrowski et al.,\textsuperscript{15} had vertebral arteries of equal size. The cervical portion of the artery was significantly narrowed in 16 cases and occluded in 3. One of the vertebral arteries could not be visualized in 6.7 per cent of all angiograms by Bauer et al.,\textsuperscript{4} nor in 9 per cent of those by Gurdjian et al.\textsuperscript{10} The right vertebral artery is most frequently abnormal. In healthy men, 12 per cent showed abnormality in the left and 38 per cent in the right vertebral artery; of the latter group, 65 per cent were not arteriosclerotic but caused by stenoses, kinks, and displacement by spondyloitic spurs (Faris et al.\textsuperscript{9}).

A case reported by Hardin et al.,\textsuperscript{11} indicated the feasibility of surgical treatment. Their patient showed signs of basilar insufficiency caused by the congenital absence of 1 vertebral artery and compression by a spondyloitic spur of the other. The course of the compressed artery was greatly improved and the patient’s symptoms were relieved by the excision of the offending spur. They explored the artery in its canal from an anterior approach between the carotid sheath and the trachea. They found adhesions between the narrowed artery and the bony mass which suggests the possibility of surgical trauma to the diseased vessel, or possible thrombosis caused by manipulation.

In the series of Bauer et al.,\textsuperscript{4} 1 patient had an anterior cervical spine fusion for treatment of osteophyctic compression of the vertebral arteries, but the result has not been reported. We believe that the effect of the operation in our cases was brought about by two factors. One is the immediate fixation by vertebral body fusion of the interspace where the artery is compressed; this effectively limits motion of the critical segment of the cervical spine. The second factor is the gradual absorption of the spondyloitic spur
itself which improved the course of the vertebral artery and eased the compression of its lumen. This was verified by angiograms of the vertebral arteries taken with the cervical spine in various positions several months after operation.

Summary

We are reporting the effect of the removal of cervical spondylotic spurs and fusion of the vertebral bodies in two patients with vertebral artery insufficiency. The favorable result included improvement in the clinical state as well as in the blood flow in the compromised vertebral artery.

References

1. Adams, J. E. Personal communication.