ORIGINAL RESEARCH ARTICLE

Role of Transcranial Doppler as a Predictor of Prognosis in Patients with Traumatic Brain Injury

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ABSTRACT

Background: Traumatic brain injury is one of the leading causes of mortality and morbidity worldwide. Cerebral perfusion abnormalities after brain injury are associated with poor outcome. Transcranial Doppler is useful to identify these subset of patients with low cerebral blood flow. In this article, we review the practical aspects of transcranial Doppler and describe its role in management of traumatic brain injury patients.

Material and methods: This is a prospective study in tertiary care hospitals in North Andhra Pradesh, on 75 patients with severe brain injury, as defined by Glasgow Coma Scale. All the patients underwent Transcranial Doppler study to assess the cerebral perfusion. The systolic, diastolic and mean flow velocities along with pulsatility index are documented in bilateral proximal middle cerebral arteries. Patients are categorized depending on normal or abnormal values. Prognosis is assessed by checking the Glasgow coma scale after one month, or by mortality.

Results: Out of 75 patients who were evaluated, thirty-six patients (48%) had normal measurements on Transcranial Doppler. Among them, 67% patients had good outcome, 19% patients had poor outcome and 14%patients died. Eighteen patients (24%) had hypoperfusion, of whom, 10 patients had severe neurological impairment and 8 patients progressed to brain death. Twenty-one patients (28%) had vasospasm. Six out of these twenty-one patients died, 11 patients had severe neurological disability and four patients were discharged in good neurological status.

Conclusion: Transcranial Doppler provides valuable information about the cerebral haemodynamics, which is essential for prognostication of patients with traumatic brain injury. The value of pulsaltility index correlates well with patient outcome. So, TCD can be used as additional modality in management of patients with TBI.

Keywords: Transcranial Doppler (TCD), Traumatic brain injury (TBI), Pulsatility index (PI), Cerebral blood flow (CBF), Glasgow coma scale (GCS).

INTRODUCTION

Traumatic brain injury is a major cause of death and disability worldwide, causing significant financial burden. Ischemic insult after severe traumatic brain injury (TBI) is usually associated with poor prognosis.[1] Although cross sectional imaging modalities like CT and MRI are used to determine the extent of brain injury, they cannot predict the impending risk of cerebral vasospasm or hypoperfusion. The cerebral perfusion anomalies associated with raised intracranial pressure after TBI, need to be detected early, in order to predict the risk of secondary neurological deterioration and to start goal directed therapy if needed.[2] In this scenario, Transcranial Doppler sonography (TCD) can serve the purpose of monitoring cerebral haemodynamics, immediately after TBI.

Transcranial Doppler permits realtime imaging of basal cerebral arteries, usually through transtemporal window. The distal internal carotid arteries and proximal middle cerebral arteries of both sides are evaluated and their blood flow velocities along with pulsatility indices are documented. The advantages of TCD are cost effectiveness, non invasive nature and portability. It also allows continuous or repeated monitoring in ICU by bedside units.[3]

In TBI, there can be cerebral hypoperfusion in the form of reduced blood flow velocities and elevated pulsatility index. Vasospasm may also be seen which is represented by elevated flow velocity. All these haemodynamic disturbances are associated with poor patient outcome and TCD is the only non invasive imaging modality, which can detect these changes directly.[4]

With this background, we conducted this Transcranial Doppler study on patients with early traumatic brain injury to establish the relation between Doppler findings and the prognosis.

MATERIAL AND METHODS

This was a prospective study conducted in the Department of Radio-Diagnosis in GIMSR, Visakhapatnam and Maharajah's institute of medical sciences, Nellimarla. A total number of 75 patients with severe TBI, who attended the hospital within 24 hours of injury and allotted a Glasgow coma scale (GCS) of less than 8, were included in the study. Only adults (>18yrs) were included in this study. Institutional board approval was taken in all the cases.

Exclusion criteria: 1. Patients who refuse to give informed consent. 2. Who present after first 24 hours of injury. 3. Open head injuries.4 patient with major injury to other organ systems (cardiopulmonary / abdominal).

TCD was performed on hospital days 1, 2, 3, 7 and at the end of 1month. Results were presented as frequencies and statistically analyzed by Chi square test.

All the TCDs were done using Colour Doppler-Ultrasound equipment, with 2MHz probe through transtemporal window.

Doppler parameters like Peak systolic velocity (PSV in cm/s), 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) were obtained in all the cases.

Hypoperfusion was defined by having two out of three of the following: mean velocity of the middle cerebral artery less than 35 cm/second, diastolic velocity of the middle cerebral artery less than 20 cm/second and a pulsatility index greater than 1.4. Vasospasm was defined by the following: mean velocity of the middle cerebral artery greater than 120 cm/second.[5]

The values obtained by TCD are correlated with patient outcome, as measured by Glasgow coma scale and Glasgow outcome scale extended (GOSE).

RESULTS

Out of 75 patients who were evaluated, 34 (45.3%) were females and 41 (55.6%) were males, mostly within the age group of 30 to 50 years (Figure-1). The most common cause of trauma was road traffic accidents, in 90% of the patients.

The patients were grouped into 3 categories, based on Doppler findings - normal, hypoperfusion and vasospasm group.

Categorization of patients based on Transcranial Doppler findings:

Group 1: Normal TCD findings: 36 patients (48%)
Group II: Hypoperfusion group: 18 patients(24%)
Group III: Vasospasm group:21 patients(28%)

Thirty-six patients (48%) had normal measurements. Out of these 36 patients, 24 patients (67%) were discharged with no significant neurological impairment, 7 patients(19%) were discharged with some kind of neurological disability and 5 patients died (14%). Three out of these five patients died from brain death.

Eighteen patients (24%) had hypoperfusion. Out of these patients, 10 patients had severe neurological impairment and 8 patients progressed to brain death (table-2).

Twenty-one patients (28%) had vasospasm. Six out of these twenty-one patients died and 11 patients had severe neurological disability. Only four patients in this group were discharged in good neurological status.

The recovery was good in patients, who had normal transcranial Doppler findings when compared to patients in other two groups. The rate of mortality is more in patients with hypoperfusion or vasospasm groups (table-2,3).

DISCUSSION

Among all the patients in our study, majority were male patients and within 30 to 50 year age group. This is similar to many other studies, as young or middle aged male patients form a major proportion of road traffic accident (RTA) victims.[6]

Ziegler et al., conducted TCD on 255 patients, in which 45% patients had normal measurements. Out of all patients with normal TCD parameters, 80% patients showed a good outcome, 14% died and 5% had poor outcome. Hypoperfusion group comprised of 72 (28%) patients, out of which 71(98%) died and one patient had poor neurological outcome. Vasospasm group comprised of 69(27%) patients, out of which 22(31%) died and 31(45%) had good outcome.[7] Our study showed similar results with good outcome in majority of patients with normal measurements on TCD and more incidence of mortality and poor neurological outcome in other two groups, i.e. vasospasm and hypoperfusion.

Gura M, in their study on 52 TBI patients, concluded that there is strong correlation between intracranial pressure and pulsatility index.[8] They suggested that PI measurements by TCD can be used in place of invasive ICP monitoring. This is in agreement with our study, where we found that there is significant correlation between PI values and patient outcome. Increased PI values are associated with

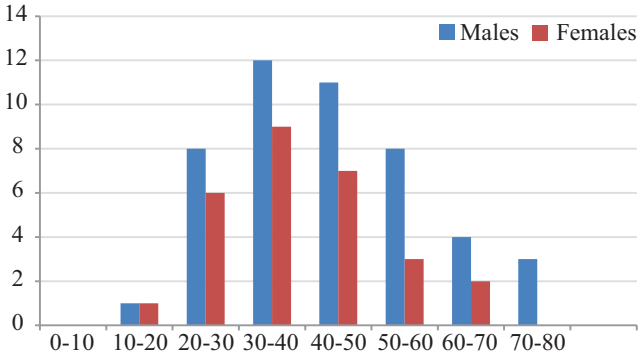

Figure-1: Age and sex distribution of patients

	Mean GCS Score	No neurological deficit	Neurological impairment	Death
Normal TCD measurements (n = 36)	7 (6 - 8)	24	7	5
Hypoperfusion (n = 18)	5 (4 - 5)	-	10	8
Vasospasm (n = 21)	5 (5 - 6)	4	11	**6**

Table-1: Showing the relation between Doppler findings and neurological outcome.

	All Patients (n = 75)	**Normal (n = 36)**	**Hypoperfusion (n = 18)**	**Vasospasm (n = 21)**	***'p'* value**
Systolic Velocity (cm/sec)	86.3 (75.6 - 99.2)	88 (80.0 -97.2)	74.2 (68.4 - 84.3)	194 (187.5 - 198.6)	< 0.001
Diastolic velocity (cm/sec)	31.2 (18.8 - 41.3)	38.45 (30.7 - 41.8)	18.3 (17.3 - 18.9)	88.3 (81.4 - 91.4)	< 0.001
Mean velocity (cm/sec)	49.9 (38.9 - 59.3)	54.3 (48 - 61.3)	33.8 (31.2 - 36.5)	121.8 (120.9 - 24.9)	< 0.001
Pulsatility index	1.09 (0.92-1.46)	0.97 (0.86 - 1.11)	1.52 (1.46 -1.66)	0.85 (0.78 -- 0.97)	< 0.001

Table-2: Transcranial Doppler data for each group.

	Normal (n = 36)	**Hypoperfusion (n = 18)**	**Vasospasm (n = 21)**	**P**
In-Hospital mortality	5(14%)	8 (44%)	6 (29%)	< 0.001
Good outcome (GOSE Score: 5 - 8)	24(67%)	10(56%)	4(19%)	< 0.001
Poor outcome (GOSE score: 1 - 4)	7(19%)	-	11(52%)	< 0.001

Table-3: Primary Outcome parameters for each group

poor patient outcome in our study.

Bouzat in his study on 98 TBI patients had formulated threshold levels of 5cm/s for diastolic blood flow velocity and 1.25 for pulsatility index.[9] He suggested that TCD can be used as an adjuvant imaging modality, in addition to CT to screen the patients at risk of secondary neurological deterioration.

H.Tan et al., in their study on 96 TBI patients concluded that mean blood flow velocity values of MCA correlated well with ICP and CPP values, when performed in first 24 hours.[10] Similar findings were observed in our study, where the changes in blood flow velocities of MCA are consistent with the pathology.

A study done by Catherine Ract et al., stated that TCD can be used to identify TBI patients with hypoperfusion.[2] In this risk group, TCD goal directed therapy can help to recover the cerebral perfusion, thereby reducing the risk of secondary neurological deterioration.

Traumatic brain injury (TBI) is one of the leading causes of death and disability all over the world. Most of the victims are young or middle aged males. The main objective of imaging in TBI is to identify the lesions which need neurosurgical intervention or to detect the findings that will alter the treatment plan. From decades, CT has been widely used as first line of investigation in head trauma. It can effectively detect the intraparenchymal and extraparenchymal brain injury, along with excellent depiction of bone injury. Later MRI was proved to be highly sensitive than CT in detecting parenchymal lesions, diffuse axonal injury, microhaemorrhages etc. The newer MRI sequences like diffusion weighted imaging, susceptibility weighted imaging and DTI are extremely sensitive in detecting trauma related changes.[1]

TCD is a non invasive method of measuring blood flow parameters in middle cerebral artery. It is a sensitive method to detect hypoperfusion, thereby predicting the prognosis in patients with TBI. TCD was initially introduced to detect the vasospasm following traumatic subarachnoid hemorrhage. However, later its use has expanded over the recent times and TCD has been widely used as a noninvasive and cost-effective tool for evaluating other important conditions like detection and follow up of vascular occlusion in stroke, to detect the stroke risk in sickle cell anemia patients, monitoring the response to thromobolytic therapy, assessing cerebral vasculopathy, as a supplementary diagnostic test for the confirmation of brain death etc.[11] It can also help in guiding the therapy in high risk group, to improve the cerebral perfusion.

Our study has few limitations. The influence of other pre-existing co-morbidities like cardio-pulmonary disorders or previous neurological disease was not taken into account in predicting the prognosis. The study sample size is less, limiting it's value. The follow up period is limited to 4 weeks, which would have been better if extended to longer duration.

CONCLUSION

Trancranial Doppler is an extremely important modality in monitoring of patients with traumatic brain injury and to predict the neurological outcome. Patients with normal cerebral haemodynamics, as detected by TCD have good prognosis and the patients with cerebral hypoperfusion or vasospasm usually show poor neurological outcome. The use of TCD should be incorporated in management

of patients with TBI. However further studies on larger patient population may be helpful in determining the efficacy of TCD in initiating and monitoring goal directed therapy.

REFERENCES

1. James M. Provenzale, Imaging in traumatic brain injury: A review of the recent medical literature; American journal of Roentgenology. 2010;194:16-19.
2. Catherine Ract, Sophie Le Moigno, Nicolas Bruder, Bernard Vigue. Transcranial Doppler ultrasound goal-directed therapy for the early management of severe traumatic brain injury, Intensive Care Med. 2007;33(4):645-651.
3. Sushmita Purkayastha, Farzaneh Sorond. Transcranial Doppler Ultrasound: Technique and Application, Semin Neurol. 2012; 32(4): 411–420.
4. Oertel M, Boscardin WJ, Obrist WD, Glenn TC, McArthur DL, Gravori T, et al. Posttraumatic vasospasm: the epidemiology, severity, and time course of an underestimated phenomenon: a prospective study performed in 299 patients. J Neurosurg 2005; 103: 812-24.
5. White H, Venkatesh B. Applications of transcranial Doppler in the ICU: a review. Intensive Care Medicine 2006; (32)7: 981– 94.
6. Frost R.B, Farrer T.J, Primosch M, Hedges D.W. Prevalence of Traumatic Brain Injury in the General Adult Population: A Meta-Analysis, Neuroepidemiology 2013;40:154–159.
7. D Ziegler, G Cravens, G Angles, R Gandhi, and P Cho., Use of transcranial Doppler in patients with severe traumatic brain injury; Crit Care. 2010; 14(Suppl 1): P292.
8. Gura M., Elmaci I, Coskun N. Correlation of pulsatility index with intracranial pressure in traumaticbrain injury; Turk Neurosurg 2011; 21(2):210-5.
9. BouzaP, Francony G, Declety P, Kaddour A et al, Transcranial Doppler to screen on admission patients with mild to moderate traumatic brain injury; Neurosurgey 2011:68(6):1603-10.
10. Tan H, Feng H, Gao L, Huang G, Liao X. Outcome prediction in severe traumatic brain injury with transcranial Doppler ultrasonography.Chinese Journal of Traumatology 2001, 4(3):156-160.
11. Hayden White, Balasubramanian Venkatesh. Applications of transcranial Doppler in the icu; a review, Intensive Care Med 2006 (32):981-994.

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