

# Interest of Transcranial Doppler (TCD) in Emergency in Traumatic Brain Injury Patients at Gabriel Touré University Hospital, Bamako, Mali

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## Abstract

**Introduction:** Transcranial Doppler is a simple, non-invasive and inexpensive examination which allows the assessment of cerebral perfusion. In countries with limited resources, which do not have a means of monitoring intracranial pressure, this examination offers hope of survival for patients with traumatic brain injury. This study was designed to investigate the incidence of early cerebral circulation abnormalities after traumatic brain injury using transcranial Doppler (TCD). **Methodology:** A descriptive and analytical study was conducted over one year, including patients with traumatic brain injury and an initial Glasgow Coma Scale (GCS) score of less than 15. **Non-inclusion criteria:** Stroke, brain tumor, cerebral abscess. **Exclusion criteria:** Inadequate insonation window. **Results:** Out of 854 traumatic brain injury patients admitted to the emergency department, 112 were included in the study. The average age was 30.14 years, with a sex ratio of 4.1. Initially, 83.5% had moderate traumatic brain injury, and 12.1% had severe traumatic brain injury. Brain CT scans were performed in 95.7% of the patients. Edematous-hemorrhagic contusion was observed in 95% of the patients. On initial TCD, the pulsatility index in the middle cerebral artery was greater than 1.3 in 49.4% of the patients. Diastolic velocity was less than 20 cm/s in 46.4% of cases, and mean velocity was greater than 150 cm/s in 8.7% of cases. In this group, low diastolic velocity indicated cerebral hypoperfusion suggestive of intracranial hypertension. When the pulsatility index was greater than 1.9, no patient had a normal diastolic velocity. Among patients with severe traumatic brain injury, 61.5% had

an abnormal pulsatility index compared to 42.3% of patients with moderate traumatic brain injury. **Conclusion:** TCD is a simple tool for analyzing intracerebral hemodynamics.

## Keywords

Traumatic Brain Injury, TCD, Neuroresuscitation, Sub-Saharan Africa

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## 1. Introduction

Transcranial Doppler (TCD) allows for the estimation of the risk of intracranial hypertension (ICH) with good performance in the first hours following traumatic brain injury before appropriate diagnostic and monitoring tools become available. It is unanimously accepted that non-contrast CT remains the reference examination, with nearly 100% sensitivity for detecting cranio-cerebral traumatic injuries. However, a major concern remains the early post-traumatic neurological deterioration [1] [2], frequently associated with ICH due to delayed diagnosis. Hence, screening for ICH is an essential objective upon admission of a traumatic brain injury patient [3]. However, the initial clinical examination and brain CT scan may fail to accurately assess this risk [2]. Therefore, TCD, a simple and effective tool for analyzing intracerebral hemodynamics, appears useful in the emergency department for patients at risk of intracranial hypertension. The analysis of velocities is easily obtainable in the middle cerebral arteries, which represent 70% of the internal carotid artery flow [4]. This pioneering study evaluates cerebral hemodynamics using TCD in traumatic brain injury patients in the emergency department in sub-Saharan Africa, aiming to assess the prevalence of ICH, and the resulting therapeutic and decision-making benefits.

## 2. Patients and Methods

**Study Type:** We conducted a descriptive and analytical, prospective, single-center, non-randomized study from February 2020 to January 2021 to evaluate cerebral perfusion by measuring velocities in the middle cerebral artery using TCD in traumatic brain injury patients.

**Study Setting:** Emergency Department, Gabriel Touré University Hospital.

**Study Participants:** All patients admitted to the emergency department for trauma, regardless of the mechanism.

**Inclusion Criteria:** Patients presenting at least one of the following criteria upon admission to the emergency department or during hospitalization:

- Traumatic brain injury with altered consciousness.
- Polytrauma with altered consciousness.
- Patients with secondary neurological deterioration.

**Non-Inclusion Criteria:** Patients admitted for stroke, brain tumor, cerebral abscess.

**Exclusion Criteria:** Inadequate insonation window, poor quality Doppler spectrum.

**Variables Studied:** Mechanism of traumatic brain injury, Glasgow Coma Scale score, tomodensitometric lesion assessment, pulsatility index (PI), systolic, diastolic, and mean velocities (Vs, Vd, Vm) in the middle cerebral artery (MCA), therapeutic modifications, and neurological outcomes.

**TCD Parameter Acquisition Method:** All TCDs were performed at the patient's bedside using a 2 MHz probe. The trans-temporal acoustic window was used. Vessels were identified using color Doppler before measuring velocities.

**TCD Validity Criteria:** Bilateral TCD measurements were obtained from a stable trace over ten cardiac cycles in a normothermic patient with a hemoglobin level > 9 g/dL. TCD was considered normal with the following velocities: PI < 1.2, Vs (cm/s)  $95 \pm 10$ , Vd (cm/s)  $45 \pm 10$ , Vm (cm/s)  $60 \pm 10$ . [5]

**Data Collection:** Information was collected on a pre-established survey form from triage sheets, medical records, admission registers, and TCD reports.

**Data Analysis:** Data analysis was performed using SPSS 19.0 software. The chi-square test was used with a significance level set at  $p < 0.05$ . Qualitative data were expressed as percentages. Quantitative data were presented as mean with their standard deviation and 95% confidence interval according to the significance level.

**Informed Consent:** Patients or their legal representatives were invited to provide informed consent before participating after being thoroughly informed about the study's purpose and procedures.

### 3. Results

During the study period, the emergency department (ED) received a total of 15,060 patients with injuries, among whom 854 were diagnosed with traumatic brain injuries. Of these patients with traumatic brain injuries, 112 underwent evaluation by transcranial Doppler (TCD). Nineteen patients were excluded from the analysis, including seventeen due to uninterpretable TCD results and two due to difficulties accessing the temporal windows. The average age of the patients was 30.14 years, with a sex ratio of 4.1. The majority of trauma cases (79.5%) were due to road traffic accidents (RTAs). Upon admission, 41.9% of patients presented with severe neurological symptoms. Pupillary abnormalities were observed in 46.2% of patients, often associated with head wounds in 66.6% of cases, including 36 cases of scalp injuries and 16 cases of ENT injuries. According to the initial neurological assessment using the Glasgow Coma Scale, patients were classified as having moderate traumatic brain injury in 83.5% of cases and severe traumatic brain injury in 12.1% of cases. An initial brain CT scan was performed in 95.7% of patients, revealing various lesions, among which edema-hemorrhagic contusions were observed in 42.4% of cases. The initial CT scan of brain lesions is summarized in **Table 1**. In 12% of these patients, a decision for neurosurgical intervention was made based on the initial brain scan. This treatment consisted of

decompressive craniotomy (27%), evacuation of the cerebral hematoma (13%), and/or elevation of a depressed skull fracture (12%). Considering the clinical condition, the main indications for TCD were the screening for intracranial hypertension (ICH) in 56% of cases, secondary neurological deterioration in 34.4% of cases, or the presence of pupillary abnormalities in 9.6% of cases.

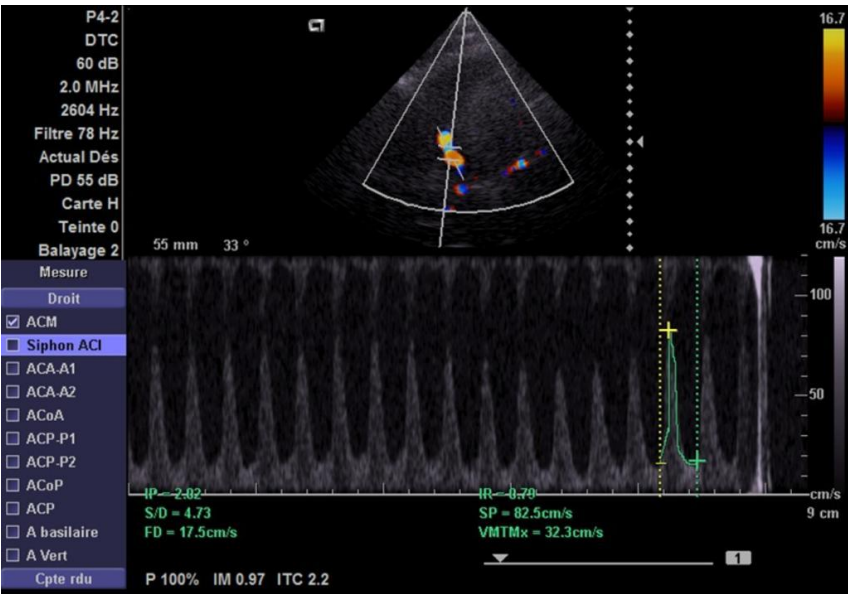
**Table 1.** Initial brain scan lesions.

Brain damage	Fréquency	Percentage
<b>Cranial Fractures and Impairments</b>	11	6.9%
<b>Edemato-hemorrhagic contusion</b>	67	42.4
<b>Extradural hematoma</b>	8	5.1%
<b>Subdural hematoma</b>	15	9.5%
<b>Subarachnoid hemorrhage</b>	48	30.4%
<b>Cerebral edema</b>	9	5.7%
<b>Total</b>	158	100%

On initial TCD, a pulsatility index (PI) greater than 1.3 was observed in 49.4% of patients in the middle cerebral artery (MCA), associated with a diastolic velocity (Vd) less than 20 cm/s in 46.4% of cases and a mean velocity (Vm) greater than 150 cm/s in 8.7% of cases. In 35.4% of cases, the PI ranged from 1.3 to 1.9. In this group, Vd was normal in 24.2% of patients, while it was less than 20 cm/s in 45.4% of patients, indicating cerebral hypoperfusion suggestive of ICH (**Table 2**). When the PI was greater than 1.9, no patient had a normal Vd, as illustrated in **Figure 1** where Vd was 17.5 cm/s in a sedated and mechanically ventilated traumatic brain injury patient in the shock room. This dangerous cerebral hypoperfusion led to rescue osmotherapy. In this context of medical practice with limited resources, the disappearance or inversion of diastolic velocities and the presence of pendular perfusion on Transcranial Doppler, as illustrated by **Figure 2**, suggest the cessation of cerebral perfusion. The persistence of this Doppler pattern despite treatment with mannitol confirmed the state of brain death in the absence of an electroencephalogram. Based on the initial severity diagnosis at admission, 61.5% of severe traumatic brain injury cases had a pathological PI, compared to 42.3% of moderate traumatic brain injury cases with abnormal PI in **Table 3**.

**Table 2.** Initial brain scan lesions.

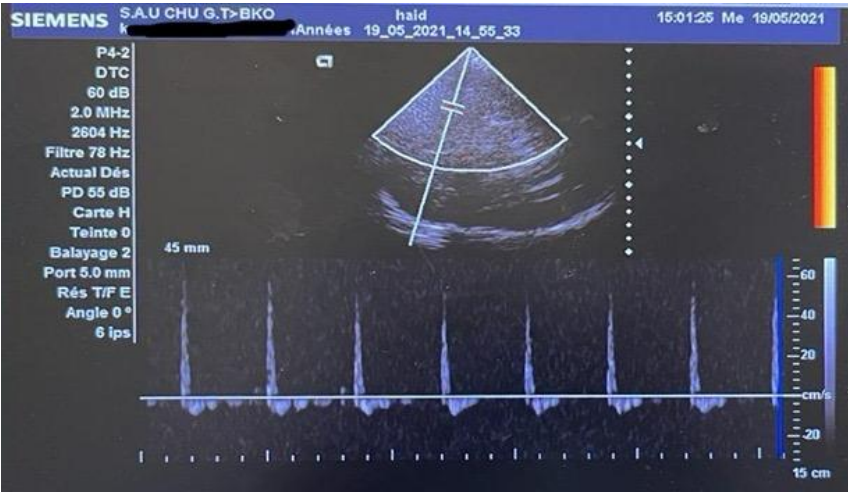
Pulsatility index	Diastolic velocity (cm/s)			<i>p</i>
	>25	[25 - 20]	<20	
<1.3	42	4	1	<i>P</i> = 0.02
[1.3 - 1.9]	8	10	15	
>1.9	0	4	9	
<b>Total</b>	<b>50</b>	<b>18</b>	25	



**Figure 1.** TCD in a patient with severe Intracranial hypertension PI at 2.02 in the emergency department of the Gabriel Touré University Hospital.

**Table 3.** Correlation between alteration of PI and clinical severity of TBI.

Clinical severity	Pulsatility index value			p
	<1.3	[1.3 - 1.9]	>1.9	
severe TBI	15	15	9	0.02
Moderate TBI	29	18	4	
Light TBI	3	0	0	
Total	47	33	13	



**Figure 2.** TCD in a patient with disappearance, inversion of diastolic velocities and the presence of a pendular perfusion on TCD, suggest the cessation of cerebral perfusion in emergency department of the Gabriel Touré University Hospital.

These results prompted modifications and/or initiation of new therapies,

argued for or against neurosurgical interventions, and supported new indications for brain CT scans in 35.5% of patients. (Table 4). The average length of stay was 73 hours, with a range from 6 hours to 168 hours. This duration may seem short given the clinical severity of the patients; however, the mission of the emergency department is to ensure the prompt reception, stabilization, and transfer of patients downstream as quickly as possible. We recorded a 30% mortality rate due to traumatic brain injury during this study. In the first 72 hours, this mortality was associated with polytrauma (23.21%) combined with hemorrhagic shock in 14.28% of cases. Later on, these deaths were attributable to septic shock of bacterial origin in 28.36% of cases, or parasitic origin, primarily malaria, in 13.43% of cases.

**Table 4.** Therapeutic modifications after DPT.

Therapeutic modifications	Fréquence	Pourcentage
Osmotherapy + neurosedation	15	16.1%
Control brain CT	7	7.5%
Indication for Surgery	1	1.1%
Neurosurgical abstention	2	2.2%
Indication for cerebral CT angiography	2	2.2%
No therapeutic modification	60	64.5
<b>Total</b>	<b>93</b>	<b>100%</b>

#### 4. Discussion and Comments

In sub-Saharan Africa, very few studies have evaluated the contribution of TCD in the emergency department as an indirect screening tool for ICH in traumatic brain injury patients. TCD's performance (speed, non-invasiveness, good reproducibility) [6] makes it an attractive technique for emergency neuro traumatology, where time is crucial for preventing secondary ischemic lesions. However, TCD is not a direct measure of intracranial pressure, although changes in PI are well correlated with cerebral perfusion. An elevated PI indicates cerebral hypoperfusion, provided Vd is less than 25 cm/s [4]. PI is not interpretable in certain ischemic situations with normal PI: vasospasm, hypercapnia, aortic dissection.

Moreover, TCD measurements are strongly influenced by physiological variables: mean arterial pressure (MAP), PaCO<sub>2</sub>, SaO<sub>2</sub>, hemoglobin levels [7]. Therefore, TCD measurements should be performed in stabilized patients without hemodynamic or respiratory failure. Detecting and preventing ischemia are the primary objectives in the first hours of traumatic brain injury management. In our context, in the absence of any intracranial pressure (ICP) monitoring, TCD results were highly valued. In a multidisciplinary setting, they allowed us to urgently associate osmotherapy with treatment in a quarter of patients, be aggressive in monitoring, organizing complementary exams, and better argue neurosurgical indications. Due to the transient nature of patients' stay in the emergency department

and the lack of data on their outcomes after leaving the emergency department, it would be difficult to establish a correlation between the transcranial Doppler results and the patients' prognosis. The value of this examination lies in its ability to prompt early management decisions that could modify certain therapeutic choices to the benefit of the patient.

These results should be confirmed in a larger prospective study. An algorithm for management based on clinical data and TCD measurements is needed.

## 5. Conclusions

TCD upon arrival of a traumatic brain injury patient is an essential initial examination. This examination provides crucial information for the initial management of these patients and allows for rapid orientation of the therapeutic strategy.

### State of Knowledge on the Subject

- TCD non-invasively measures the velocity of red blood cells in cerebral arterial trunks.
- A PI of  $1.0 \pm 0.2$  and a diastolic velocity (Vd) of  $40 \pm 10$  cm/s indicate normal cerebral hemodynamics.
- A PI  $> 1.4$  associated with a Vd  $< 20$  cm/s is a cerebral hemodynamic emergency requiring immediate treatment.

## Contribution of Our Study to Knowledge

- Half of the traumatic brain injury patients managed in the emergency department had cerebral perfusion abnormalities during TCD examination.
- In the absence of direct intracranial pressure (ICP) measurements, TCD played an essential role in major therapeutic decision-making during the initial management phase of severe traumatic brain injury patients.

## Conflicts of Interest

The authors declare no conflicts of interest.

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