

Transcranial Doppler as an Early Predictor of Neurological Outcome in Mild and Moderate Traumatic Brain Injury

استخدام الموجات فوق الصوتية عبر الجمجمة كمؤشر مبكر لتوقعات حالة الجهاز العصبي في إصابات المخ البسيطة والمتوسطة

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**إيفاء جزئيا
لشروط الحصول علي درجة الدكتوراه
في
التخدير والعناية المركزة الجراحية
وعلاج الألم**

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Introduction

Traumatic brain injury (TBI) is a major cause of mortality and disability worldwide. More than 80% of TBI cases presenting to the emergency room (ER) are classified as mild to moderate (Glasgow Coma Scale (GCS) score, 9-15)¹.

Despite their apparent low severity on admission, mild and moderate TBI can proceed to intracranial complications in up to 20% of cases, some of which will require neurosurgical intervention ^{2,3}. Crucially, patients with mild to moderate TBI are also susceptible to sudden early neurological deterioration and described as the “patients who talk and die”⁴.

Such secondary neurological deterioration (SND) occurs primarily within the first week after injury and results from several causes: cerebral edema, intracerebral or subdural hematoma, subarachnoid hemorrhage, seizures, symptomatic hydrocephalus, or the cerebral consequences from extracranial injuries⁵.

Detecting patients at risk for early SND after mild to moderate TBI on admission has received relatively little attention. Most studies have been conducted to identify predictors of unfavorable outcome at least 6 months after mild or moderate TBI^{6,7}.

Biochemical serum markers such as protein S-100b have been used to assess functional outcome, symptoms, and measures of neuropsychological impairment several months after injury, not to screen patients at risk of early neurological complications⁸. As a result, most emergency management protocols focus exclusively on using CT scans to identify the relatively small number of patients who may require early neurosurgical procedures^{9,10}.

Transcranial Doppler (TCD) is a technique that explores cerebral blood flow velocities¹¹. In patients with TBI, this technique can reveal low diastolic blood flow velocity (FVd) and high pulsatility index (PI) values induced by high vascular bed resistance. TCD has been used on admission to improve cerebral hemodynamics in patients with severe TBI¹². Surprisingly, little studies conducted in patients with mild and moderate TBI.

In a study by **Bouzat et al., 2011**, including patients with normal or mild brain lesions on initial CT scan, they found a correlation between TCD measurements on admission and early neurologic status. The thresholds of 1.25 and 25 cm/s for PI and FVd accurately predicted neurologic worsening with 90% sensitivity and 91% specificity².

Also, cohort study by **Bouzat et al., 2016**, found that TCD measurement threshold had high negative predictive value (NPV) to predict neurological worsening despite low incidence while the positive predictive value (PPV) of TCD to predict SND was low⁵.

As it was a limitation in previous study, we will use wider range of threshold rather than strict cutoff threshold.

Aim of the work

The aim of our research will be to study the utility of Transcranial Doppler Pulsatility Index in mild and moderate traumatic brain injury for early prediction of neurological deterioration.

Patients and methods

This prospective study will be carried out in Tanta Emergency Hospitals for one year starting after approval from Ethics Committee on 105 patients with mild to moderate traumatic brain injury (TBI).

After approval from Institutional Ethics Committee an informed consent will be obtained from each participant. All data of patients will be confidential with secret codes and private file for each patient. All given data will be used for the current medical research only.

Any unexpected risks appeared during the course of the research will be cleared to participants and the ethical committee on time. Each participant will receive an explanation to the purpose of the study and have secret code number to ensure privacy to participants and confidentiality of data.

Inclusion criteria:

Any adult patient aged (25_60) years presented with mild to moderate TBI (GCS 9 – 15) admitted to Emergency Hospitals within 12 hours following the trauma.

Exclusion criteria:

- Patient underwent head surgical procedure before admission.
- History of previous intracranial lesion.
- History of treatment with anticoagulant and /or antiplatelet.
- TBI more than 12 hours following trauma.
- Mechanically ventilated patients with sedation on admission.
- Systolic arterial blood pressure less than 90 mmHg and /or arterial pulse oximetry less than 90%.

- Evidence of severe brain lesions on initial CT scan (*i.e.*, *Traumatic Coma Data Bank* TCDB classification III-VI)¹⁴
- Any craniotemporal lesion impeding satisfactory TCD examination

Each patient will be undergoing:

- History (from patient and attendance).
- General and neurological examination.
- Monitoring (noninvasive blood pressure, Electrocardiography, oxygen saturation (SaO₂))
- Laboratory investigation(Hb concentration, serum Na and K concentration and arterial blood gases (ABG))
- Equipment:
Doppler Ultrasound machine (SonoScape[®], SSI-6000, China).
Ultrasound probe 2 - 5 MHz.
Sterile gloves, towels and gel.
- Method:

Both middle cerebral arteries will be insonated through the transtemporal window at a depth of 50 to 60 mm, and tracings will be recorded for at least 10 cardiac cycles in patients showing stable conditions, *i.e.*, no agitation or pain, no cardiorespiratory distress. The clinoid process of the sphenoid bone and the brain stem will be initially identified. Color-coded sonography will enable identification of the circle of Willis. The middle cerebral artery (MCA) will be identified and manual angle correction then will be applied to measure blood flow velocity in each MCA (in centimeter per second). Tracings will be stable over a 30-s recording period. Time-averaged mean blood flow velocity (FVm), systolic blood

flow velocity (FVs), diastolic blood flow velocity (FVd) (in centimeter per second) and the PI $[(FVs - FVd)/FVm]$ will be calculated².

All patients will have TCD measurements immediately on admission and will be classified into groups according to PI value and the outcome.

Measurements:

All data will be recorded by a physician not included in the research.

- Age, sex, Glasgow coma scale¹³, comorbidities and the cause of trauma.
- The length of stay in the hospital and ICU.
- The heart rate, blood pressure, SaO_2 and $Paco_2$ every 12 hr in first 48 hr then every day till 7th day.
- Head CT classification by (TCDB classification) ¹⁴ on admission.
- Pulsatility index (PI) will be measured on admission then every 12hr following admission for 1st 48 hour after that every day till 7th day.
- Secondary neurological deterioration (SND)¹⁵ (one of the two objective criteria: (1) a decrease in GCS of greater than 2 points from the initial GCS in the absence of pharmacologic sedation (2) a deterioration in neurologic status sufficient to warrant intervention, *i.e.*, mechanical ventilation, sedation, osmotherapy, or neurosurgical intervention) after 48hr till the 7th day.
- Extended Glasgow Outcome Scale (GOSE) ¹³after one month.

Primary outcome:

SND at 7th day post traumatic.

Secondary outcomes:

Length of stay in ICU and GOSE after one month.

Sample Size Calculation:

Using MedCalc program version 18.2.1 (MedCalc Software, Ostend, Belgium), the sample size is calculated as 105 patients. The sample size calculated by the following criteria:

- 5% confidence limit.
- 80% power of the study.
- According to a previous study ⁽²⁾, area under the curve (AUC) for PI to predict the outcome (SND) was 0.86 and 6% of patients developed SND within the first week after trauma.
- 16 cases were added to overcome drop out.

Results

All results will be tabulated and statistically analyzed.

Discussion

The results will be discussed later.

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