Case Report

Journal of Emergency Medicine Case Reports

The Contribution of Measuring the Optic Nerve Sheath Diameter by using Ultrasonography to the Diagnosis and Monitoring of Intracranial Hypertension

Özlem Tolu Kendir[1], Hayri Levent Yılmaz[1], Ahmet Kagan Ozkaya[1], Sinem Sarı Gökay[1], Sevcan Bilen[1]

Cukurova University, Pediatrics, Emergency Care Unit, Balcalı Hospital Adana Turkey

Abstract

Background: Intracranial hypertension, which may have a number of different causes, is a medical emergency. Although difficult to identify due to non-specific symptoms, it must be treated appropriately. An early sign of intracranial hypertension is an increase is observed in the optic nerve sheath diameter. . Ultrasonography is a rapid and easy-to-apply method to detect an increase in optic nerve sheath diameter, and may be useful for the emergency diagnosis and treatment, as well as contributing to clinical follow-up.

Case Presentation: In the present study, seven patients with clinical suspicion for rapid intracranial pressure were admitted. Clinical scenarios included traffic accident, metabolic imbalance, infection, and intracranial mass. The pediatric emergency specialist performed optic nerve sheath measurement by using ultrasonography and a dilatation was detected. All measurements were taken by the certified and experienced pediatric emergency specialist blinded to the patient's clinical state and also the specialist was under observation of a lecturer during the measurements. Except for one patient, the control optic sheath diameter measurements were performed in the period, when they had no complaint, and the values were determined to be normal. To our knowledge, this case series is the first one examined in Turkey. The data from cases was collected between 2015 and 2016.

Conclusion: Optic nerve sheath diameter measurement is a non-invasive method that offers ease of diagnosis and follow-up of suspected intracranial hypertension.

Key Words: Optic nerve sheath diameter measurement, intracranial hypertension, ultrasonography

Background

Intracranial hypertension is a condition that may result in mortality or negative neurological consequences, and therefore requires emergent diagnosis and treatment. Computed tomography of the head is preferred as the first option in order to support clinical assessment, however, involves radiation exposure. It may not be possible to perform the lumbar puncture or invasive intracranial monitoring under specific conditions. Fundoscopic examination may also be misleading since the papilla stasis is a late-phase symptom of intracranial hypertension. Ultrasound, which is a non-invasive and rapid method that is useful in during the acute period and follow-up, may be an option for measuring the optic nerve sheath diameter. The present case series demonstrates how measurement of the optic nerve sheath diameter may contribute to diagnosing and following intracranial hypertension.

Cases Presentation

After obtaining the written consents of their parents, seven patients with suspicion of intracranial hypertension (IH), who were admitted to the Pediatric Emergency Department of Medical Faculty of **Çukurova** University due to traffic accident, metabolic imbalance, infection, and intracranial mass formation, are presented. The data of patients can be seen in Tables 1 and 2. Six of the patients had undergone control ultrasonography (USG) when they arrived to the polyclinic. No control USG was applied to one of these patients because the patient was followed-up in another center after the discharge from hospital.

Method

After the first examination, transorbital ultrasonography was performed by placing the patient in supine and neutral position with closed eyes. Sonosite Edge ultrasonography device was used with the high frequency (15-6 MHz) planar probe and gel. The diameter of optic nerve sheath, which is seen as a hypoechoic double-sided line at the 3mm depth of globe that is known to be most sensitive to the intracranial pressure changes, was measured in both longitudinal and transverse cross-sections, and the mean value was calculated[1] (Figure 1-2). All of the measurements were performed

Corresponding Author: Özlem Tolu-Kendir **e-mail:** otolu80@yahoo.com

Received: 05.02.2019 • **Accepted:** 05.03.2020

DOI:10.33706/jemcr.522919

DOI:10.33706/jemcr.522919
Journal of Emergency Medicine Case Reports 2020; 11 (1):21-26

Table 1. Age, gender, and vital findings of patients, Glasgow Coma Scale

Patient	Age	Gender	Body Temperature °C	Heart rate /min	Respiration rate /min	Blood pressure (mmHg)	GCS
1	12 year-old	Girl	36.5	152	8	80-40	5 (PTS<8)
2	28 month-old	Girl	36.5	144	46	85-40	6
3	4.5 year-old	Girl	38.5	132	24	110-60	10
4	7 year-old	Boy	38	135	48	100-60	13
5	17 year-old	Girl	37.8	88	22	110-60	13
6	17 year-old	Boy	38.3	100	24	110-70	14
7	10 year-old	Boy	36.4	118	24	100-60	14

by a pediatric emergency subspecialist having USG training background.

Discussion and Conclusions

Intracranial hypertension requires early rapid diagnosis, however, clinical symptoms and findings may be confused with other conditions. In the present study, three patients were found to have IH because of infectious factors, two patients because of metabolic and autoimmune encephalopathy, one patient because of a non-vehicular traffic accident and one patient because of intracranial mass.

In practice, the diagnosis of IH is made based on the basis of clinical findings. This case series describes the usability of USG, which is a non-invasive monitoring method, in measuring optic nerve sheath diameter (OSND) for these patients.

The ultrasonography is a non-invasive, reliable, affordable, repeatable, and highly available method that has no known adverse effect. In 1990s, emergency specialists, who had USG training from American College of Emergency Physicians (ACEP), started to use the USG in emergency units, and the first guideline on this subject was published in 2001. The documents published by Council of Emergency Medicine Residency Directors between 2009 and 2012 were used as a reference for the relevant procedures[2]. Even though no specific guideline on the use of USG in pediatric emergency has been published yet, the focused use became a very increasingly popular[2].

When diagnosing the intracranial hypertension, Computed Tomography (CT) is used as the primary option in practice. Disadvantages include radiation exposure, and difficulties associated with patient transportation. However,

Table 2. Complaints and clinical conditions of patients, radiologic assessment, and ONSD measurements

Patient	Complaint	BBT	Papilla stasis	ONSD mm (avg.)	Diagnosis	Clinical course	Control ONSD
1	ADTK	Cerebral edema (moderate)-subaracnoid-intraparenchymal hemorrhage	+	0.59	ADTK	Discharged with recovery	0.41
2	Drowsiness	Disseminated cerebral edema –subfalcine herniation	+	0.77 (ODE+)	Encephalopathy/hyperammoniemia	Discharged with recovery	-
3	Drowsiness - Fever-Vomiting	Cerebral edema (moderate-severe), Leptomeningeal contrast	+	0.68 (ODE+)	Meningoencephalitis	Discharged with recovery	0.45
4	Fever-Vomiting	Normal	-	0.55	Meningoencephalitis	Discharged with recovery	0.45
5	Drowsiness - Fever-Vomiting	Cerebral edema (mild)	+	0.64	Ensefalit (otoimmun)	Discharged with recovery	0.44
6	Diarrhea, then drowsiness	Leptomeningeal contrasting, no edema	-	0.54	Meningoensefalit	Discharged with recovery	0.38
7	Headache-vomiting	Cystic lesion in left frontoparietal	+	0.64 (ODE+)	Cyst hydadid	Discharged with recovery	0.38

Figure 1. An application from the study

Figure 2. Images of Optic Nerve Sheath Diameter of the patients from this study

magnetic resonance (MR) is not an examination method that can be easily accessed, or that yields fast results. Neither CT nor MR is solely practical or non-risky in the acute setting[3].

Lumbar puncture can be used to directly measure the cerebrospinal fluid pressure, however, it is invasive, and contraindicated under certain conditions[4]. On the other hand, papilla stasis can be examined by using the fundoscopic examination. The examination depends on the individual. Normal findings may be achieved in early periods of IH, and there may be misleading findings under the emergency conditions because of mid-term/delayed identification of IH[5, 6].

In the present study, no invasive method was applied in order to confirm the diagnoses. The CT images of two patients were found to be normal, whereas there was cerebral edema in the others and one of these patients had post-herniation syndrome (Figure 3). All of the patients seen to have edema in CT images were determined to have papilla stasis, whereas it was not observed in other two cases.

Even though it was at lower levels in two patients, who were clinically projected to have IH and in CT images of whom we found no cerebral edema, it was determined that all the patients had dilated ONSD and these values exceeded the cut-off value reported in literature. No papilla stasis was found in ophthalmologic examination of two patients, who were found to have no cerebral edema. It was determined that there was a recovery in ONSD measurement values of both patients in the period, when the general clinical conditions of them gradually recovered. There was no patient which had intracranial hypertension has measurement within normal ONSD range.

The optic nerve is surrounded by three meningeal membranes, and the cerebrospinal fluid (CSF) freely circulates in intracranial and intraorbital subarachnoid space. In case of IH, the increase in intracranial subarachnoid pressure reflects on the intraorbital subarachnoid space[4, 6]. In the previous studies, it was reported that the increase in ONSD could be determined to be unechoic most accurately at 3 mm posterior to the globe. Even though there still is no standard cut-off value, it is asserted that ONSD values of 4.5 mm for children and 5mm for adults are suggestive of increased intracranial pressure[7, 8, 9].

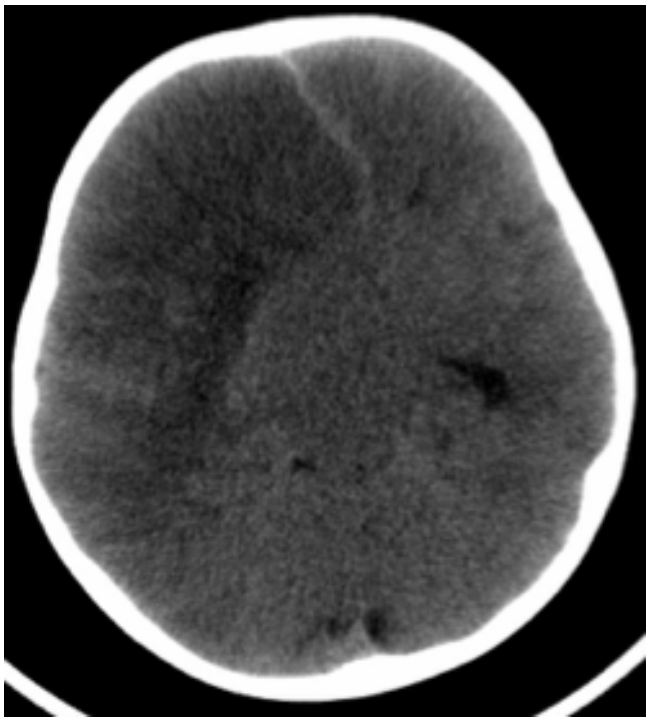

Figure 3. Subfulccial herniation in CT image of second patient

DOI:10.33706/jemcr.522919
Journal of Emergency Medicine Case Reports 2020; 11 (1):21-26

As in two patients in this series, the ONSD dilatation can be showed before the papilla stasis develops and cerebral edema is detected using radiologic method. Thus, the treatment can be started in early period before the clinical symptoms and findings become severe[5]. From another perspective, ONSD was larger in seven patients, for whom we confirmed the diagnosis of cerebral edema by using radiologic and fundoscopic methods. Our two cases with severe cerebral edema had optic disc elevation (ODE) in which the optic disc has process towards the posterior camera. One of them had subfalcine herniation. ODE in literature has been presented as indication of severe cerebral edema like our cases[10, 11].

In literature on examining the advantages of ONSD measurement, the studies using CT, lumbar puncture and/or papilla stasis as the gold standard reported the ONSD measurement as a reliable diagnostic modality. In their study on the patients having non-traumatic radiographic (CT) cerebral edema, Salahuddin et al. (2016) reported the cut-off value to be 0.57cm, sensitivity to be 84%, specificity to be 71%, and AUC to be 0.785. In their study on 16 patients aged between 12 and 18 years and suspected to have pseudo-tumor cerebri, Irazuzta et al. (2016) reported the mean ONSD to be 0.51cm±1.2 mm for those having cerebrospinal liquid pressure (CFP) of >20 cm-H_2O, and 0.38±0.02 cm for those with CFP <20 cm-H_2O ($p<0.01$) [12, 13]. In their study on 76 patients, Marchese et al. (2017) taking the fundoscopic examination as reference detected papilla stasis in 20 (26%) of IH cases, in which they observed ONSD enlargement (cut-off:0.45) (sensitivity: 90% and specificity: 55%). In their study carried out on 174 patients, Padayachy et al. (2016) took the intracranial pressure measurement as a reference and found the cut-off value to be 0.55 when the intracranial pressure at the moment of lumber puncture is below > 20 mmHg (sensitivity:92.2% - specificity: 74%)[14, 15].

In the case series presented here, it was determined that, ODE was observed and the level of increase in ONSD was higher when the cerebral edema was detected by using fundoscopic and radiologic methods, and that the cerebral edema can be detected in much earlier phase. It was determined that, in the period when the clinical symptoms of IH regressed, the ONSD measurements approached the upper limit of normal.

Based on the findings obtained in this study, it can be thought that the ONSD measurement might support the early diagnosis, that it is useful in follow-up period, and that this method is a highly available, affordable and useful, and may protect the patients from exposure to radiation. In order to make clearer inferences, more comprehensive studies on higher number of patients are needed.

Acknowledgements: N/A.

Abbreviations

IH: Intracranial Hypertension
USG: Ultrasonography
MR: Magnetic Resonance
CT: Computer Tomography
LP: Lumber Puncture
ONSD: Optic Nerve Sheath Diameter Measurement by using Ultrasonography
GKS: Glasgow Coma Scale
CFP: Cerebrospinal Fluid Pressure
PTS: Penetrant Trauma Score
ODE: Optic Disc Elevation

Declarations

- **Ethics approval and consent to participate:** This article does not contain any studies with human or animal subjects performed by any of the authors.
- **Consent for publication:** Authors have permission from the patient's parents as written and also there is no any information in the main text related with patients.
- **Availability of data and material:** All required data can be found in the case report
- **Competing interests:** The authors declare that they have no competing interests
- **Funding:** There is no any funding for this article.
- **Authors' contributions:** Each author have participated sufficiently in the work to take public responsibility for appropriate portions of the content.
- **Acknowledgements:** There is no any contributor out of Author list.

References

1. Del Saz-Saucedo P, Redondo-González O, Mateu-Mateu Á, Huertas-Arroyo R, García-Ruiz R, Botia-Paniagua E. Sonographic assessment of the optic nerve sheath diameter in the diagnosis of idiopathic intracranial hypertension. J Neurol Sci. 2016; 361:122-127
2. Marin JR, Lewiss RE. Point-of-Care ultrasonography by pediatric emergency medicine physicians. Pediatrics. 2015; 135(4): 1113-22.
3. Marchese RF, Mistry RD, Scarfone RJ, Chen AE. Identification of optic disc elevation and the crescent sign using point-of-care oculer ultrasound in children. Pediatr Emerg Care. 2015; 31(4): 304-7.
4. Amin D, McCormick T, Mailhot T. Elevated intracranial pressure diagnosis with emergency department bedside ocular ultrasound. Case Rep Emerg Med. 2015; 385970: 3p.

5. Zaidi SJH, Yamamoto LG. Optic nerve sheath diameter measurements by CT scan in ventriculoperitoneal shunt obstruction. Hawaii J Med Public Health. 2014; 73(8): 251-5.
6. Qayyum H, Ramlakhan S. Can oculer ultrasound predict intracranial hypertension? A pilot diagnostic accuracy evaluation in a UK emergency department. Eur J of Emerg Med. 2013; 20(2):91-97
7. Maude RR, Hossain A, Hassan MU, Osbourne S, Sayeed KLA, et al. Transorbital sonographic evaluation of normal optic nerve sheath diameter in healthy volunteers in Bangladesh. PLoS One. 2013; 8(12): e81013.
8. McLario DJ, Sivitz AB. Point of care ultrasound in pediatric clinical care. *JAMA Pediatr*. 2015;169(6):594-600.
9. Yakov MB, Desjardins MP, Fischer JWJ. Emergency point-of-care ultrasound detection of papilledema in the pediatric emergency department. Pediatr Emerg Care. 2015; 31(11): 766-70.
10. Stone MB. Ultrasound diagnosis of papilledema and increased intracranial pressure in pseudotumor cerebri. Am J Emerg Med. 2009; 27(3): 376.e1–376.e2.
11. Lochner P, Nardone R, Tezzon F, Coppo L, Brigo F. Optic nerve sonography to monitor treatment efficacy in idiopathic intracranial hypertension: A Case Report. J Neuroimaging. 2013; 23: 533-534.
12. Salahuddin N, Mohammed A, Alharbi N, Ansari H, Zaza KJ, Marashly Q et al. The incidence of increased ICP in ICU patients with non-traumatic coma as diagnosed by ONSD and CT: a prospective cohort study. BMC Anesthesiology. 2016; 16(1):106.
13. Irazuzta JE, Brown ME, Akhtar J. Bedside optic nerve sheath diameter assessment in the identification of increased ıntracranial pressure in suspected idiopathic intracranial hypertension. Pediatr Neurol. 2016; 54: 35-38.
14. Marchese RF, Mistry R, Binenbaum G, Liu GT, Scarfone RJ, Woodford AL et al. Identification of optic nerve swelling using point-of-care ocular ultrasound in children. Pediatr Emerg Care. 2018; 34(8): 531-536.
15. Padayachly LC, Padayachly V, Galal U, Gray R, Fieggen AG. The relationship between transorbital ultrasound measurement of the optic nerve sheath diameter (ONSD) and invasively measured ICP in children. Childs Nerv Syst. 2016; 32:1769–1778.