Am J Transl Res 2021;13(4):3466-3472
www.ajtr.org /ISSN:1943-8141/AJTR0123359

Original Article

Ultrasonic measurement of optic nerve sheath diameter in elderly patients with craniocerebral injury

Zhifei Qiao, Lei Wang, Shutie Li, Yuanli Li, Naikun Gao, Liqun Jia, Chunyan Liu, Liping Zhai, Fulong Li

Department of Critical Care Medicine, The First Affiliated Hospital of Hebei North University, Zhangjiakou, Hebei, China

Received September 29, 2020; Accepted December 9, 2020; Epub April 15, 2021; Published April 30, 2021

Abstract: Objective: To explore the application value of ultrasonic measurement of optic nerve sheath diameter in elderly patients with craniocerebral injury. Methods: 86 cases of elderly patients with craniocerebral injury treated in our hospital between January 2017 and December 2018 were included, all of whom had the invasive monitoring of intracranial pressure (ICP) and optic nerve sheath diameter (ONSD) in ultrasonic testing. According to ICP measurement results, patients were divided into a normal ICP group (n = 44) and an increased ICP group (ICP ≥ 20 mmHg stood for increased ICP, n = 42). Gender, age, systolic blood pressure, blood glucose, hospital stay, oxyhemoglobin saturation, ISS score, ONSD value, hematoma type, primary injury, associated injury and complications of the patients were compared. Results: The univariate analysis showed that the systolic blood pressure in the ICP increased group was significantly decreased while the blood glucose, ISS and ONSD values showed significant increase ($P < 0.05$). The multivariate analysis showed that associated injury, systolic blood pressure and ONSD value had a significant influence on the increase of intracranial pressure (all $P < 0.05$). ONSD is positively correlated with ICP ($r = 0.855$, $P = 0.000$). The areas of systolic blood pressure and ONSD value under the curve in diagnosis of increased intracranial pressure in elderly patients with craniocerebral injury were 0.717 and 0.780, respectively. When the ONSD value was 4.90 mm, the area under the curve was 0.780, the sensitivity and specificity were 89.00% and 91.00%, respectively. When the ONSD value predicted that the critical value of good/poor prognosis of patients was 4.70 mm, the area under the curve was 0.796, the sensitivity was 91.00%, and the specificity was 90.00%. Conclusion: Ultrasound measurement of optic nerve sheath diameter can diagnose the increase of intracranial pressure in elderly patients with craniocerebral injury, and can better predict the prognosis.

Keywords: Ultrasound, optic nerve sheath diameter, craniocerebral injury, application value

Introduction

Craniocerebral injury is an emergent and severe disease, which is often accompanied by intracranial pressure (ICP). If the increase of intracranial pressure is not diagnosed and treated timely, irreversible brain injury and disability will often occur. In severe cases, a cerebral hernia may be formed and causes death [1]. For elderly patients with craniocerebral injury, they usually have a history of chronic disease and associated injuries. Their craniocerebral injury tends to be more severe with a relatively long duration of coma and a higher incidence of complications after the injury. As a result, the rate of death and disability caused by craniocerebral injury in the elderly is higher than that in young adults [2]. Therefore, it is of great significance for clinical decision-making to quickly and effectively detect the increase of ICP at early stage. At present, the invasive monitoring of intracranial pressure is still the golden standard for ICP detection [3]. But the cost and risk are rather high, and there are many contradictions. Complications such as bleeding and infection cannot be completely avoided either during the monitoring [4]. Therefore, its clinical application is limited to a certain extent. Optic nerve sheath is a direct extension of the intracranial dura mater, which contains a cross-beam subarachnoid space. When intracranial pressure (ICP) increases, the pressure of the subarachnoid space will increase, and the optic nerve sheath will also increase accordingly. Then, the diameter of ONSD can indirectly predict the increase of ICP in patients with craniocerebral injury [5].

Ultrasonic measurement of ONSD has a great advantage for predicting ICP increase, which is characterized by non-invasive, fast, low cost and bedside action, and thus will have a broader application value [6]. However, ultrasound measurement of ONSD has not been widely used to evaluate ICP increase; the optimal threshold value and standard for the diagnosis of increased ICP with ONSD is different at home and abroad [7]. In consequence, further research is still needed to evaluate the application value of ICP by using the ultrasonic measurement of ONSD. In order to determine the application effect of ONSD value measured by ultrasound in elderly patients with craniocerebral injury, the clinical data of 86 elderly patients with the disease admitted to our hospital from January 2017 to December 2018 were selected for the retrospective analysis. This study was grouped based on ICP. Clinically, early detection and treatment of ICP can reduce the occurrence of secondary brain injury, especially for patients with severe traumatic brain injury. At present, there are few studies on the relationship between ONSD and ICP measured by ultrasound in patients with traumatic brain injury, and the ONSD threshold for diagnosing increased ICP has not been unified. This study uses ICP to measure ONSD after grouping, aiming to explore the ultrasound measurement of ONSD diameter in the future and correlation with direct measurement of ICP, and detect the threshold of ONSD measurement to predict the increase of ICP as well.

Materials and methods

General materials

In total, 86 cases of elderly patients with craniocerebral injury treated in our hospital between January 2017 and December 2018 were selected as research subjects. The research was conducted according to the principles of the World Medical Association Declaration of Helsinki. This study was approved by the ethical medical committee of the First Affiliated Hospital of Hebei North University. All subjects gave written informed consent. According to their ICP measurement results, patients were divided into a normal ICP group and an increased ICP group (ICP ≥ 20 mmHg stood for increased ICP). There were 44 patients in the normal group and 42 ones in the latter. Inclusion criteria: ① patients diagnosed with craniocerebral injury by cranial CT examination; ② patients who met the diagnostic criteria of craniocerebral injury [8]; ③ patients whose Glasgow Coma Scale (GCS) is not greater than 8 points, and the duration of coma is greater than 6 hours; ④ patients who had received ICP monitoring and ONSD ultrasonic measurement.

Exclusion criteria: Patients with eye diseases such as eye trauma, optic neuritis, glaucoma, and optic nerve tumors; CT examination of the head showed substantial lesions; history of craniocerebral surgery.

Research methods

Retrospective analysis was conducted on the clinical data of the patients, including: ① General materials such as gender, age, medical history and causes of injury; ② Admission assessment, which mainly contained the Glasgow coma scale (GCS), the nature of brain injury (such as brain contusion and laceration, brain stem injury, etc.), injury severity score (ISS), the presence of hematoma (such as epidural hematoma, subdural hematoma within the brain, etc.), hematoma volume, blood pressure after craniocerebral injury, blood glucose on the admission, serum albumin, whether there was hypoxemia or changes of blood coagulation, whether there was acidosis, etc.; ③ The diagnosis and treatment of the patients mainly included the time from the craniocerebral injury to the surgery, the surgical methods, the length of hospital stay, whether the trachea had been opened, whether hormone drugs had been used, etc.; ④ The occurrence of complications, such as pneumonia, infectious complications and other complications during hospitalization; ⑤ The patients were followed up for half year, and the prognosis of the patients was evaluated according to the Glasgow Outcome Score (GOS) they got half year after the craniocerebral injury. The GOS score of 1-3 points indicated poor prognosis, while that of 4-5 points suggested a good prognosis [9].

Treatment methods

Of the 86 cases of craniocerebral injury, 16 cases were given non-surgical treatment, 70 cases underwent craniotomy, including removal of intracranial hematoma, removal of intracranial hematoma and fragmented brain tissue plus decompressive craniectomy, etc., 35

Table 1. Comparison of clinical data between the two groups ($\bar{x} \pm s$)

Variates	ICP normal group (n = 44)	ICP increased group (n = 42)	*t*	*P*
Age (years old)	72.34±6.78	73.19±6.23	0.605	0.547
Systolic blood pressure (mmHg)	123.96±12.61	95.48±10.42	11.440	< 0.001
Blood glucose (mmol/L)	4.07±1.31	8.46±1.85	12.750	< 0.001
Hospital stay (h)	3.78±1.02	3.86±1.13	0.345	0.731
Oxyhemoglobin saturation (%)	97.61±10.24	96.98±10.07	0.288	0.774
ISS (points)	13.79±3.65	29.46±5.74	15.180	< 0.001
ONSD (mm)	4.52±0.47	5.13±0.56	5.481	< 0.001

Table 2. Comparison of clinical data between the two groups [n (%)]

Variables		ICP normal group (n = 44)	ICP increased group (n = 42)	X^2	*P*
Gender	Male	26 (59.09)	25 (59.52)	0.002	0.967
	Female	18 (40.91)	17 (40.48)		
Hematoma types	subdural hematoma within the brain	16 (36.36)	29 (69.05)	9.202	0.002
	epidural hematoma	28 (63.64)	13 (30.95)		
Primary injury	Primary brain stem injury	20 (45.46)	16 (38.10)	0.478	0.489
	cerebral contusion and laceration	24 (54.54)	26 (61.90)		
Associated injury	Yes	19 (43.18)	30 (71.43)	6.994	0.008
	No	25 (56.82)	12 (28.57)		
Complications	Yes	23 (52.27)	24 (57.14)	0.206	0.650
	No	21 (47.73)	18 (42.86)		

cases underwent tracheotomy. After operation, treatments such as dehydration and lowering of intracranial pressure, anti-infection, neurotrophic drugs, improvement of microcirculation, mild hypothermic neuroprotection, comorbidities handling and prevention and treatment of complications were given.

Statistical methods

SPSS24.0 was used for the statistical analysis in this study. T-test was adopted for measurement data ($\bar{x} \pm s$), while chi-square test was utilized for the enumeration data (n, %). Logistic regression was used for the multivariate analysis. Spearman correlation analysis was used to analyze the correlation between ONSD and ICP. ROC curves was drawn on ONSD and ICP to evaluate the clinical efficacy of ONSD in diagnosing ICP. $P < 0.05$ was considered statistically significant.

Results

Comparison of clinical data between the two groups

No statistically significant differences were found between the two groups in gender, age, hospital stay, oxyhemoglobin saturation, type of primary injury and complications ($P > 0.05$). The systolic blood pressure in the ICP increased group was significantly decreased, while the blood glucose, ISS and ONSD values showed a significant increase; there were significant differences in hematoma types and associated injury between the two groups. Therefore, systolic blood pressure, blood glucose, ISS, ONSD values, hematoma types and associated injuries were influencing factors for increased intracranial pressure in elderly patients with craniocerebral injury ($P < 0.05$). The results were as shown in **Tables 1** and **2**.

Multivariate analysis

Intracranial pressure was taken as the dependent variable (0 = no, 1 = yes), and the above factors which may be the influencing factors of intracranial pressure in elderly patients with craniocerebral injury were evaluated and a multifactorial analysis was carried out (see **Table 3**). Results showed that associated injury, systolic blood pressure, and ONSD value had an obvious influence on ICP increase with statistically significant differences. These were therefore independent factors for the ICP increase of

Table 3. Possible influencing factors and evaluation of increased intracranial pressure in elderly patients with craniocerebral injury

Variates	Code	Evaluation
Hematoma type	X1	0 = epidural hematoma, 1 = subdural hematoma within the brain
Associated injury	X2	0 = no, 1 = yes
Systolic blood pressure (mmHg)	X3	0 = ≥ 100, 1 = < 100
Blood glucose (mmol/L)	X4	0 = ≤ 6.0, 1 = > 6.0
ISS (points)	X5	0 = ≤ 20, 1 = > 20
ONSD (mm)	X6	0 = ≤ 4.80, 1 = > 4.80

Table 4. Multivariate analysis of increased intracranial pressure in elderly patients with craniocerebral injury

Independent variable	B	Wald χ^2	*P value*	OR (95% CI)
Hematoma type	0.627	2.218	0.059	1.872 (0.962, 6.369)
Associated injury	0.864	5.697	0.023	2.373 (1.012, 7.846)
Systolic blood pressure (mmHg)	0.923	1.991	0.005	2.517 (1.107, 7.938)
Blood glucose (mmol/L)	0.798	11.730	0.126	2.221 (1.101, 7.675)
ISS (points)	0.952	10.343	0.064	2.591 (1.265, 7.974)
ONSD (mm)	1.231	4.239	0.008	3.425 (1.954, 8.782)

Table 5. ROC curve analysis of systolic blood pressure and ONSD in diagnosing increased intracranial pressure

Influencing factor	AUC	Cut-off value	Sensitivity	Specificity	*P value*	95% CI	
						Lower limit	Upper limit
Systolic blood pressure	0.717	105.10	80.00	85.00	0.009	96.38	122.96
ONSD value	0.780	4.90	89.00	91.00	0.024	4.53	5.12

elderly patients with craniocerebral injury (all P < 0.05). The results are shown in **Table 4**.

Analysis of the correlation between ONSD and ICP

Spearman correlation analysis results showed that ONSD is positively correlated with ICP (r = 0.855, P = 0.000).

ROC curve analysis of systolic blood pressure and ONSD in diagnosing increased intracranial pressure

ROC curve analysis found that the area under the curve of systolic blood pressure and ONSD value in diagnosing increased ICP of elderly patients with craniocerebral injury was 0.717 and 0.780, respectively. When the ONSD value was 4.90 mm, the area under the curve was 0.780, and the sensitivity and specificity were 89.00% and 91.00%, respectively. See **Table 5** and **Figure 1** for details.

ROC analysis curve of ONSD in predicting the prognosis of elderly patients with craniocerebral injury

According to the GOS assessment of patient's prognosis, there were 45 patients with poor prognosis and 41 patients with a good prognosis. ROC curve analysis showed that the ONSD value in elderly patients with craniocerebral injury prognosis of the area under the curve was 0.796, the cut-off value was 4.70 mm, the sensitivity was 91.00%, and the specificity was 90.00%. See **Figure 2**.

Discussion

Craniocerebral injury is an emergent and severe disease. Elderly patients with craniocerebral injury usually have a history of chronic disease before the injury, accompanied by many associated injuries. They may have severe craniocerebral injuries, a relatively long duration of coma, and a high probability of

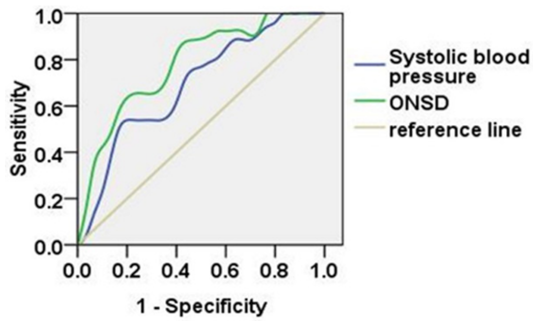

Figure 1. ROC analysis curve of systolic blood pressure and ONSD in diagnosis of increased intracranial pressure.

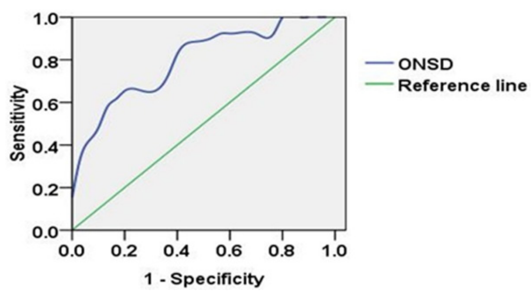

Figure 2. ROC analysis curve of ONSD predicting the prognosis of elderly patients with head injury.

complications after injury. So, the rate of mortality and disability of craniocerebral injury in the elderly is higher than that of young adults [10, 11]. Increased ICP is commonly seen in patients with craniocerebral injury and has a certain impact on patients' prognosis. So, it contributes to clinical decision-making to strengthen the monitoring of ICP in patients with craniocerebral injury, taking active measures to control the increase of ICP, improving the prognosis of patients, and lowering mortality and morbidity rates [12]. The current golded standard for the detection of ICP is invasive monitoring, which has a good monitoring effect [13] although with many disadvantages and contradictions. The occurrence of complications such as bleeding and infection cannot be completely avoided during the monitoring process. Its safety needs to be further improved [14, 15]. In addition, the invasive monitoring of ICP takes a long time from the beginning of the operation to the result of ICP detection [16], which can easily delay the treatment and seriously affect the early rescue. Therefore, its clinical application is limited to a certain extent. In the meantime, studies have found that the ultrasonic measurement of ONSD can indirectly reflect the ICP increase in patients with craniocerebral injury [17]. In our study, the single-factor analysis showed that compared with the normal ICP group, systolic blood pressure in the increased ICP group was obviously lower, while the blood glucose, ISS, and ONSD value increased significantly; and significant differences were found between the two groups in terms of the type of hematoma and associated injury. These were considered as influencing factors for the ICP increase in patients with craniocerebral injury ($P < 0.05$). We have shown that associated injury, systolic blood pressure, and ONSD value had significant impacts on elderly patients with craniocerebral injury, and thus were independent factors of the ICP increase in the elderly patients with craniocerebral injury (all $P < 0.05$). It verified that the ONSD value of the ultrasonic measurement is associated with the intracranial pressure of craniocerebral injury patients. The results were consistent with the report. The reason may be that the visual nerve belongs to the central nerve, and the orbital cavity is partially enclosed by the optic nerve sheath and is formed by three layers of dura mater. The space is clear between the three layers of the dura and the subarachnoid space and the intracranial subdural space, and contains cerebrospinal fluid. When intracranial pressure rises, the pressure travels along the optic nerve to the optic nerve's head. The cerebrospinal fluid from the cranium will then be squeezed into the optic nerve sheath accordingly, which can further widen the space within the nerve sheath [18]. Eventually, the ONSD is increased. Therefore, the measurement of ONSD can be used to indirectly reflect the intracranial pressure of patients with craniocerebral injury, and the changes of intracranial pressure can be reflected according to the changes of ONSD. The ultrasonic measurement of ONSD is of application value to detect increased ICP and plays an auxiliary role in the diagnosis of patients' condition. The measurement of ONSD by bedside ultrasound, as a non-invasive and fast intracranial pressure detection method [19], will receive more and more clinical attention. However, the critical value of ONSD for diagnosing ICP increases in patients with craniocerebral injury is yet not unified. In foreign studies, the ONSD value of 5 mm is regarded as the best critical value for determining ICP increase. However, domestic studies suggest that the critical value is 4.8 mm [20]. And when the ONSD value of 4.90 mm was regarded as the critical value of increased ICP, the diagnostic sensitivity was 89.00%, the specificity was 91.00%, indicating that the ONSD value can better diagnose ICP increase in elderly patients with craniocerebral injury. The reasons for the differences in ONSD thresholds at home and abroad may be related to the ethnicity of the subjects and the severity of the patient's disease. Moreover, this study only focused on elderly patients with craniocerebral injury, which has certain limitations. The difference between ONSD critical values may also be related to the age of subjects. According to the above results, it has been verified that ONSD values can help diagnose ICP increase. The research showed that the increase of ICP is likely to lead to the death and disability of patients with craniocerebral injury [21], and the prognosis was poor. But whether the ONSD value can help directly predict the prognosis of patients with craniocerebral injury remains to be further studied. The study also found that, according to the follow-up of GOS, patients with poor prognosis had a larger ONSD value; when 4.70 mm was considered as a critical ONSD value for a good/bad prognosis in elderly patients with craniocerebral injury, the sensitivity was 91.00%, the specificity was 90.00%, suggesting that the prognosis of elderly patients with craniocerebral injury can be better predicted with ONSD value. When intracranial pressure increases, the ONSD value will also increase, thus affecting the prognosis of patients. Therefore, ultrasonic measurement of ONSD can effectively monitor intracranial pressure, and the increase of ICP can be detected quickly before the symptoms and signs of intracranial hypertension appear. Ultrasonic measurement of ONSD plays a suggestive role in clinical decision-making, avoids the delay and deterioration of patients' condition, and is conducive to reducing the occurrence of disability and death, thus improving the prognosis of elderly patients with craniocerebral injury. Therefore, rapid and effective ICP monitoring in the early stage of craniocerebral injury is of great significance for the prognosis of patients.

In summary, ultrasonic measurement of optic nerve sheath diameter can detect the increase of intracranial pressure in elderly patients with craniocerebral injury, and can better predict their prognosis.

Acknowledgements

Supported by Youth Science and technology project of Hebei Provincial Department of health in 2018, No. 20180849.

Disclosure of conflict of interest

None.

Address correspondence to: Zhifei Qiao, Department of Critical Care Medicine, The First Affiliated Hospital of Hebei North University, 12 Changqing Road, Qiaoxi District, Zhangjiakou 075000, Hebei, China. E-mail: feiqiao05@126.com

References

[1] Wang LJ, Chen LM, Chen Y, Bao LY, Zheng NN, Wang YZ and Xing YQ. Ultrasonography assessments of optic nerve sheath diameter as a noninvasive and dynamic method of detecting changes in intracranial pressure. JAMA Ophthalmol 2018; 136: 250-256.

[2] De Bernardo M and Rosa N. Measuring optic nerve sheath diameter as a proxy for intracranial pressure. JAMA Ophthalmol 2018; 136: 1309-1310.

[3] Hassen GW, Bruck I, Donahue J, Mason B, Sweeney B, Saab W, Weedon J, Patel N, Perry K, Matari H, Jaiswal R and Kalantari H. Accuracy of optic nerve sheath diameter measurement by emergency physicians using bedside ultrasound. J Emerg Med 2015; 48: 450-7.

[4] Kim SE, Hong EP, Kim HC, Lee SU and Jeon JP. Ultrasonographic optic nerve sheath diameter to detect increased intracranial pressure in adults: a meta-analysis. Acta Radiol 2019; 60: 221-229.

[5] Goel RS, Goyal NK, Dharap SB, Kumar M and Gore MA. Utility of optic nerve ultrasonography in head injury. Injury 2008; 39: 519-524.

[6] Wang LJ, Chen HX, Chen Y, Yu ZY and Xing YQ. Optic nerve sheath diameter ultrasonography for elevated intracranial pressure detection. Ann Clin Transl Neurol 2020; 7: 865-868.

[7] Tayal VS, Neulander M, Norton HJ, Foster T, Saunders T and Blaivas M. Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients. Ann Emerg Med 2007; 49: 508-14.

[8] Roque PJ, Wu TS, Barth L, Drachman D, Khor KN, Lovecchio F and Stapczynski S. Optic

nerve ultrasound for the detection of elevated intracranial pressure in the hypertensive patient. Am J Emerg Med 2012; 30: 1357-63.

[9] Beare NA, Kampondeni S, Glover SJ, Molyneux E, Taylor TE, Harding SP and Molyneux ME. Detection of raised intracranial pressure by ultrasound measurement of optic nerve sheath diameter in African children. Trop Med Int Health 2008; 13: 1400-4.

[10] Sangani SV and Parikh S. Can sonographic measurement of optic nerve sheath diameter be used to detect raised intracranial pressure in patients with tuberculous meningitis? A prospective observational study. Indian J Radiol Imaging 2015; 25: 173-6.

[11] Kerscher SR, Schöni D, Neunhoeffer F, Wolff M, Haas-Lude K, Bevot A and Schuhmann MU. The relation of optic nerve sheath diameter (ONSD) and intracranial pressure (ICP) in pediatric neurosurgery practice - Part II: Influence of wakefulness, method of ICP measurement, intra-individual ONSD-ICP correlation and changes after therapy. Childs Nerv Syst 2020; 36: 107-115.

[12] Thotakura AK, Marabathina NR, Danaboyina AR and Mareddy RR. Role of serial ultrasonic optic nerve sheath diameter monitoring in head injury. Neurochirurgie 2017; 63: 444-448.

[13] Singh SK and Bhatia K. Ultrasonographic optic nerve sheath diameter as a surrogate measure of raised intracranial pressure in severe pregnancy-induced hypertension patients. Anesth Essays Res 2018; 12: 42-46.

[14] Cammarata G, Ristagno G, Cammarata A, Mannanici G, Denaro C and Gullo A. Ocular ultrasound to detect intracranial hypertension in trauma patients. J Trauma 2011; 71: 779-81.

[15] Li Z, Zhang XX, Yang HQ, Zhao LP, Jia JP, Sun F and Liu DC. Correlation between ultrasonographic optic nerve sheath diameter and intracranial pressure. Zhonghua Yan Ke Za Zhi 2018; 54: 683-687.

[16] Bratton SL, Chestnut RM, Ghajar J, McConnell Hammond FF, Harris OA, Hartl R, Manley GT, Nemecek A, Newell DW, Rosenthal G, Schouten J, Shutter L, Timmons SD, Ullman JS, Videtta W, Wilberger JE and Wright DW. Guidelines for the management of severe traumatic brain injury. VI. Indications for intracranial pressure monitoring. J Neurotrauma 2007; 24 Suppl 1: S37-44.

[17] Rehman Siddiqui NU, Haque A, Abbas Q, Jurair H, Salam B and Sayani R. Ultrasonographic optic nerve sheath diameter Measurement for raised intracranial pressure in a Tertiary care centre of a developing country. J Ayub Med Coll Abbottabad 2018; 30: 495-500.

[18] Osei-Ampofo M, Flynn-O'Brien KT, Owusu-Dabo E, Otupiri E, Oduro G, Donkor P, Mock C and Ebel BE. Injury patterns and health outcomes among pregnant women seeking emergency medical care in Kumasi, Ghana: challenges and opportunities to improve care. Afr J Emerg Med 2016; 6: 87-93.

[19] Rosenberg JB, Shiloh AL, Savel RH and Eisen LA. Non-invasive methods of estimating intracranial pressure. Neurocrit Care 2011; 15: 599-608.

[20] Maissan IM, Dirven PJ, Haitsma IK, Hoeks SE, Gommers D and Stolker RJ. Ultrasonographic measured optic nerve sheath diameter as an accurate and quick monitor for changes in intracranial pressure. J Neurosurg 2015; 123: 743-7.

[21] Amini A, Kariman H, Arhami Dolatabadi A, Hatamabadi HR, Derakhshanfar H, Mansouri B, Safari S and Eqtesadi R. Use of the sonographic diameter of optic nerve sheath to estimate intracranial pressure. Am J Emerg Med 2013; 31: 236-9.