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ROLE OF TRANSOCULAR ULTRASOUND IN IDENTIFYING RAISED INTRACRANIAL PRESSURE AND PREDICTING INTRACRANIAL BLEED IN TRAUMATIC BRAIN INJURIES

Muhammad Asim Ghauri, Ahmed Mujadid Khan Burki, Anum Sultan, Hassan Masood, Muhammad Umer Hayat, Muhammad Awais Qarni,

Combined Military Hospital/National University of Medical Sciences (NUMS) Rawalpindi Pakistan

ABSTRACT

Objective: To know the efficacy of transocular ultrasound (TOU) in identification of elevated intracranial pressure (eICP) and early prediction of intracranial bleed in traumatic brain injuries (TBI).

Study Design: Descriptive study.

Place and Duration of Study: Department of Anaesthesiology and Critical Care Combined Military Hospital Rawalpindi, from Jan 2017 to Dec 2017.

Subjects and Methods: This study was conducted after approval from the ethical committee. Total 60 patients with traumatic brain injuries having Glasgow Coma Scale <9, 20-60 years of age and previous no history of head and facial trauma, were included in this study by non-probability purposive sampling. The patients were assessed systematically and their optic nerve sheath diameter (ONSD) was measured through transocular ultrasonograhy. The examination was performed over a closed eyelid in the supine position with head of bed elevated 30°. The optic nerve sheath diameter was measured 3mm posterior to the optic disk in two orthogonal planes with the probe held perpendicular to the coronal plane of the globe. Optic nerve sheath diameter of >0.5cm was taken as an elevated intracranial pressure and a predictor of CT findings of sub arachnoid hemorrhage, subdural hematoma, extradural hematoma and cerebral edema.

Results: Mean OND of right and left eye were 0.5895 ± 0.059 cm and 0.5735 ± 0.078 cm respectively in patients of traumatic brain injury. The results are significant as OND was >0.5cm and showed increased intracranial pressures in patients with traumatic brain injuries.

Conclusion: Use of transocular ultrasonography can detect elevated intracranial pressures quiet early. It is a non-invasive procedure, and can easily be inducted in early surveillance of traumatic brain injuries to reduce morbidity and mortality.

Keywords: Intracranial bleed, Intracranial pressure, Optic nerve sheath diameter, Transocular ultrasound.

INTRODUCTION

Traumatic brain injuries add up to the mortality percentage of the data of any hospital in any part of the world. A large road traffic injury surveillance study (n>100,000) in Pakistan showed that nearly a third of patients had a traumatic brain injury and of them about 10% percent had moderate to severe a traumatic brain injuries[1], whereas in United States traumatic brain injuries contribute to about 30% of all injury deaths[2]. The overall mortality and morbidity of a traumatic brain injury is 30%[3] and 40%[4] respectively, which is a very big figure and the patients become a liability.

Correspondence: Dr Muhammad Asim Ghauri, Classified Anaesthetist, CMH Rawalpindi Pakistan

Email: drasimghauri@gmail.com

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The rising trend in a traumatic brain injuries and associated increase in morbidity and mortality asks for newer and more rapid trends of assessing and diagnosing the patient and thus planning a streamlined management rather than haphazard treatment and assessing in emergency department, as timely diagnosis and treatment can help decrease long term morbidity in these patients as primary damage cannot be undone but secondary damage can be controlled[5,6]. There is a set criteria by the Brain Trauma Foundation (BTF) which suggests to keep the systolic BP>90 mmHg and oxygen saturation >90%, maintenance of intracranial pressure (ICP) and mean arterial pressure i.e. MAP so that cerebral perfusion pressure (CPP) remains adequate i.e. between 50-70mmHg. An increase in intracranial pressure of more than 20 mmHg calls for the initiation of treatment or some intervention[5].

Ultrasonography has played a vital role in advancement of all medical fields, speaking specifically of ICU setup; ultrasonography has raised the bar of critical care to a very high standard by introducing novel investigations like lung ultrasonography at bedside with high sensitivity index which enables the intensivists and surgeons to make prompt decisions. One such easy and fancy investigation is transocular ultrasonography (TOU), which enables us to visualize the optic nerve. Actually, the optic nerve sheath contains fluid in which the optic nerve is enclosed. The sheath attaches to the posterior aspect of the globe and is contiguous with the subarachnoid space. Accordingly, the Optic Nerve Sheath Diameter (ONSD) can act as a surrogate for intracranial pressure.

There is discrepancy as to the usefulness and lack of high quality data to support the routine use of TOU in trauma and ICUs[7], but recent meta-analysis proved the validity of a good cerebral perfusion's association with improved outcomes to about 12%[8]. Monitoring of invasive intracranial pressure is not possible in every patient and is contraindicated in some as they pose the patient to the risk of bleeding, meningitis, sepsis etc, so a less invasive and sensitive test is needed to do measure the intracranial pressure at bedside and have an idea of intracranial pressure in a traumatic brain injury patients. This study was done to establish the efficacy of transocular ultrasonography as an accurate investigation to identify elevated intracranial pressure (eICP) so that measures should be taken timely to keep cerebral perfusion pressure (CPP) optimal i.e. between 50-70 mmHg.

The relationship between optic nerve sheath diameter ONSD and EICP is established by a few researches in the past. Hansen and helmke in 1997, reported that ONSD will remain at a baseline diameter of 0.4 cm up till the intracranial pressure of 15-30mmHg[9], and they said these results are repeatable and predictable in every patient. Whereas, other studies done used the universal 20mmHg threshold for reference of elevated intracranial pressure (eICP) and checked the range of optic nerve sheath diameter (ONSD) which happened to be 0.48-0.70cm[10,11]. Nash *et al* in 2016 used 0.5 cm as a cutoff point to diagnose elevated intracranial pressure (eICP)[12].

The rationale of this study was to make transocular ultrasonography a recommended protocol investigation in trauma and intensive care units (ICUs) in early identification of increased intracranial pressure in traumatic brain injury patients so as to reduce the morbidity and mortality in the long run by keeping the brain well perfused.

MATERIAL AND METHODS

This descriptive study was conducted in Department of Anaesthesiology and Critical Care Combined Military Hospital Rawalpindi from January 2017 to December 2017 after approval of ethical committee of the hospital. Total 60 patients with the history of traumatic brain injuries having Glasgow Coma Scale <9, 20-60 years of age and previous no history of head and fascial trauma, were included in this study by non-probability purposive sampling. The sample size was calculated by using WHO sample size calculator, keeping confidence level 80%, anticipated population proportion 10%, and absolute precision 5%. Data was collected in TBI patients coming to the ICU from trauma center or operation theatre directly. The patients were assessed systematically and their ONSD was measured along with the clinical examination and was noted.

A 7.5 MHz linear probe was used with an ultrasound machine. The examination was performed over a closed eyelid in the supine position with head of bed elevated 30°. The ONSD was measured 3mm posterior to the optic disk in two orthogonal planes (longitudinal and transverse) with the probe held perpendicular to the coronal plane of the globe. Optic nerve sheath diameter (ONSD) >0.5cm was taken as a surrogate for elevated intracranial pressure (eICP) and a predictor of CT findings of sub arachnoid hemorrhage (SAH), subdural hematoma (SDH), extradural hematoma (EDH) and cerebral edema (CE). ONSD was measured in both the eyes and noted.

Ultrasound measurements of the optic nerve sheath diameter (ONSD) were not used to make treatment decisions during this phase of the study. Rest of the treatment was same as the treatment protocols of the institute. Informed consent was not necessary as no intervention was done in the patients and no change was done and suggested in the treatment.

Patient's in hospital mortality & morbidity was also noted by his residual losses in brain and motor functions and was later on matched with level of optic nerve sheath diameter (ONSD) at the time of presentation. Whether the patient required surgery or not was also compared with our data of elevated intracranial pressure (eICP) deduced from optic nerve sheath diameter (ONSD).

Data was analyzed in SPSS version 21. Descriptive statistics like mean, standard deviation, frequency and percentages were calculated.

RESULTS

Total 60 patients were selected with mean age of 32.20 ± 15.14. Fifty four (90%) patients were males and 6 (10%) were females. Five patients had normal ONSD and 55 patients had raised ONSD in the right eye (fig-1). Nine patients had normal ONSD and 51 patients had raised ONSD in the left eye (fig-2). Mean ONSD of right and left eye was 0.5895 and 0.5735 respectively (table). Mean Glasgow coma scale (GCS) at presentation was 6.33 ± 1.73. Mechanism of injury is shown in fig-3. From CT scan findings 3 (5%) patients have SDH (RT) + Fracture Skull RT, 3(5%) had Traumatic SAH + cerebral contusion, 3 (5%) had SDH i.e. SDH RT and two (3.3%) had Rt EDH. Total 45 (75%) patients were surgical and 15 (25%) were non-surgical. Mortality and morbidity was 22 (36.6%) and 30 (50%) respectively. In surgical patients mean

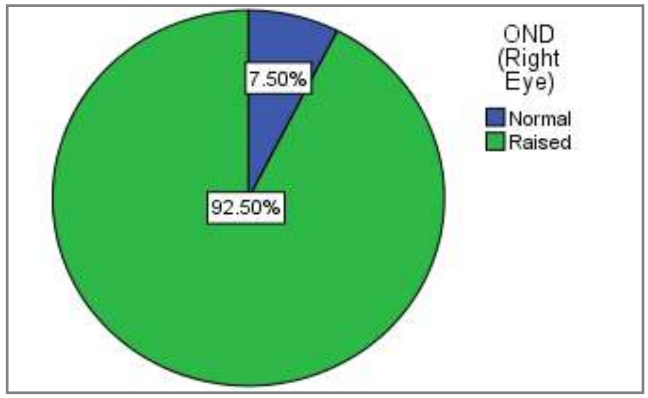

Figure-1: Optic Nerve Diameter in Right Eye.

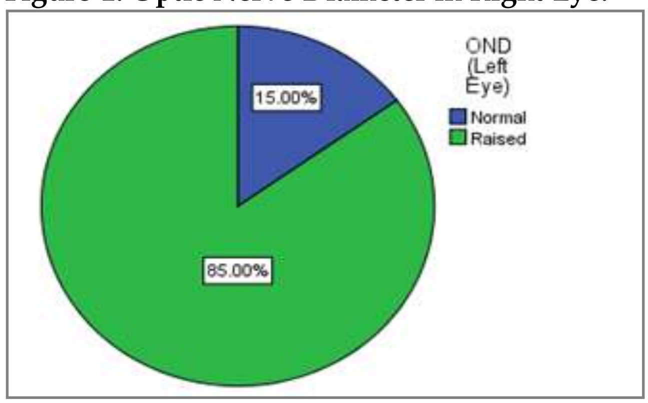

Figure-2: Optic Nerve Diameter in Left Eye.

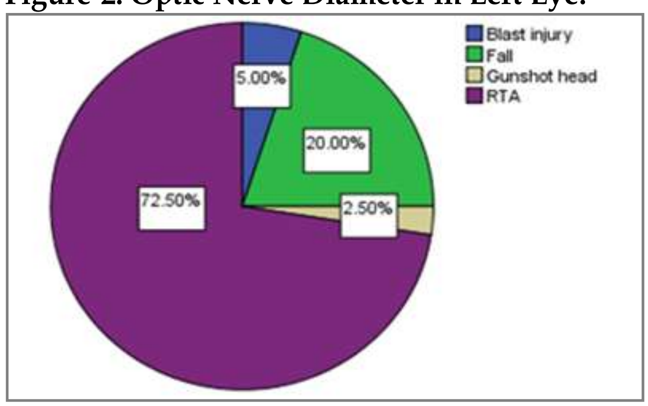

Figure-3: Mechanism of Injury.

ONSD right and left is 0.592 and 0.562 respectively (table).

DISCUSSION

Intensive care all over the world is incorporating the use of ultrasonography in various examinations like bedside lung ultrasonography, FAST scan for early detection of abdominal cavity injuries and so on. Transocular ultrasonography is the new addition to the list of noninvasive / less invasive procedures, which is gaining popularity. It not only saves the patient from risks associated with invasive procedures like hemorrhage, infection, sepsis etc but also is able to give accurate results. The usefulness of this procedure and accuracy validated by various studies makes it an ideal tool for patients who present with head injuries and require urgent diagnosis and prompt treatment.

The results of this study were consistent with the latest trends of transocular ultrasonography measurements in traumatic brain injury patients. The results of our study very much authenticate the previous researches carried out in this particular aspect i.e. it supports the use of transocular ultrasonography in traumatic brain injuries to diagnose any intracranial bleed and also the use of transocular ultrasonography as a surrogate of invasive measurement of ICP.

A recent pilot study done by Nash *et al* in 2016, also establishes the utility of transocular ultrasonography in a traumatic brain injury in timely diagnosing increased intracranial pressure[12]. All these studies had the same goal to establish the efficacy of transocular ultrasonography in a traumatic brain injury to identify elevated intracranial pressure and thus timely surgical interventions and if surgery is not the answer then noninvasive techniques/medical management to keep the cerebral perfusion pressure (CPP) within the normal range as measurement of intracranial pressure (ICP) is an invasive and cumbersome procedure.

Hansen and Helmke in 1997, reported that optic nerve sheath diameter (ONSD) will remain at a baseline diameter of 0.4 cm up till the intracranial pressure (ICP) of 15-30mmHg[9] which is a value less than found in our study, but this is quite an old study and newer studies reveal that the diameter is more than 0.4 cm whenever there is evidence of increased intracranial pressure. Other recent studies in this regard used the universal 20mmHg eICP threshold for reference of eICP and checked the range of ONSD which happened to be 0.48-0.70 cm[10,11] which were comparable to our results. Nash *et al*[12] suggested a value > 0.5cm on transocular ultrasonography suggests eICP, and in our study the mean value of right and left eye in TBI patients were 0.5895 ± 0.059 and 0.5735 ± .078 respectively, which suggests eICP. Our study suggests that ONSD of more than 0.5 cm is possibly due to any intracranial bleed in traumatic nerve sheath diameter and needs to be catered for immediately, as risk of morbidity and mortality increases firstly due to direct effects of the intracranial pathology and secondly due to hypo perfusion of brain matter causing decreased cerebral perfusion pressure.

Table: Optic Nerve Sheath Diameter in Rt and Lt eyes.

		OND (Right)	OND (Left)
		Mean ± SD	**Mean ± SD**
		0.5895 ± 0.059	0.5735 ± 0.078
Surgery	Surgical (N=45)	0.592 ± 0.06	0.562 ± 0.08
	Non-Surgical (N=15)	0.581 ± 0.06	0.608 ± 0.07

Early detection due to transocular ultrasonography enables the physicians and surgeons who are attending a traumatic brain injury patient to maintain high perfusion pressure by increasing the mean arterial pressure, thereby significantly reducing morbidity and mortality associated with traumatic brain injuries. It is a fact that all patients who have undergone any traumatic injury to the brain resulting into SDH, SAH, CE, EDH have increased IC pressures. Such patients need prompt identification and maintenance of cerebral perfusion pressures so that to avoid furthermore hypoxic injury to the brain; usually trauma patients have associated other injuries leading to hemorrhage and shock, furthermore decreasing mean arterial pressures (MAP) and thus cerebral perfusion pressure (CPP) in patients who already have eICP as CPP=MAP-CPP. In such cases patient is very much prone to low mean arterial pressure due to constantly decreasing intravascular volume on the other hand there is constantly increasing intracranial pressure due to intracranial bleed, these two phenomena are associated with poor prognosis in long term if not addressed promptly. One should aim for cerebral perfusion pressure (CPP) of 50-70mmHg to avoid any hypoxic injury to the brain[5] as already blood is being lost from other injuries in trauma patients.

Use of TOU in trauma bays, surgical high dependency units and intensive care unit setups can be very useful to identify any trauma to brain and measures should be taken to maintain the CPP even before the radiological evidence is there as contrast tomography of brain takes longer time especially in setups where facilities are limited. A preemptive protocol for brain injury can be set just by finding the optic nerve sheath diameter through transocular ultrasonography, a value more than 0.5cm should be directed towards managing on lines of eICP. This approach can markedly reduce mortality and morbidity in trauma patients, which is 30%[3] and 40%[4] now. This procedure can be taught to dedicated staff and junior doctors in trauma so that they can easily register any intracranial bleed in traumatic brain injury patients coming in emergency bay. This could be a very use full tool in non traumatic intracranial bleed, papilledema due to brain tumors like posterior fossa tumors etc and can lead towards a diagnosis even before the CT scan can be done.

The guidelines of the Brain Trauma Foundation (BTF) also suggests to keep the systolic BP>90 mmHg and oxygen saturation >90%, maintenance of intracranial pressure (ICP) and mean arterial pressure i.e. MAP so that cerebral perfusion remains adequate i.e. between 50-70mmHg. An increase in ICP of more than 20 mmHg calls for the initiation of treatment or some intervention[5]. As this reduces the CPP to a point where there is risk of hypoxic damage to the brain, which if not treated in 3-5 minutes can lead to irreversible brain injury causing hemiparesis, hemiplegia, aphasia etc which cause serious functional limitations to the patient.

The morbidity and mortality in our study was 36.6% and 50% respectively which is more than the 30%[3] and 40%[4] as per previous studies. This shows the immense need of a change in treatment protocol as this makes almost half of the patient coming to the trauma bays with traumatic brain injury.

Most of the patients are left with lifelong morbid conditions, and prognosis of traumatic brain injury patients is overall very poor with 30%[3] morbidity and 40%[4] mortality, which is a huge figure. The morbidity of these patients have is life long and causes immense limitation to their daily routine and overall quality of life as most of them are left with hemiplegia, aphasia, hemiparesis etc which can cause severe limitations. This can be improved with change in treatment guidelines and introduction of newer techniques like transocular ultrasonography[5,6].

Traumatic brain injury patients make a huge part of our population. A large road traffic injury surveillance study (n>100,000) in Pakistan showed that nearly a third of patients had a traumatic brain injury, and of them about 10% percent had moderate to severe a traumatic brain injuries[18]. Out of these almost half have to live with lifelong morbidities, this transfers a great burden on the economy of the country as these patients are in need of continuous rehabilitation and treatment of concurrent illnesses like bedsores, UTIs leading to sepsis and so on, the treatment of these conditions require hospital admissions and strict asepsis, this poses a great economic burden on the healthcare setups and country.

This study was done to find the efficacy of TOU in trauma and critical care units for traumatic brain injury patients in identification of increased ICP due to any intracranial bleed, and we found it to be very helpful and useful instrument which can timely detect intracranial bleed, indirectly, if one has a high index of suspicion and patient history is also in favor. These patients can be managed promptly and timey and morbidity and mortality can be effectively reduced by making transocular ultrasonography a part of routine surveillance of traumatic brain injury patients. For this matter junior doctor, residents and even senior nursing staff can be taught this procedure as mostly these are the first contact of the patients in trauma bays and even in intensive care units.

The limitations of our study were that it was a descriptive study and findings of TOU did not guide the surgeons and intensivists, their plan of action, for example whether the patient needs urgent decompression or not, moreover ICP was not measured invasively so as to compare it with the findings of TOU. We suggest more studies should be done in this field to document and emphasize the utility of transocular ultrasonography in traumatic brain injury patients.

CONCLUSION

Use of transocular ultrasonography can detect elevated intracranial pressures quiet early. It is a non-invasive procedure, and can easily be inducted in early surveillance of traumatic brain injuries to reduce morbidity and mortality.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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