Acute Ischaemic Stroke: Part II. The Vertebrobasilar Circulation

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ABSTRACT

Objective: *To review recent advances in the management of acute ischaemic stroke in a two part presentation.*

Data sources: *Articles and a review of studies reported from 1990 to 2000 and identified through a MEDLINE search of the English language literature on acute ischaemic stroke.*

Summary of review: *An acute ischaemic stroke of the vertebrobasilar circulation is investigated initially with a cerebral computed tomography scan largely to differentiate it from a haemorrhagic stroke. However, cerebral magnetic resonance imaging identifies the ischaemic brainstem lesions more accurately and is often performed with MR angiography to determine the site and extent of the ischaemic vertebrobasilar lesion.*

Treatment with aspirin (150 - 300 mg) within the first 48 hr as well as management in a specialised unit focusing on resuscitation and prevention of complications has reduced morbidity and mortality. While therapy to improve cerebral blood flow or agents to reduce further neuronal damage have not produced consistent improvement in outcome, numerous small studies using intravenous or intraarterial thrombolytics, percutaneous transluminal angioplasty or stents have reported improved outcome in selected cases.

Conclusions: *An acute ischaemic stroke in the distribution of the vertebrobasilar circulation requires aspirin 150 - 300 mg daily and management in an acute stroke unit. Intra-arterial or intravenous thrombolytic therapy and percutaneous transluminal angioplasty or stents to improve cerebral blood flow (even up to 24 hours after the event) have been reported to be beneficial in selected cases.* (**Critical Care and Resuscitation 2000; 2: 140-145**)

Key Words: Acute ischaemic stroke, vertebrobasilar circulation, cerebral thrombosis, intra-arterial thrombolysis, percutaneous transluminal angioplasty

The posterior cerebrovascular (i.e. vertebrobasilar) circulation begins with the right and left vertebral arteries which arise from the innominate artery on the right and the subclavian artery on the left. They enter the vertebral foramen, traversing from C6 to C2, circle around the arch of the atlas and join the other vertebral artery to form the basilar artery (Figure 1).

An acute cerebral ischaemic episode of the vertebrobasilar circulation may present as either a transient ischaemic attack or a stroke. While transient ischaemic attacks (TIAs) are often defined as sudden focal neurological deficits that last for less than 24 hr and are totally reversible, the median duration of TIAs of vertebrobasilar distribution is 8 minutes (compared with 14 minutes for the carotid circulation).[1] Vertebrobasilar TIAs are caused in patients who have an arterial narrowing of the vertebrobasilar circulation by either a threshold episode of ischaemia or atheromatous plaque induced platelet emboli, although they may also be caused by a subclavian stenosis induced subclavian-vertebrobasilar vascular 'steal' (Figure 2).[2]

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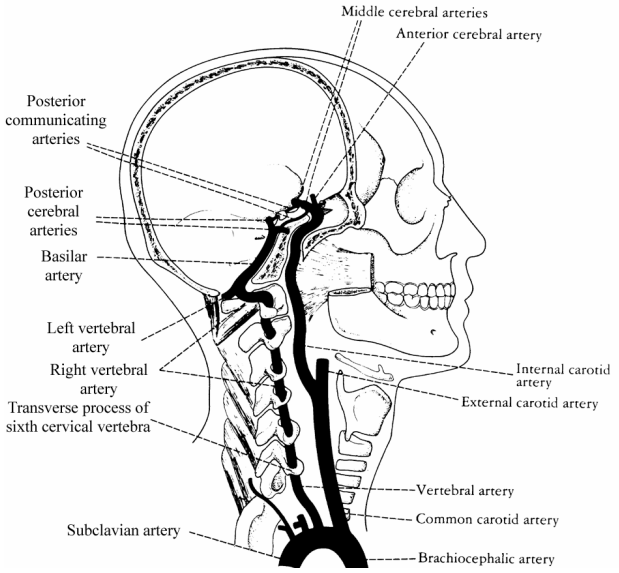

Figure 1. The origin and courses of the carotid and vertebral arteries as they ascend the neck and enter the skull to form the circle of Willis (Modified from Snell RS. Clinical neuroanatomy for medical students. 2nd Ed, Little Brown and Co, Boston 1987).

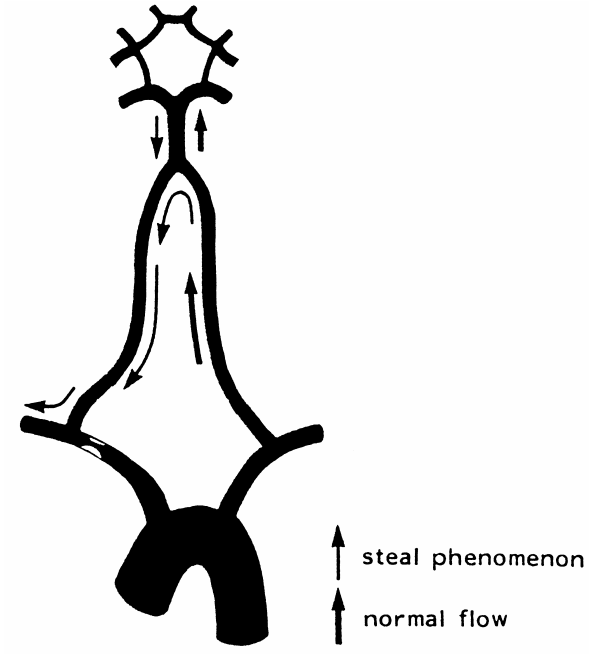

Figure 2. Mechanism of subclavian 'steal' (Modified from Bornstein and Norris. Lancet 1986;ii:303-305).

Vertebrobasilar stroke can be caused by basilar artery thrombosis or embolus, or vertebral artery, thrombus, embolus or dissection. Vertebral artery dissection commonly originates at the level of C1-C2 and can be caused by minor trauma.[3]

CLINICAL FEATURES

Clinical features involving the vertebrobasilar distribution relate largely to the region of the brain supplied by the occluded artery including the brainstem (e.g. medulla, pons and midbrain) and cerebellum. Severe vertebrobasilar stroke usually presents with vertigo, ataxia, vomiting, headache, varying cranial nerve abnormalities, bilateral long tract neurological signs (e.g. quadraparesis, extensor response to pain), 'locked in' syndrome or impaired consciousness (e.g. coma if upper midbrain is involved) and complex ocular signs (e.g. pinpoint pupils that react sluggishly to light, horizontal and vertical gaze abnormalities) or cortical blindness (if posterior cerebral artery occlusion leads to occipital infarction).

Occlusion of specific vertebrobasilar arteries may cause characteristic syndromes. For example,

The posterior inferior cerebellar artery supplies the lateral medulla and inferior surface of the cerebellum and its occlusion may produce the lateral medullary syndrome, which includes,

- ipsilateral 5th nerve lesion (with pain and numbness), nystagmus, diplopia, nausea, vomiting, Horner's syndrome, bulbar palsy (with 9th and 10th cranial nerve lesions), numbness of ipsilateral arm, trunk and leg, hiccups (where baclofen 10 mg 6-hourly is the initial treatment of choice)[4], and
- contralateral impaired pain and temperature sense.

The anterior inferior cerebellar artery supplies the medullary structures of the spinothalamic tract, vestibular and seventh nerve and middle cerebellar peduncle, and its occlusion may produce the lateral inferior pontine syndrome, which includes,

- ipsilateral facial weakness, deafness, tinnitus, nausea, vomiting, Horner's syndrome, paresis of conjugate lateral gaze, and
- contralateral impaired pain and temperature sense.

The lower basilar artery which supplies (with its pontine arteries) the medial medulla and occlusion may produce the medial medullary syndrome which includes,

- ipsilateral 12th nerve paralysis and
- contralateral paralysis of arm and leg (sparing the face).

The superior cerebellar artery which supplies middle and superior cerebellar peduncles and its occlusion may cause,

- ipsilateral cerebellar ataxia, nausea and vomiting, dysarthria and
- contralateral loss of pain and temperature sensation over the body and face and Horner's syndrome.

Blood pressure is measured in both arms (a difference may indicate proximal subclavian artery stenosis or dissecting aneurysm), and supine and erect

blood pressure may reveal postural hypotension. With cardiac auscultation one may detect bruits to indicate a cause for cardiac embolism. A subclavian stenosis may be associated with a 'bruit' in the supraclavicular fossa, unequal radial pulses and symptoms induced by exercising the arm supplied by the subclavian artery involved (i.e. subclavian steal syndrome, figure 2). Fundoscopy may also reveal hypertensive or diabetic changes and cholesterol particles that embolise to the eye (i.e. Hollenhorst plaques).

INVESTIGATIONS

Investigations include:

Routine tests: similar to those performed with an acute ischaemic stroke of the anterior circulation (see part I).

Computed tomography: while a cerebral CT scan is routinely performed in patients with a vertebrobasilar stroke and is mandatory in patients in whom thrombolytic or anticoagulant therapy is being considered (to exclude intracranial blood), it usually demonstrates brainstem structures inadequately due to bony artifacts and demonstrates infarction of the brainstem structures (e.g. medulla, pons and midbrain) poorly (with the exception of the cerebellum where CT scanning may detect a large cerebellar infarction in the territory of the posterior inferior cerebellar artery).[5]

Magnetic resonance imaging (MRI): compared with computed tomography, magnetic resonance imaging has the advantage of being able to clearly identify structures in the posterior fossa. It detects cerebellar infarction earlier, detects lateral medullary infarction, and provides a useful way to investigate cerebrovascular symptoms due to brainstem lesions.[6] In addition, magnetic resonance angiography can be performed easily and can identify an obstructive or near obstructive vertebrobasilar lesion, to guide the need, or otherwise, for angiography.

Angiography: is the definitive procedure for demonstrating arterial stenosis or occlusion, and is always performed when intra-arterial thrombolysis or percutaneous transluminal angioplasty or stenting are being considered.

Ultrasound: duplex transcranial Doppler may be used to assess blood flow in the vertebrobasilar system and in the presence of complete, or near complete, obstruction can assess the collateral flow across the anterior or posterior circle of Willis.

Echocardiography: this should be performed in all patients who have a high probability of cerebral embolic disease.[7]

Lumbar puncture: following a cerebral CT scan, a lumbar puncture may be performed to detect cerebrospinal haemorrhage or infection in patients who have subarachnoid haemorrhage or meningitis masquerading as a vertebrobasilar stroke.

TREATMENT

An acute stroke requires early management as the time window for at least partial reversibility of local ischaemic injury in humans is probably within 24 hours of the onset of symptoms. The principles of management of an acute vertebrobasilar stroke are similar to those outlined in the previous section for acute ischaemic stroke of the carotid circulation and include resuscitation and therapy to prevent complications as well as therapy to facilitate reperfusion (e.g. thrombolysis, aspirin) and to protect the ischaemic brain tissue from further damage. The following measures are used.

Resuscitation and preventative therapy

Stroke units have been shown to reduce morbidity and mortality,[8,9] although the improved outcomes are most likely due to those features which characterise the intensive care unit. Management includes; respiratory support (e.g. maintaining a clear airway, and preventing aspiration, hypoxia, and hypercapnoea particularly in patients who are drowsy or unconscious, or have brainstem dysfunction with reduced glottic reflexes and vomiting), cardiovascular support (e.g. systolic or diastolic blood pressure up to 185 mmHg and 110 mmHg, respectively, are tolerated)[10] and metabolic support (e.g. hydration, electrolyte, acid-base balance, and nutrition are monitored and maintained).

If the patient has a reduced conscious state then standard management of an unconscious or partially conscious patient applies to prevent deep vein thrombosis, pressure sores and contractures. To decrease the incidence of deep vein thrombosis, routine leg exercises, intermittent pneumatic leg or calf compression,[11] elastic stockings, physiotherapy and early mobilization should be considered. Pressure sores are reduced by regularly altering the patient's position, supporting the area surrounding pressure points and alternating pressure airflow mattresses,[12] and physiotherapy with active and passive range movements and splints can prevent contractures.[13] A urinary catheter will be necessary if the patient is incontinent or unconscious.

Drugs to improve blood flow

Antiplatelet agents

As recommended for the management of patients with an acute ischaemic stroke of the carotid circulation, aspirin (150-300 mg daily and continued long term) should be administered to all acute posterior circulation atherothrombotic strokes as soon as the diagnosis of cerebral vertebrobasilar infarction (i.e. < 48 hr) has been

made.[14,15] Patients who are intolerant of aspirin should be given clopidogrel (75 mg daily) or modified release dipyridamole.

Anticoagulants

There is no evidence to support the use of anticoagulants for the treatment of acute stroke as the beneficial effects of immediate heparin (standard or low dose, fractionated or unfractionated) use in reducing early recurrent ischaemic stroke or pulmonary embolism, in a patient with an acute non progressive stroke appear to be outweighed by haemorrhagic side effects.[15] Physical methods should be used to prevent deep vein thrombosis in patients with stroke, although symptomatic thromboembolism should be managed using heparin.

However, in individual cases heparin may be administered to patients who have a documented evolving thrombosis (i.e. progressive or stepwise neurological deficit greater than 24 hr duration and evolving up to 3 days despite aspirin therapy) and only when the patient's hypertension is controlled (i.e. less than 180/100 mmHg). Anticoagulants are also administered to patients with a cerebral embolism due to an underlying cardiac disease (e.g. atrial fibrillation, to keep the INR between 2.0 and 3.0; and mechanical prosthetic valves, to keep the INR between 2.5 and 3.5),[16] with warfarin therapy beginning after the required delay[17] (i.e. up to 5 days[18] in patients with mild strokes, or greater than 2 weeks in patients with more severe strokes).

To exclude haemorrhage as the cause of the stroke, a CT scan or lumbar puncture are usually performed no sooner than 24 hr but less than 48 hr after the stroke.[19,20] Anticoagulants, rather than antiplatelet agents, may be used in patients with TIAs who do not respond to antiplatelet drugs, who are not suitable for surgery, who are compliant, are relatively young and who do not have uncontrolled hypertension. Anticoagulants are contra-indicated in patients who have cerebral haemorrhage and are not indicated in patients who have bacterial endocarditis or a completed ischaemic stroke.[21]

In progressive vertebrobasilar ischaemia, when basilar artery thrombosis is demonstrated on angiography, heparin is usually indicated following thrombolytic therapy to reduce the incidence of rethrombosis.

Thrombolytic agents

As an acute severe ischaemic vertebrobasilar stroke may be associated with a poor prognosis and as posterior circulation strokes (particularly if embolic and in a young patient with good collateral circulation)[22] may be more responsive to thrombolytic therapy than an acute carotid or middle cerebral artery ischaemic stroke, thrombolytic therapy may be of greater benefit in the management of acute ischaemic strokes of the vertebrobasilar circulation compared with the carotid circulation. In 12 patients with acute vertebrobasilar ischaemia (2 of whom presented in coma), intravenous thrombolytic therapy within 3 hr of the onset of symptoms (rt-PA 0.9 mg/kg, 10% as a bolus followed by the remainder over 1 hr) had a success rate of 83% at three months.[23] Intra-arterial urokinase (e.g. 250,000 u/hr for 4 hours with heparin 1000 u/hr) even up to 24 hours after the onset of symptoms, has also been associated with an improved outcome,[24-27] although poor clinical condition (e.g. coma or quadraparesis) at the time of rethrombosis usually indicates a poor outcome.[28] As rethrombosis may occur with a vertebrobasilar thrombotic stroke due to the residual atherosclerotic stenosis, abciximab[29] and endoluminal angioplasty[30,31] may also be required.

However, there have been no prospective, randomised controlled trials confirming the value of thrombolytic therapy in vertebrobasilar ischaemic stroke.[33] Currently, thrombolytic therapy for acute ischaemic stroke (in either carotid or vertebrobasilar circulations) requires further testing in large randomised controlled trials before it can be recommended routinely, because the risks are substantial (all trials have shown an increased incidence of intracranial haemorrhage with the risk of fatal intracerebral haemorrhages increasing from an average of 1.2% to 6.3%),[32] the benefit uncertain, the time window for effective treatment unclear.[33,34]

Endoluminal angioplasty and stenting

Basilar artery occlusion with successful reperfusion using a percutaneous endovascular stent and good neurological recovery has been described.[35] In a report of 21 patients with symptomatic vertebrobasilar ischaemia, percutaneous endovascular angioplasty and stent produced a cure in 57% of patients.[36] In another report of 4 patients with symptomatic vertebrobasilar artery ischaemia, percutaneous transluminal angioplasty successfully dilated the lesions.[37]

Neuroprotective agents

While cerebral 'protection' agents, hypothermia, hypervolaemic haemodilution, and non specific treatment for cerebral oedema (e.g. glycerol or mannitol), have all been used, they have not been shown to benefit ischaemic or haemorrhagic stroke patients.[38-45] Some believe that mannitol may even be contraindicated in the management of acute ischaemic stroke as it can activate apoptotic cell death and inflammatory

mediators, and may cause rebound cell swelling, all of which may increase ischaemic neuronal injury.[46]

PROGNOSIS

While in general 80% of patients who present with posterior circulation infarcts survive to live an independent existence after one year,[47] in one study of selected patients with symptoms consistent with vertebrobasilar occlusion the hospital mortality was 86%.[48]

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