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Significance of Transcranial Doppler in Predicting Outcome of Traumatic Brain Injury

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Abstract

Background: This article is to assess the role of transcranial Doppler (TCD) in predicting neurological outcome in traumatic brain injury (TBI) and we review its practical aspects in management of TBI.

Material and Methods: This was a prospective study conducted on 50 patients with traumatic brain injury in the Neurosurgery department of a tertiary care hospital in Rajasthan. Transcranial colour Doppler was done in all the patients to assess the cerebral perfusion. Doppler parameters like Peak systolic velocity, End diastolic velocity, Mean flow velocity and Pulsatility index in bilateral proximal middle cerebral arteries were obtained in all the cases. Patients are categorized into normal, hypoperfusion and vasospasm groups depending on the values. Prognosis was assessed by the neurological deficit and mortality.

Results: Among thirty six patients (51%) who had normal measurement on TCD, 72% patients had good outcome, 18% patients had poor neurological status and 10%patients died. Out of these eleven patients (23%) who had vasospasm, three died, six had severe neurological disability and two patients were discharged in good neurological status. Eighteen patients (26%) had hypoperfusion, of whom, 7 patients had neurological impairment and 5 patients progressed to brain death.

Conclusion: TCD is a valuable imaging tool in prognostication of patients with TBI information by providing information about the cerebral blood flow. It is an emerging modality in predicting neurological outcome in patients with TBI.

Keywords: Transcranial Doppler; Traumatic brain injury; Cerebral blood flow.

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INTRODUCTION

Traumatic brain injury (TBI) may lead to cascade of events in brain which affects brain function and determines outcome of head injury. Severity of TBI depends upon clinical presentation and neurological status. As per WHO about 70-90% of brain injury are mild.[1,2]

Mechanical forces during the trauma may cause primary brain injury by affecting the structural and functioning component of brain.[3] It may complicate to cerebral changes which includes ischemia, hypoxia, altered cerebral perfusion, brain edema and increased intracranial pressure.[4]

TBI may alter the intracranial blood flow leading to hypoperfusion in early days of trauma followed by hyperemia and vasospam in later days which in turn leads to increased ICP.[5,6]

There are various methods for evaluating intracerebral perfusion after head injury which includes 133 Xn clearance, PET and thermal detection probe. These methods are time consuming, expensive and patient's transportation is required to the imaging centre making it difficult for the patients who are on ventilator support.

Transcranial colour Doppler (TCCD) is simple, less expensive, portable, non-invasive, risk free and can be done at bedside also.[7] TCCD establishes linear correlation among blood flow velocities in different cerebral arteries. It can monitor CBF and can measure pulsatility index of MCA to determine ICP. It helps in monitoring development of cerebral vasospasm after subarachnoid hemorrhage.[8,9]

TCCD has significant limitations which includes limited partial resolution, operator dependency and not very useful in patients with inadequate acoustic temporal window for insonation.[8-12]

The aim of our study is to establish the role of Doppler findings in predicting the prognosis. We also aim to describe its significance in management of patients with brain injury.

MATERIAL AND METHODS

This was a prospective study conducted in the Department of Neurosurgery in S.N. Medical College and attached Mathura Das Hospital, Jodhpur from April 2022 to March 2023. This study included fifty patients with head trauma.

Inclusion Criteria:

1. Adults above 18 yrs of age.
2. Patients who came to the hospital within 24 hours of injury.
3. Patients with Glasgow coma scale (GCS) of less than 8.

Exclusion criteria:

1. Patients who refused to give informed consent.
2. Patients who were admitted after 24 hours of injury.
3. Patients with open head trauma.
4. Patient with major injury to other organs of the body including heart, lungs and other abdominal organs.

TCD was performed on consecutive three days of admission, after a week and at the end of one month of trauma. Chi square test was used to stastically analyse the final result. Two MHz probe of colour Doppler ultrasound machine was used to perform TCD through transtemporal window. Doppler parameters like Peak systolic (PSV) and end diastolic velocity (EDV in cm/s), Mean flow velocity (MFV in cm/s), Pulsatility index (PI), Resistivity index (RI) and Systolic diastolic ratio (S/D) of middle cerebral arteries (MCA) were obtained in all the cases.

Hypoperfusion was defined by having two out of three of the following:

I. Mean flow velocity of MCA less than 35 cm/ second.

II. End diastolic velocity of MCA less than 20/ second.

III. PI greater than 1.4.

Vasospasm was confirmed by the mean flow velocity of the MCA greater than 120 cm/second.

Patient's neurological outcome was measured by Glasgow coma scale and Glasgow outcome scale extended (GOSE) which was then correlated with TCD.

RESULTS

Graph one showing agewise distribution of the patients. Age group of 30-50 years compiles majority of the patients which was 66%. Table one also shows that 58% were males and 42% were females.

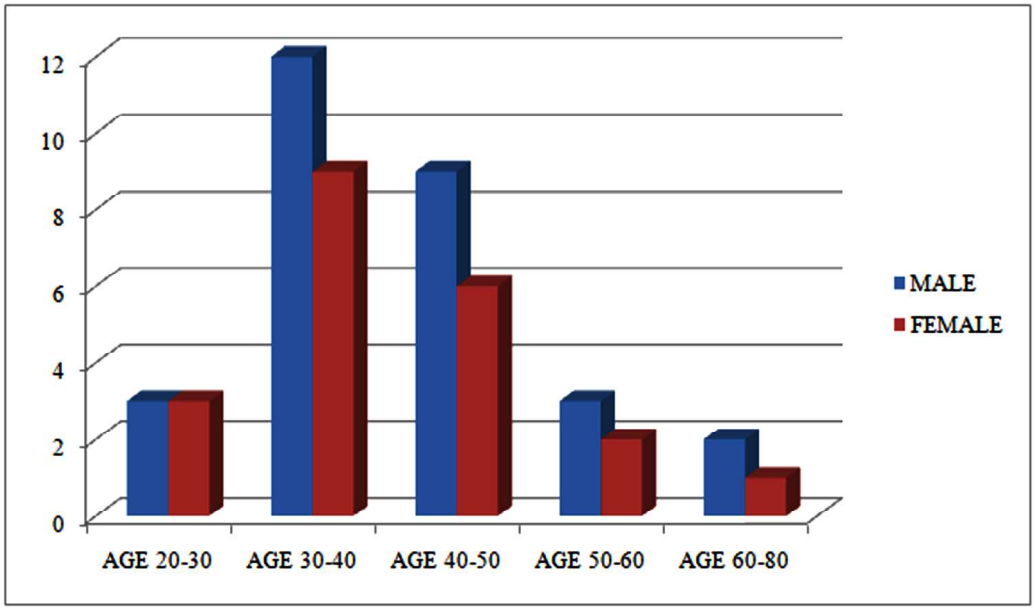


Fig 1: Showing age wise and sex wise distribution

Table one showing the correlation of doppler findings and neurological outcome. Among the patients with normal TCD measurement 72% had no neurological deficit while 18% had neurological impairment on discharge. Among 26 patients with normal TCD 10% died. Hypoperfusion was observed in thirteen patients (26%) with mean GCS score of five. Among these 13 patients with hypoperfusion 52% had neurological impairment while 41% died. Eleven patients (23%) showed vasospasm on TCD. neurological deficit was noticed in 52% of the patients with vasospasm while 27% died with vasospasm.

Table 1: Showing correlation of doppler findings and neurological outcome

-	GCS Score	No Neurological Abnormality	Neurological Deficit	Mortality
Normal TCD Parameters (51%=26)	7 (6-8)	72%	18%	10%
Hypo perfusion (26%=13)	5 (4-5)	7%	52%	41%
Vasospasm (23%=11)	5 (4-5)	21%	52%	27%

Table two showing transcranial doppler data in each group. Majority of the patients had Mean velocity less than 35cm/sec and diastolic velocity less than 20cm/sec in hypoperfusion group while pulsatility index was raised (>1.4). In vasospasm group majority of the patients had mean velocity more than 120cm/sec.

Table 2: Transcranial Doppler Values for Each Group

	All patients	Normal	Hypoperfusion	Vasospasm	P value
	(n=50)	(n=26)	(n=13)	(n=11)	
Systolic velocity (cm/s)	84.8 (72-98)	86 (78-95)	72 (66-81.8)	198 (189-199)	<0.001
Diastolic velocity (cm/s)	34 (21-44)	35.6 (33-40)	19.2 (17.8-19.9)	89 (82.1- 93.1)	<0.001
Mean velocity (cm/s)	47 (35-57)	56 (49-63)	34.2 (30.4-37.6)	123 (121-25.6)	<0.001
Pulsatility index	1.07	0.91	1.61 (1.52-1.71)	0.82 (0.76-0.99)	<0.001

Table three explaining the primary outcome parameters for each group. In hospital mortality was only 10% in the patients with normal TCD measurement while it was observed in 41% of the hypoperfusion group and 27% of the patients with vasospasm. 72% of the patients with normal TCD has good neurological outcome while only 7% of patient with hypoperfusion were neurologically normal. 21% of patients with vasospasm had no neurological deficit. 52% of the patients in each group of hypoperfusion and vasospam had poor neurological outcome.

Table 3: Primary Outcome Parameters For Each Group

-	Normal Tcd Parameters	Patients with Hypoperfusion	Patients with Vasospasm	P Value
	(n=26)	(n=13)	(n=11)	
In Hospital Mortality	10%	41%	27%	<0.001
Good Outcome (Gose Score: 5-8)	72%	7%	21%	<0.001
Poor Outcome Gose Score: 1-4)	18%	52%	52%	<0.001

DISCUSSION

In our study 58% of the patients were male and majority of them were of age group 30 to 50 years. Similar results were observed by Prasad *et al* and Zieger *et al*[7,13] in their studies. TCCD was conducted on 50 patients in our study, Out of which 51 percentage had normal measurements, 26% showed hypoperfusion while Vasospasm was seen in 23% of patients. Similar findings were observed in this study conducted by Prasad *at al*, Ract *et al*, while bouzat *et al* found normal TCD in 69.6 percentage of the patients.[7,14,15]

Among all patients with the normal TCD measurement 72% showed better neurological outcome with no neurological deficit while 10% died and 18% had poor outcome which was also seen in the study conducted by Jigger *et al* and Prasad *et al*.[7]

Prasad *et al* observed neurological impairment in 55% of the patients with hypoperfusion on TCD. 44% died. Our study showed similar results while Zieger *et al* observed 98% death in patients with hypoperfusion.[7,13]

Study conducted by Zieger *et al* had vasospasm in 27 percent of the patients, out of them 31% expired and 45% had good neurological result. Similarly in our study death was observed in 27% of the patients, 21% had good outcome.[13] Similar results were obtained in study conducted by Prasad *et al*.

In our study, overall results suggested that majority of the patients with normal TCD measurements had good neurological outcome and while the other two groups showed increased mortality and poor neurological outcome.

Ract *et al* In his prospective study on 24 patients with TBI concluded that the risk of secondary brain injury can be reduced by using TCD in identification of brain injured patients with hypoperfusion so that TCD goal directed therapy can restore normal cerebral blood flow.[14]

Bouzat *et al* conducted a prospective study on 98 patients with the TBI with initial GCS score of 9-15.[15] He performed TCD of two middle cerebral arteries with the threshold limits of 25 cm/sec for diastolic blood flow velocity and pulsatility index of 1.25 and concluded that TCD on admission along with CT Brain can accurately screen patients who are at risk of Secondary neurological damage.

Gura M in his study has suggested that pulsatility index measurement by TCD can replace invasive ICP monitoring.[16] Similarly, we also found strong correlation of pulsatility index with patient outcome in our study.

Zayton *et al* in his study On 120 patients with TBI who underwent TCD in within 24 hours of admission, he considered that pulsatility Index on TCD is a good predictor of mortality and neurological outcome at 3 month.[17]

TBI is one of the leading causes of mortality and morbidity all over the world. CT scan has been prioritized in investigating the case of head trauma to detect the site of lesions in brain and to detect bone injury as well. Later MRI has been an emerging investigation tool which can detect diffuse axonal injury and microhemorrhages effectively. Newer MRI sequences which include susceptibility weighted imaging, diffusion weighted imaging and DTI have been proved highly sensitive in detecting parenchymal lesions related to trauma.[18]

TCD of middle cerebral artery is non invasive,

less expensive and sensitive method to detect hypoperfusion and vasospasm in head trauma patients, Thereby helps in predicting the prognosis in traumatic brain injury. Use of TCD has also been increased in evaluating other conditions like stroke where it can detect and follow up the vascular changes. It can also be used in patients undergoing thrombolytic therapy to monitor the response. It can assess cerebral vasculopathy and can be used as supplementary imaging test for confirmation of brain death.[19] To improve cerebral perfusion TCD guided therapy is also available in brain injury patients with hypoperfusion.

CONCLUSION

TCD is an emerging important modality in predicting neurological outcome in patients with the traumatic brain injury. Patient with normal TCD measurements have good neurological outcome while the patients with hypo perfusion and vasospasm on TCD have poor prognosis. We concluded from the study that the transcerebral colour Doppler should be included in the management of patients with traumatic brain injury for better outcome.

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