The role of transcranial doppler in localizing stroke lesion: A valuable tool in low resource setting

VATSALA SHEKHAR, NAMRATA KAHLON, MAYANK SRIVASTAVA, S. ZAFAR ABBAS, ANIL PANDEY, ASIM DAS, K.K. DEEPAK

ABSTRACT

The use of transcranial Doppler (TCD) ultrasound in acute cerebrovascular events has not been widely adopted although it can help clinicians make informed decisions in the early evaluation of patients. A 74-year-old female presented to the emergency department with an acute onset of weakness of the left upper and lower limbs, along with slurring of speech, for the last 12 hours. Non-contrast CT of the head showed a hypodense area in the right frontotemporal region, suggestive of cerebral oedema. A TCD study through the transtemporal window showed increased pulsatility index (PI) of right internal carotid artery and right middle cerebral artery when compared with a control subject. A contrast-enhanced magnetic resonance angiography showed findings consistent with those obtained with the TCD. The TCD clearly indicated the regional involvement in a patient who presented with stroke-like symptoms and, in resource-limited settings, may help in making early treatment decisions.

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INTRODUCTION

Stroke constitutes a major health problem and is the second most common cause of morbidity and the leading cause of disability worldwide.[1] In India, stroke is one of the leading non-communicable diseases causing major disability and is the fourth leading cause of death.[2–4] The physiological mechanisms involved in maintaining a constant cerebral blood flow are disrupted after stroke, leading to changes in cerebral perfusion pressure. Additionally, impaired cerebral auto-regulation has been noted in patients with both ischaemic and haemorrhagic strokes and renders the brain more vulnerable to further injury from oedema or haemorrhagic conversion.[5]

Transcranial Doppler (TCD) is a non-invasive, reproducible, bedside ultrasound technique to assess the rate and direction of blood flow inside the arteries of the brain. TCD is a valuable, non-invasive diagnostic neuroimaging tool that provides real-time information about cerebral haemodynamics.[6] The analysis of TCD flow velocity waveform measures peak systolic velocity (PSV), end diastolic velocity and mean flow velocity, which can calculate resistive index (RI) and pulsatility index (PI), the most practical parameters for assessing the haemodynamic status of the extracranial and intracranial arteries.[6] PI assesses vascular resistance and is considered a marker of small vessel disease,[7,8] whereas RI relates to vessel wall elasticity.[9] The normal values for PI and RI are typically <1.25 and <0.75, respectively.[10] Assessment of PSV, PI, and RI can provide important information for making diagnostic and therapeutic decisions and help as a prognostic tool in patients with ischaemic stroke.

We report a case to show the possible use of TCD in identifying the need of magnetic resonance angiography (MRA) in further management.

THE CASE

A 74-year-old female presented to the emergency room with acute onset of weakness of the left upper and lower limbs, along with slurring of speech for the past 12 hours. She was conscious and oriented to place and people. She had left-sided hemiplegia with 0/5 power in both upper and lower limb, along with dysarthria. Clinically, a cerebrovascular attack was suspected, and a CT scan of the brain showed a right middle cerebral artery (MCA) territory infarct involving the right fronto-temporal cortex, without haemorrhagic transformation (Fig. 1). The infarct was 60×30 mm in size extending from the cortex to the periventricular region.

She was started on conservative management including antiplatelets and statins. Her MRA showed an acute infarct in right fronto-parieto-temporal region with mild oedema, along with relative narrowing of the right internal carotid artery (ICA), A1 segment of the right anterior cerebral artery (ACA) and MCA with paucity of M3 and M4 branches of right MCA (Fig. 2). She had a TCD sonography (Fig. 3) done, and the right ICA, MCA, and ACA were insonated through the right transtemporal acoustic window using a 2 MHz Doppler probe. The spectral Doppler analyses showed markedly increased blood flow velocities and PI in the right ICA and MCA (Fig. 3a and b), suggestive of increased resistance to flow along with slightly elevated PI in the right ACA (Fig. 3c, Table 1). The TCD findings were concordant with those of MRA. The recordings with normal blood flow in the spectral Doppler were shown for right ICA (Fig. 3d), right MCA (Fig. 3e), right ACA (Fig. 3f) in normal person for comparison. The patient gradually improved with medication and physical rehabilitation and was discharged on the 13th day of admission. Power in her upper limb increased to 1/5 and that in her lower limb to 2/5 in 3 months, and her dysarthria completely resolved.

DISCUSSION

Acute ischaemic stroke is a medical emergency characterized by focal neurological deficits resulting from arterial thrombi occluding cerebral arteries. Prompt and accurate diagnosis is crucial for initiating appropriate treatment.[11]

ESIC Medical College and Hospital, Faridabad, Haryana, India
VATSALA SHEKHAR, NAMRATA KAHLON, ANIL PANDEY Department of Physiology
MAYANK KUMAR SRIVASTAVA Department of Neurology
S. ZAFAR ABBAS Department of Radiology

ESIC Medical College and Hospital, Alwar, Rajasthan, India
ASIM DAS Department of Physiology

Indian Institute of Technology (IIT) Delhi, New Delhi, India
K.K. DEEPAK Centre for Biomedical Engineering

Correspondence to K.K. DEEPAK; *kkdeepak@gmail.com*

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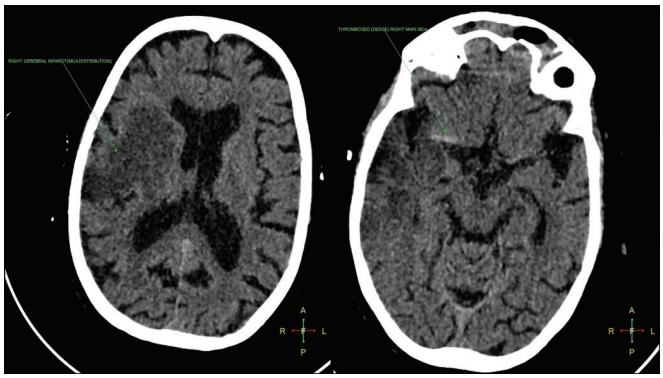

FIG 1. Non-contrast computerized tomography showing hypodense area in right frontotemporal region

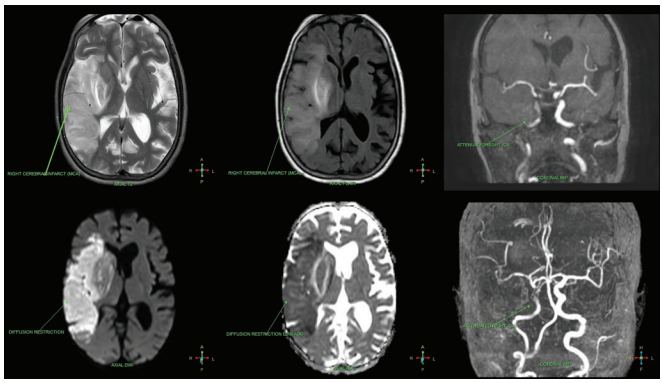

FIG 2. Contrast-enhanced magnetic resonance imaging and magnetic resonance angiography images suggest an acute infarct in right fronto-parieto-temporal region with mild oedema along with relative narrowing of the right internal carotid artery, A1 segment of right anterior cerebral artery and middle cerebral artery with thinning of the M3 and M4 branches of right middle cerebral artery

TABLE 1. Blood flow velocities through right transtemporal window on transcranial doppler in the patient

Blood vessel	PSV (cm/sec)	MFV (cm/sec)	PI	RI	EDV (cm/sec)
ICA-R	73.3	35.7	1.58	0.77	16.8
MCA-R	99.9	52.8	1.34	0.71	29.3
ACA-R	78.3	42.5	1.26	0.69	24.6

PSV peak systolic velocity MFV mean flow velocity PI pulsatility index RI resistivity index EDV diastolic velocity ICA-R right internal carotid artery MCA-R right middle cerebral artery ACA-R right anterior cerebral artery

TCD has emerged as a valuable tool in the early evaluation of acute cerebrovascular events. TCD demonstrates high concordance with brain CT angiography, making it a reliable screening tool for acute cerebral ischemia. Its portability and bedside applicability enhance its utility in time-sensitive scenarios, such as the emergency room setting.[12]

In our patient, we found that the PI and PSV were increased in right ICA and MCA, suggestive of an increase in intracranial pressure. Increase in RI >0.70 and PI >1.25 in the MCA are prognostic indicators of unfavourable outcome in ischaemic stroke. Uzuner *et al.*[13] suggested that PI may play a role in predicting the functional and clinical outcome after thrombolytic therapy in patients with acute ischaemic stroke.

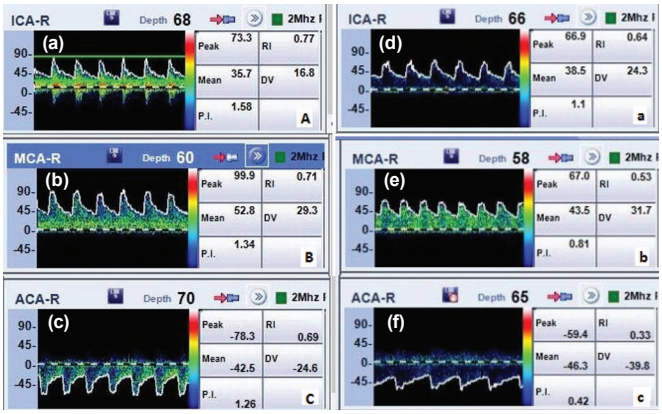

FIG 3. Transcranial doppler (TCD) spectrum in stroke patient (a) for right internal carotid artery (ICA-R), (b) for right middle cerebral artery (MCA-R), (c) for right anterior cerebral artery (ACA-R). TCD spectrum in normal person (d) for ICA-R, (e) for MCA-R, and (f) for ACA-R. *Significance of blue, red and green colour:* When the wave spectra display shows a mixture of colours (mosaic appearance), such as red, blue, yellow, and green, this usually suggests increased velocity variability or turbulence in the artery Depth in cm is on Y-axis PI pulsatility index RI resistivity index DV diastolic velocity

Kim *et al.*[14] demonstrated that PI was an independent determinant of infarct volume in acute stroke. The PI value measured in acute stroke may be a surrogate marker of the extent of ischaemic injury. Kidwell *et al.*[15] concluded that elevation in PI as measured by TCD shows a strong correlation with MRA evidence of small-vessel disease. TCD may be a useful physiological index of the presence and severity of diffuse small-vessel disease.

TCD has not been regularly used in the early management of acute cerebrovascular events. In our patient, diagnostic findings were identified using TCD before MRA, illustrating the complementary information that TCD provided and demonstrating its utility. While MRA remains a valuable imaging modality, certain limitations warrant consideration, highlighting the need for alternative diagnostic approaches like TCD. TCD addresses the concerns of affordability for patients and healthcare systems. The compact nature of TCD equipment facilitates its use in diverse clinical settings, including remote or low-resource settings. Early use of TCD may provide information to justify further imaging in acute cerebrovascular episodes in resource-limited settings.

Conclusion

This illustrative case is instructive, educationally useful and opens a new approach for cost-effective early detection of local vascular functionality in the case of hemi-infarct by using TCD. To substantiate this comparative data with contrast-enhanced magnetic resonance, MRA and non-contrast computed tomography is presented. TCD clearly showed increased PI on the affected side suggesting serious local haemodynamic insult. TCD is the only non-invasive examination that provided reliable evaluation of intracranial blood flow patterns in real time, combining physiological and anatomical information. Early use of TCD may provide enough additional insight to justify further imaging in acute cerebrovascular episodes in resource limited settings. This presents an opportunity in the early evaluation of patients

that can help clinicians make informed decisions in suspected acute ischaemic stroke.

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