Transcranial Doppler ultrasound for the brain

Transcranial Doppler (TCD) is a non-invasive method of measuring cerebral blood flow velocity (CBF-V) and its derived parameters. Its use was first described by Aaslid *et al.* in 1982.[1] Although initially employed for detecting vasospasm following sub-arachnoid haemorrhage, the device's scope has been expanded and it is now a proven, cost-effective and a credible tool in evaluating cerebral arterial patency, in detecting arterial stenosis and in sensing the collateral blood flow patterns in the cerebral circulation.

The device works on the Doppler effect. It relies on pulsed-wave Doppler to image vessels at various depths.[2] Acoustic windows are the parts of the skull which transmit sound waves to basal arteries. There are four acoustic windows: transtemporal, sub-occipital, transorbital and sub/retro-mandibular. Middle cerebral artery is the most common artery to be insonated as it is easily accessible through the temporal window. Further, as middle cerebral artery is said to take care of up to 50%–60% of ipsilateral carotid artery blood flow, it is taken that it represents the blood flow to ipsilateral hemisphere. To access the middle cerebral artery, the ultrasound probe has to be placed in front of tragus just above zygomatic arch. Commonly employed windows and vessels insonated through them are mentioned in Table 1.[3]

Table 1: Commonly used acoustic windows, vessels insonated through them, depth, direction of flow and mean velocities

Artery	Acoustic window	Depth (mm)	Flow direction	MFV (cm/s)
MCA	Temporal	30-65	Towards	55±12
ACA	Temporal	60-75	Away	50±11
ICA bifurcation	Temporal	40-70	Both sides	
PCA (P1)	Temporal	60-70	Towards	39±10
PCA (P2)	Temporal	60-70	Away	40±10
BA	Sub-occipital	80-120	Away	41±10
VA	Sub-occipital	60-75	Away	38±10
OA	Transorbital	45-55	Towards	21±5
Extra cranial ICA	Retro-mandibular	45-50	Away	30±9

ICA=Internal carotid artery; MCA=Middle cerebral artery; ACA=Anterior cerebral artery; PCA=Posterior cerebral artery; BA=Basilar artery; VA=Vertebral artery; OA=Ophthalmic artery; MFV=Mean flow velocity

Dynamic monitoring of CBF-V and vessel pulsatility over extended time period is a major application of TCD in clinical practice. Systolic, diastolic and mean flow velocities (MFV) will be derived from the obtained waveform. Decreased MFV is observed in hypotension and in conditions where there is an increase in intracranial pressure or a decrease in CBF. MFV is increased by either vasospasm or by an increase in blood flow, which can be differentiated by a derived index, Lindegaard ratio.[4] Gosling's pulsatility index is a derived index which is reduced with proximal obstruction and is increased with distal obstruction.

Applications of transcranial Doppler

TCD being non-invasive is touted as an alternative to four-vessel angiography for monitoring vasospasm, stenosis, stroke and cerebral circulatory arrest. TCD identifies middle cerebral artery and basilar artery vasospasm with high degree of sensitivity and specificity. It is also highly predictive in the detection of proximal anterior circulation. It is 100% specific and 96% sensitive in diagnosing brain death.[5]

Limitations

TCD uses CBF-V as a surrogate measure of CBF, and CBF-V is proportional to CBF only when vessel cross-sectional area remains constant. There may be absence of adequate acoustic window in about 8% of patients.[6] Operator experience is required for accurate assessment as improper vessel identification, and aberrant vessel course can confound even experienced sonographers in diagnosing vasospasm.

There are several advantages of using transcranial imaging. It is quick, with no radiation exposure, and unlike for magnetic resonance imaging and computed tomographic scan, it does not require any patient transport. Once the learning curve has been passed, it is easy to use.

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Conflicts of interest

There are no conflicts of interest.

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