

Subclavian Steal Syndrome

By Marta Thorup

Definition

Subclavian steal syndrome (SSS), is a constellation of signs and symptoms that arise from retrograde flow of blood in the vertebral artery, due to proximal stenosis or occlusion of the subclavian artery. The arm may be supplied by blood flowing in a retrograde direction down the vertebral artery at the expense of the vertebrobasilar circulation. This is called the subclavian steal.

Hemodynamics

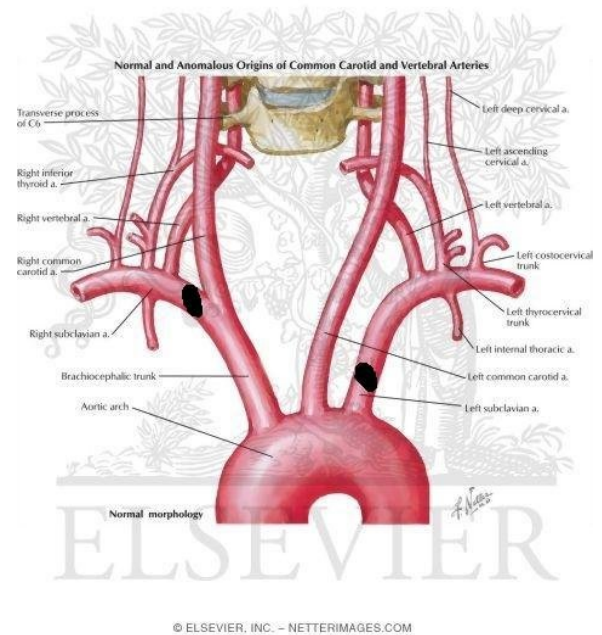
Blood, like an electrical current, flows along the path of least resistance. Resistance is affected by the length and width of a vessel, but crucially in the human body the width is generally more limiting than length because of Poiseuille's Law. Thus, if blood is presented with two paths, a short one that is narrow or a long one that is wide, it will take the long and wide path, the one with the least resistance.

Vascular Anatomy

The blood vessels that supply the brain arise from the vertebral arteries and internal carotid arteries and are connected to one another by communicating vessels that form a circle known as the Circle of Willis. The right vertebral artery arises from the innominate artery and the left vertebral artery arises from the subclavian artery.

Path of the Blood (SSS)

In SSS there is a reduced quantity of blood flow through the proximal subclavian artery. As a result, blood travels up one of the other vessels to the brain such as the contralateral vertebral or the carotid, through the basilar artery or goes around the cerebral arterial circle and descends via the ipsilateral vertebral artery to the subclavian with the proximal blockage and feeds blood to the distal subclavian artery which supplies the upper limb and shoulder.



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Signs/Symptoms of SSS

SSS may be suspected when there is a reduction of blood pressure on the affected arm by 15-20 mmHg.

Most common symptoms include;

Arm claudication occurring at regular intervals. Rest pain is not a symptom usually associated with subclavian stenosis. Thromboembolism would be considered in setting of rest pain.

Visual loss, which may range from total blindness to unilateral visual field loss or amaurosis fugas.

Vertigo, Syncope

Diplopia, dysarthria, ataxia, and dysphagia

Pulsatile tinnitus

Numbness or tingling of the face, transient hemiparesis, or sensory hemianaesthesia

Treatment for SSS

The goal of surgical therapy is to restore antegrade blood flow in the vertebral artery, thereby alleviating symptoms. This goal can be achieved by restoring adequate perfusion pressure to the affected arm so that collateral blood flow from the head and neck are not required during arm exercise. Endovascular catheter-based stenting of the proximal subclavian artery is the most common way that proximal subclavian lesions are treated today. The technical success rate is 86-100%, and complication rate is low.

DISCUSSION

Normal findings

Qualitatively, the spectral Doppler velocity waveform in the vertebral artery should appear as a scaled-down version of flow in the internal carotid artery, since both directly supply the low-resistance intracranial vascular system. The waveform should have a well-defined systolic peak with sustained flow throughout diastole. There is wide variability in the absolute peak systolic velocity in normal patients, with a range of 20-60 cm/sec. From 1/3-1/2 of patients have a dominant vertebral artery, which demonstrates larger size and higher flows than the contralateral side. In such cases, the nondominant, anatomically small vertebral artery may demonstrate flow characteristics of increased vascular resistance, with diminished flow velocities at peak systole and throughout diastole.



Abnormal findings

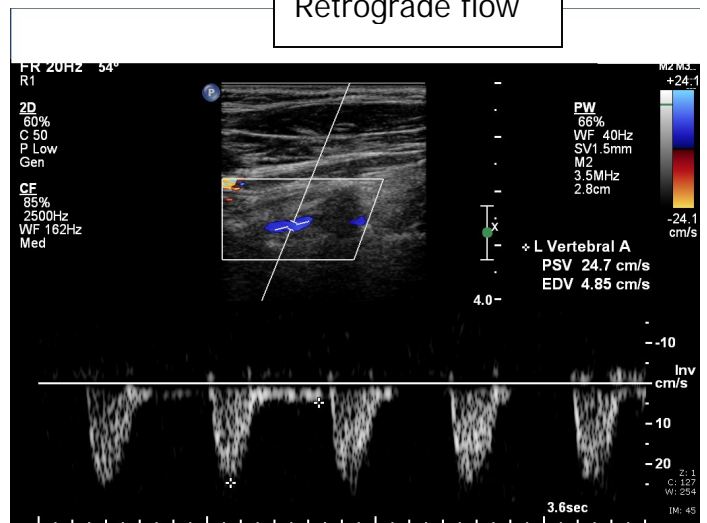
The most common abnormal flow pattern seen is retrograde vertebral flow. This is a simple diagnosis to make with duplex ultrasound when retrograde vertebral artery flow is seen throughout the cardiac cycle, although it is important not to confuse pulsatile vertebral vein flow for retrograde vertebral artery flow.

90% of SSS occurs on the left side.

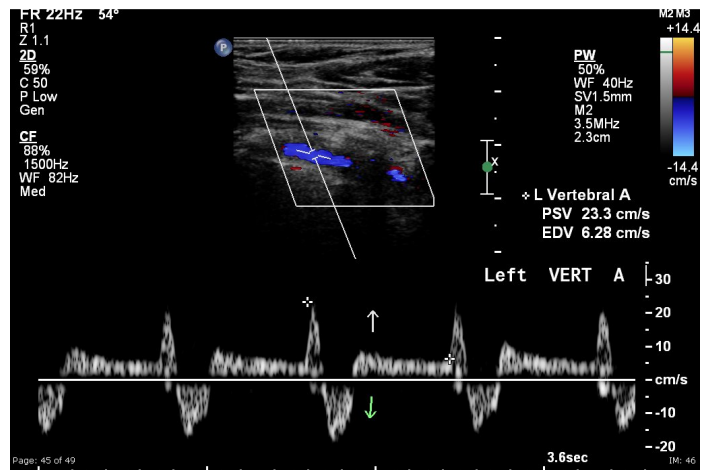
When vertebral flow reversal is seen on the right side, it is important to determine whether the source of the steal is the subclavian artery, which affects only vertebral artery flow, or the innominate artery, which has a significant effect on both the right common carotid and vertebral arteries. As a secondary diagnostic finding in patients with SSS, it should also be possible to document abnormal flow velocity waveforms in the distal segment of the affected subclavian artery.

Frequently, in cases of subclavian steal there may be a subclavian artery obstruction at its origin that is significant but not so severe as to cause a complete reversal of flow in the ipsilateral vertebral artery. The changing balance of hemodynamic forces during the cardiac cycle causes systolic flow deceleration in the vertebral artery, which if severe enough, is manifest as bi-directional flow. When the balance of hemodynamic forces produces a bi-directional flow pattern, the overall effect is a net volume blood flow in the vertebral artery that is very small, on the order of only a few milliliters per minute. This net flow may be either antegrade or retrograde, and angiographically, the low flow rate may result in nonvisualization of the vertebral artery, mimicking occlusion.

Retrograde flow

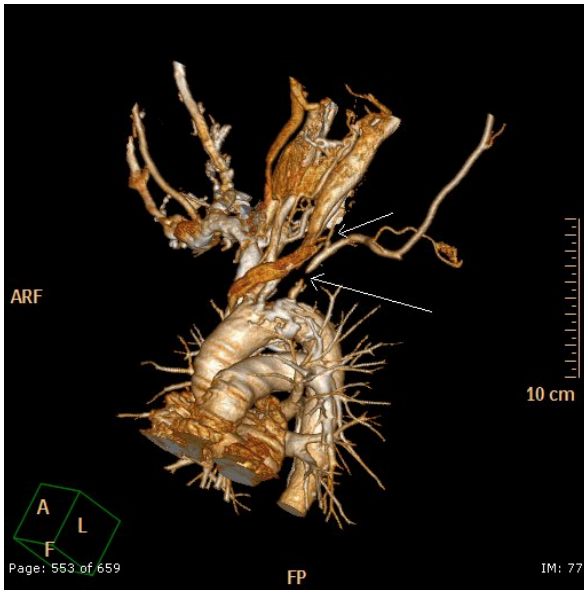


Bi-directional flow



Although the proximal subclavian stenosis or occlusion may be difficult to image, particularly on the left, the vertebral artery waveform abnormalities correlate with the severity of the subclavian disease.

Doppler evaluation of the vertebral artery reveals four distinct abnormal waveforms that correlate with subclavian or vertebral artery pathology on angiography.



Lt subclavian artery occlusion on CT

ABNORMAL VERTEBRAL ARTERY WAVEFORMS

- COMPLETE SUBCLAVIAN STEAL

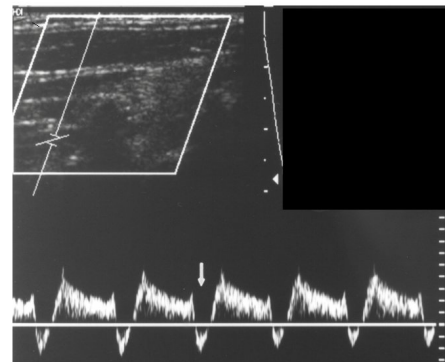
Reversal of flow within the vertebral artery ipsilateral to the stenotic or occluded subclavian or innominate artery

- INCOMPLETE OR PARTIAL SUBCLAVIAN STEAL

Transient reversal of cerebral artery flow during systole
 May be converted into a complete steal using 5 minute exercise or inflation of sphygmomanometer cuff to induce rebound hyperemia
 Suggests stenotic, not occlusive, lesion

- PRE-STEAL PHENOMENON

“Bunny” waveform: systolic deceleration less than diastolic flow
 May be converted into partial steal by exercise or cuff maneuver
 Seen with proximal subclavian stenosis



Rohren E M et al. AJR 2003;181:1695-1704

- TARDUS-PARVUS OR DAMPED WAVEFORM
Seen with vertebral artery stenosis

CONCLUSION

The subclavian steal phenomenon occurs when there is high-grade stenosis or occlusion of the proximal subclavian or innominate arteries with patent vertebral arteries bilaterally. The artery of the ischemic limb "steals" blood from the vertebrobasilar circulation via retrograde vertebral artery flow, which may result in symptoms of vertebrobasilar insufficiency. Symptoms are usually most pronounced during exercise of the upper extremity.

The SSS is most commonly caused by atherosclerotic disease, although traumatic, embolic, surgical, congenital, and neoplastic factors have also been implicated.

Resources

Papermed.com

ajronline.org American Journal of Roentgenology

Wikipedia.org

<http://emedicine.medscape.com/article/462036-treatment#a1128>

Introduction to Vascular Ultrasonography fifth edition Zweibel, Pellerito

Diagnostic ultrasound volume 1 third edition Rumack, Wilson, Charboneau

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