

The Vertebral Artery Syndrome

A Review Article

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Abstract :

Vertebral artery syndrome, although commonly due to cervical spondylosis and cerebral atherosclerosis, can be due to several other causes. Due to the anastomosis between vertebrobasilar and carotid artery systems, involvement of the later by atherosclerosis is critical to the development of symptoms. A variety of cerebral and other symptoms might develop; vertigo visual disturbances, sensory and motor deficits being the prominent ones. A combination of these factors is necessary for the diagnosis. Anatomical aspects, vertebral arteriography and conservative and surgical treatment modalities are also described. Proper investigation to find out the etiology is stressed.

Keywords :

Arteriography Atherosclerosis, Cervical Spondylosis, Vertebral Artery syndrome, Vertebrobasilar Insufficiency Vertigo.

The Vertebral Artery Syndrome

The vertebral artery syndrome is one of the common conditions encountered in orthopaedic, ENT and neurologic practice. It is characterised by recurrent transient episodes of relative ischemia at the base of the brain, producing cerebral symptoms of vertigo, nystagmus, ocular symptoms and so called 'drop attacks' due to temporary occlusion of the vertebral artery caused by rotation and hyperextension of the neck. Also called vertebrobasilar insufficiency (VBI), it is caused by a variety of causes ranging from cervical spondylosis to tumour emboli. As far as Orthopaedicians and Physiatrists are concerned, a combination of arteriosclerosis of cerebral vessels and cervical spondylosis is fundamental to this syndrome.

About 50% of people over the age of 50

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and 75% over the age of 65 years have typical radiological changes of cervical spondylosis³⁵. Furthermore, 40% of those over 50 years had some limitation of their neck movement, while 60% had some neurological abnormality²³. Likewise postural vertigo is also a very common symptom in greater than 50 years age group. But all cases having symptoms of vertebrobasilar insufficiency with suggestive radiological features of cervical spondylosis cannot be bindly labelled as due to the latter. A diligent search should be done to rule out other causes before making this diagnosis.

The syndrome of vertebro-basilar infraction was first well defined in 1946 by kubik and Adams. Millikan and Siekert emphasised the frequent occurence of symptom-complexes which were initaly of transient character and served as warning

of independing vertebro-basilar infraction, i.e. Vertebro-basilar Transient Ischaemic Attacks. Since then many authors have described this syndrome, vertebral arteriography as well as treatment of this condition.

Relevant Anatomy

The Vertebro-basilar system consists of

TABLE -I
ETIOLOGY OF VERTEBRAL ARTERY SYNDROME

TYPE	CAUSE
EXTRINSIC	COMPRESSION KINKING
INTRINSIC	ATHEROSCLEROSIS ARTERITIS THROMBOSIS CONGENITAL ANOMALIES.

TABLE-II
SITES WHERE VERTEBRAL ARTERY IS PRONE TO INJURY
(BY TRAUMA OR MANIPULATION)

SITE	CAUSE/MECHANISM
1. Entry into the foramen transversarium of C ₆ vertebra	flattening and kinking of subclavian artery against last cervical vertebra and scalene muscles.
2. Anywhere in the bony canal (C ₁ - C ₆)	Secondary to the displacement of foramina following fracture dislocation of the spine. — Particularly susceptible to the stretching and shearing forces
3. Intervertebral foramen of atlas and (C ₁ - C ₂) Junction	— Atlanto-axial dislocation causing compression, chiropractic manipulation.
4. Course of the artery from C ₁ foramen to entry into the skull	— Stretched a roles bony structures and atlanto-occipital ligament.

two vertebral arteries joining together to form basilar artery at the base of the brain. It communicates with carotid supply through two posterior communicating branches. The vessels supplying the brain anastomose at three different levels:

1. Extracranial
2. Circle of Willis
3. Leptomeningeal

The Vertebral artery arises from the subclavian artery adjacent and proximal to the origin of the internal mammary and thyrocervical arteries. It passes posterosuperiorly to enter the foramen transversarium of the sixth cervical vertebra. This has been referred to as the first part of vertebral artery. The Vertebral artery ascends vertically encased in the bony canal formed by the transverse foramina of the upper six cervical vertebra lying anterolateral to the neurocentral joint of Luschka (the second part of the vertebral artery). The third part of the artery emerges from the transverse foramen of the atlas and runs horizontally posteromedially on the posterior arch of the atlas. The fourth part of the vertebral artery passes anterior to the oblique ligament of atlas entering the vertebral canal and then ascending up intradurally in to the posterior fossa to join its counterpart to form the basilar artery.

Spinal branches arise from second portion artery, pass through the intervertebral foramen to enter the vertebral canal and give off twigs to the roots of spinal nerves which anastomose with the anterior and posterior spinal arteries, These may be impinged upon by osteophytes in cervical spondylosis and cause additional ischemic cord damage^{31,34}.

Pathology and Etiopathogenesis

In a normal person, there is a decrease in vertebral artery circulation on one side when head is turned backward and to opposite side. There

are no symptoms during this as there is adequate collateral circulation from the other side and from the carotids. Only when these arteries are diseased or absent there will be symptom and signs¹⁰(Table 1).

During ordinary head movement of daily life there is an asymmetric eccentric rotation of the atlas fixed on the atlantooccipital joint of opposite side. On rotation to right the right atlantooccipital joint is fixed and the left side of the atlas rotates on axis, first asymmetrically and then symmetrically³⁶. Ponticles of the atlas are considered a significant factor in vertebrobasilar insufficiency⁶.

The circulatory effects occur when there are vascular abnormalities, when there is moderate to severe arteriosclerosis, when only the vertebral artery is filling the basilar system, when there is pressure on the vertebral artery by cervical osteophytes (Radner) or when there is an incipient thrombotic lesion in the basilar system^{10,36}.

There is another mechanism for the compression of the vertebral artery which is relevant surgically¹¹. The posterior origin of the vertebral artery lies between the vertebral column posteromedially and the part of the subclavian artery anterolaterally covered by the anterior scalene muscles. Turning the head more or less flattens that segment of the subclavian artery against the last cervical vertebra and kinks its origin leading to vertebrobasilar insufficiency in people with deficient intracranial anastomoses. With ageing elongation of the vertebral artery occurs, predisposing to kinking in vertebral and subclavian arteries leading to vertebrobasilar ischaemia¹¹.

In degenerative disease of the cervical spine, the osteophytes at the intervertebral foramina displace and compress the vertebral artery. This is increased on hyper-extension and rotation of the neck to the opposite side. This

osteophytic compression is most pronounced at C5-C6, less often at C4-C5 and much less commonly at C3-C4 and C2-C3^{24,31}. In the presence of advanced cervical degeneration only a small amount of neck motion may be sufficient to cause complete vertebral artery block. Stenosis and occlusion of other major cerebral vessels due to atherosclerosis or developmental anomalies predispose the subject to symptoms due to spondylotic vertebral artery compression³¹, thus increasing the frequency of ischemic episodes (cervical migraine of Bartschi-Rochaix w)²⁴. Repeated ischemic episodes eventually produce permanent brain stem damage. It is gradually becoming more apparent that spondylotic compression of the vertebral artery may be responsible for a chronic or an acute central hypoxic gradient in the cervical anterior spinal artery resulting in a syringomyelic lesion²⁴.

Hemodynamic factors have been attributed an important role in the genesis of symptoms of vertebrobasilar insufficiency whose incidence is 31% in carotid stenosis³⁸. Disappearance of Transient Ischemic Attacks (TIA) in vertebrobasilar territory was noted after endarterectomy in patients with severe carotid stenosis while no benefit was seen in patients with less than 50% stenosis²².

Anomalies of the circle of willis or the major arteries have a significant role in the development of both hemodynamically and thromboembolically mediated posterior circulation (VBI) symptoms in the presence of carotid stenosis²². Thus due to collateral deficiencies or secondary intracranial disease, however the terminal distribution of an artery may be relatively ischemic or at least unable to compensate for a fall blood pressure in the presence of an extracranial obstruction, though the total flow is normal³³. If stenosis of the vertebral artery develops slowly, sufficient collateral circulation may form distally.

Cervical spine trauma and injury to the neck can lead to symptoms of vertebro-basilar insufficiency. Bose et. al (1985) reported a case of transient ischemia in the distribution of basilar artery following a C4-C5 fracture-dislocation (with quadriplegia) during rugby. Traumatic internal carotid artery thrombosis or spasm in craniocervical trauma may be present whenever a severe contusion is noted in the cervical area as also in manipulation of the neck²⁹ which is due to injury at different sites (Table 2). vertebral artery syndrome can occur due to cervical sprains and cervical herniated discs²⁰.

Vertebral artery injuries have been described following yoga cervical manipulation, callisthenics, trauma, overhead work and cervical traction. All mechanism of injury involve either cervical hyperextension, excessive contralateral rotation or most commonly, a combination of both²⁸. Distal vertebral artery and basilar artery are injured in the form of intimal tears, pseudoaneurysm formation, AV fistulae, subintimal hematomas and dissection and complete thrombotic occlusion. Intermittent or partial obstruction of the blood flow in the vertebral artery may lead to a secondary thrombosis of the basilar artery higher up in the circulation leading to brainstem ischaemia, infraction and eventually softening in the cerebellum and the brainstem^{15,18,31}. Symptoms can occur by patient moving his own neck in specific position (hyper-extension or rotation) and last for few minutes after reversing back to neutral attitude^{3,36}.

A defective odontoid process due to injury or developmental defect leads to excessive mobility and displacement of axis with transient obstruction of vertebral artery and symptoms of VBI^{15,36}. Congenital anomalies in the vertebrobasilar and carotid systems, basilar artery hypoplasia and aneurysms of the vertebral artery termination or of the vertebrobasilar junc-

tion can produce symptoms of vertebrobasilar insufficiency³⁴. Other causes are fibromuscular hyperplasia, cranial arteries and fusiform ectasia. The factors that must also be considered include hypotension, hypertension, cardiac arrhythmia, platelet or septic or tumor emboli, polycythemia, hyperlipidaemia^{4,35}.

Artherosclerosis of extracranial vessels is an important concomitant of this syndrome. Extracranial vessels are more commonly involved than intracranial vessels. The proximal portion of the left subclavian artery and both proximal vertebral arteries are frequent sites of obstructing atherosclerotic lesions¹³ as are also internal carotid artery and bifurcation of carotids. In carotico-vertebral stenosis, collateral flow maintains circulation in midline vital centres but areas of hindbrain become infarcted. Atherosclerosis of the vertebro-basilar system is only seen in the basilar artery and third and fourth part of vertebral artery¹⁶. However with cervical spondylosis, atherosclerosis may also be seen in second part of vertebral artery.

The vertebral and basilar arteries are, for their size, amongst the most important in the human body and vital to the continuation of life just like the coronaries. Multiple neuroanatomical structures are concentrated in areas of their primary supply which include medulla, pons, midbrain, cerebellum, thalamus, part of posterior cerebral cortex (visual cortex and inferior basal areas of temporal lobes) and cervical spinal cord. With diminished blood flow through the internal auditory artery vertigo and impairment of hearing may be present. Hypoxia to the nuclear regions in the brain stem supplied by the pontine arterial branches may result in diplopia. Transient blindness may follow decreased circulation in the posterior cerebral arteries which supply the visual cortex in the occipital lobes. Reduced blood supply in posterior inferior cerebellar arteries results in 8,9,10 and 12 cranial nerve impairment. Vertebro-

basilar insufficiency can take two different forms :

- (a) Intermittent insufficiency due to transient repetitive occlusion of a major vessel, usually one of the vertebral arteries.
- (b) Steady reduction of the vascular reserve, due to thickening of the walls of small and middle size arteries with eventual formation of small infarcts⁸.

Clinical Approach to a patient of Vertebro-basilar Artery Syndrome

A patient with vertebral artery syndrome, in addition to its features, has features of causative condition like cervical spondylosis or atherosclerosis. The symptoms can be inferred as vascular because they are often transient and episodic involving regions of the nervous system above the rarely below the cervical area and precipitated in a predictable manner by hypertension and rotation of the neck³¹.

The typical symptoms are vertigo, light headedness, hearing loss, visual symptoms like diplopia, visual field defects, floating black dots that may have scintillating margin, paresis, ataxia, numbness etc. (Table 3)^{4,11,18,31, 36}. Rarely there are complaints of paraesthesias of upper thoracic dermatomes due to interference with blood supply of anterior spinal artery. In some patients of cervical spondylosis there is wasting, weakness of the hands with depressed tendon jerks and spasticity of lower limbs due to direct compression of the spinal cord and nerve roots by the osteophytes. There is frequent occurrence of symptoms and signs due to compression of the vertebral artery in the neck in cervical spondylosis (although this should not be over diagnosed-35, Table 4), these may occur in the absence of compression of cervical cord and roots. They are reversible in early stages (i.e. amenable to treatment), but later lead to progressive irreversible brainstem damage³¹.

TABLE-III
CLINICAL PICTURE OF VERTEBRO-BASILAR ARTERY INSUFFICIENCY

S. No.	SIGNS & SYMPTOMS	ANATOMIC SITE
I.	MOTOR WEAKNESS	
1.	Hemiparesis	Corticospinal fibres
2.	Quadriparesis	Corticospinal fibres
3.	Paraparesis	Corticospinal fibres
4.	Spasticity	Corticospinal fibres
5.	Facial	Cranial nerve VII
II	SENSORY LOSS	
1.	Face	Spinal tract of V
2.	Extremities & Trunk	Spinothalamic tract
III	VISUAL	
1.	Diplopia	Cranial nerves and nuclei of III, IV, VI.
2.	Conjugate gaze palsy	Paraabducens nuclei.
3.	Horner's Syndrome	Descending sympathetic tract.
IV	ATAXIA	
1.	Gait	Inferior cerebellar peduncle, cerebellum midline.
2.	Limb	Cerebellar hemispheres.
V	Unilateral Tremor	Cerebellum and red nucleus fibres.
VI	Slurred Speech (Dysarthria)	Corticobulbar fibres (to 9,10, 12 cranial nerves).
VII	Swallowing Problem (Dysphagia)	Nucleus Amiguos
VIII	Nausea and Vertigo	Vestibular Nucleus.
IX	Hearing Loss	Auditory Nerve
X	Temporal lobe seizures and Peduncular hallucinosis	Temporal lobe.
XI	Coma	Reticular formation
XII	Drop Attacks	Ischaemia at pyramidal decussation.
	Headache	

TABLE-4

Incidence of symptoms in vertebral artery syndrome

S. No.	Symptoms/Signs	Incidence out of 25 cases
1.	Dizziness and/or Vertigo	18
2.	Episodic visual disturbaness	14
3.	Ataxia-Transient or evident to the examiner	18
4.	Drop Attacks	2
5.	Postural Vertigo/blurred vision at examination	5
6.	Absence of dizziness and ataxia (both)	3
7.	Headache, neck pain	22 (Common)

A dizzy or giddy patient may have vertigo (i.e. spinning), unsteadiness (lightheadedness as in severe influenza) or the cause may be uncertain. Unsteadiness occur rarely in bed or with exercise and is seen when about to leave home during shopping and can occur due to 'Hyperventilation Syndrome'⁴. Crandle 1996 feels that vertigo seldom figures as a prominent symptom in large series of verified cases of cervical spondylosis. Compression of the vertebral artery by osteophytes is not a very common disease^{9,35}.

Cervical vertigo can be seen in three groups of patients²⁷- firstly in those with cervical spondylosis, secondly in those patients treated by neck traction and who developed vertigo and finally in patients with certain types of neck injuries. The last group of patients, in whom vertigo is probably due to alteration in proprioceptive impulses reaching cerebellum and vestibular nuclei from end organs, complaining pain in the neck, stiffness and recurrent postural vertigo and nystagmus³⁶. A combination of three symptoms and signs suggests the diagnosis of vertebral artery syndrome or VBI rather than

any one of them. When episodic postural vertigo is unaccompanied by any other neurological symptom or sign, it is extremely unlikely to be due to VBI, more so secondary to cervical spondylosis, even if X-rays demonstrate the latter. These patients are treated symptomtically. This non-VBI vertigo can be a self limited idiopathic (epidemic) vertigo or a postural vertigo^{8,35}.

Abnormalities of oculomotor function are the early findings in vertebral artery syndrome and are best noted when testing for optokinetic nystagmus⁸.

Drop attacks which occur in some patients of vertebral artery syndrome are pathognomonic. In this, on hyperextension or rotation of the head, the patient develops tetraparesis or tetraplegia and falls to the ground without losing consciousness. Rapid recovery occurs in a few minutes.³¹

Vertebrobasilar ischaemic disease causing vertebrobasilar on non-hemispheric transient ischaemic attacks (TIAs) are physiopathologically of four type²⁵.

First type (21%) are non postural due to

atherosclerosis and thromboembolism, second type (4.5%) are postural, third type (20.6%) are mixed type while fourth variety (12.7%) are due to uncertain cause.

In diagnosing a case of vertebral artery syndrome, various causes of dizziness particularly due to labyrinthine or cerebellar disease should be excluded, whereas the drop attacks should be differentiated from epilepsy, syncope and Stokes-Adams syndrome. Two conditions that require description are carotid sinus syndrome and subclavian steal syndrome. The former can be diagnosed by carotid sinus sensitivity and its cardioinhibitory and vasodepressor reflexes in ECG while the carotid sinus is massaged. In the '*Subclavian steal syndrome*' the total cerebral blood flow decreases by 41% due to vertebral artery contributions to collateral circulation about the shoulder in a person with stenosis or occlusion of the portion of the subclavian artery proximal to the origin of the vertebral artery²⁶. The symptoms of vertebral artery syndrome with arm symptoms occur on exertion of the upper limb with physical features of occlusion and ischemia in the upper limb. Arteriography shows filling from opposite sided subclavian and vertebral arteries to ipsilateral vertebral and finally ipsilateral subclavian artery.

Investigations

A variety of investigative procedures may be required to establish the diagnosis as well as to detail the possible etiopathogenesis.

Vertebral Arteriography

Contrast medium (50% Renograffin or Hypaque) may be injected via a polyethylene catheter inserted by the Seldinger method into the brachial artery in the antecubital fossa. Average vertebral artery in x-ray measures 3-4 mm in diameter. In 30% both are of equal size, in 40% left vertebral artery is large and 30% have larger right vertebral artery³⁴. The vertebral artery in severe cervical spondylosis has a

strikingly tortuous (wash board) appearance with multiple signoid curves, the lateral concavities of which lie opposite an intervertebral space. Stenosis is frequent and occlusion rare. Oblique and anteroposterior films show osteophytes pressing on vertebral artery. The stenosis becomes complete obstruction by rotation of the neck³¹. All patients with VBI symptoms have hemodynamically significant stenosis (i.e. more than 50%)³⁷.

Intrinsic cause of narrowing are arteriosclerotic tortuosity and atherosclerotic plaques. Arteriosclerotic types of tortuosity occurs at two sites : firstly at the origin of the subclavian artery before it enters the foramen transversarium at C6 vertebra and secondly at the point where it leaves transverse foramen of atlas where it is so elongated and tortuous as to get kinked during extension and rotation of the neck to the same or opposite side³¹. Concomitant carotid angiography is must as their involvement is needed for symptoms to appear. In post-traumatic cases of vertebral artery syndrome also, cerebral arteriography is useful, when it might show site of occlusion of the vertebral artery and sometimes non-visualisation of basilar artery (especially the proximal part)^{5,28}.

Among other investigations, x-rays are worth mentioning first especially in cervical spondylosis³¹. Vestibulo-oculomotor tests like pure tone audiometry, caloric test and electronystatogram are required to rule out other causes. In vertebral artery syndrome the results may be abnormal although there is no consistent pattern^{8,35}. Neurological tests including EEG may also be required. A CT Scan may be indicated in severe cases before embarking on medical treatment to exclude the possibility of cerebellar infraction or hemorrhage which require acute surgical decompression.

Treatment

In general, vertebral artery syndrome is treated conservatively. Surgery is warranted when disease is progressing as evident by increasing symptoms and neurologic deficits. During acute episodes complete bed rest for three weeks and instruction to avoid hyperextension and rotation of the head as much as possible. The treatment is directed at preventing attacks while collateral circulation is being reestablished. A light weight plastic neck collar can be given to reduce movement. In initial stages, prolonged, strong cervical traction and hot packs to the neck and postural training are often effective^{20,31}. In severe compression and stenosis of the vertebral artery occurs, fragmentation and embolisation of mural thrombus can be prevented or reduced by anticoagulant therapy³¹ which is also used in patients with TIAs or progressive stroke¹⁸. During this the therapeutic prothrombin time levels are approximately 32 seconds and above³⁶. Anticoagulant therapy (antiplatelet or antithrombotic) is statistically valuable ($p=0.01$) in prevention of vertebrobasilar infraction from TIAs. Xidifon has been used in vertebral artery syndrome during exacerbation³⁰. Anticoagulant therapy with heparin is useful in cases after chiropractic manipulation²⁸. Various causes which produce symptoms of vertebral artery syndrome also need appropriate treatment. For drop attacks a cervical collar, correction of various causes of orthostatic hypotension are used.

For unilateral or bilateral internal carotid artery stenosis in association with symptomatic vertebrobasilar occlusive disease, carotid endarterectomy is done. It is the most widely used technique even in vertebral artery syndrome¹¹. 93% became asymptomatic or improved postoperatively if posterior communicating artery was visualized preoperatively by angiography¹⁷. Endarterectomy can also be used for subclavian

and vertebral artery (here along with dilatation) stenoses in selective cases^{7,11,33}.

Other surgeries available for vertebral artery syndrome and subclavian steal syndrome are scalenotomy, vertebral artery bypass², direct subclavian to common carotid anastomosis, aorta to subclavian and common carotid bypass and division of periarterial constricting or restricting fibrous bands^{11,13}. In cases of vertebral artery syndrome due to cervical spondylosis, fixation of neck (fusion) to limit motion and decompression of the foramen transversarium by transversectomy and uncossectomy can be done^{31,32}. In cases due to cervical sprains and cervical herniated discs, stabilisation is useful in severe cases²⁰.

Conclusions

Vertebral artery syndrome can be due to multiple causes. A detailed clinical workup of the patient with suggestive symptoms followed in some cases by angiography can lead to proper diagnosis. Treatment is generally conservative although surgery may be needed in some cases. Tendency to label all cases of vertebral artery syndrome where x-rays show cervical spine osteoarthritis as due to cervical spondylosis should be avoided and replaced by an urge to probe for the underlying cause.

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