The Comparison of Measuring Optical Nerve Sheath Diameter Via Ultrasound Versus Magnetic Resonance for Elective Brain Tumor Surgery

Original Article

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ABSTRACT

Background: The intracranial pressure (ICP) could be measured via non-invasive and direct evaluation techniques. The objective of study was to determine the pre-post anaesthetic status of ICP, using ultra-sonography (USG) and magnetic resonance imaging (MRI) measurement of optic nerve sheath diameter (ONSD) in- patient scheduled for elective brain tumor surgery.

Methods-Results: A prospective observational study was contucted among 27 patients undergoing elective brain tumor surgery. A total of 27 cases between the ages of 18–65 (46,7±14,5 years) have been enrolled in our study. The gender distribution was quite even 55.6% (*n*= 15) of them were women and %44.4 (*n*= 12) of them were male. The mean duration of surgery was 202.2±56.9 hours and the mean time to discharge was 5.04±1.7 days. The ONSD measurements in pre and post-operative periods via USG and MRI indicated statistical significance ($p<0.05$).

Conclusions: In this study we did not find a statistical correlation on the measurement of ONSD with USG and MRI. We need large-scale studies with a better training program fort the safe use of USG for ONSD measurement to monitor ICP.

Key Words: Brain tumor surgery, Magnetic resonance imaging (MRI), Optic nerve sheath diamater, Ultra-sonography (USG).

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INTRODUCTION

Brain tumors encompass a diverse range of abnormal cell growths originating from intracranial tissues and the meninges, exhibiting a spectrum of malignancy from benign to aggressive[1]. Raised intracranial pressure (ICP) is a very common condition in patients undergoing brain tumor surgery[2]. ICP increase may originate soon after surgery and is a major prognostic determinant[3,4]. The early diagnosis and intervention plays a crucial role as this condition could be life threatening. ICP measurement can be done by invasive and non-invasive methods. Although the gold standard for measuring ICP is invasive method, with ventricular or intraparenchymal probes, there is a risk of bleeding and infection during long-term foloow-up[5].

The increase in intracranial pressure (ICP) can be attributed to either a direct compressing effect of a lesion or obstructive hydrocephalus. Predicting the exact ICP status in the immediate preoperative period is challenging, and anesthetists often rely on clinical indicators such as headache, nausea, vomiting, or visual disturbances. While these parameters are sometimes helpful, their consistency in reflecting the severity of the disease is questionable[6].Today, computed tomography (CT) and magnetic resonance imaging (MRI) are routinely used in the diagnosis of ICP. Additionally, the significance of routinely performed CT/MRI scans is reported to be compromised because they provide only a snapshot of information.Serial CT/MRI imaging in ICU follow-up is difficult and risky as it requires frequent transfers in these multiple monitored and unstable patients. In case of frequent imaging, increased cumulative radiation and increased care costs as a result of these examinations should be taken into consideration. Additionally, the need for an expert radiologist's opinion to interpret these images is a significant disadvantage[7].

Optic nerve sheath diameter (ONSD) measurement is a non-invasive method used in the diagnosis of ICP in both pediatric and adult patient groups. The optical nerve has natural associations with the subarachnoidal cavity and in case of ICP increase, the diameter of the optic nerve that is covered by arachnoidal membrane is subjected to dilatation while this cannot be observed in the structures of cranial zone. Optical nerve sheath is contiguous with the duramater, and its contents are contiguous with the subarachnoid space. Thus, raised ICP leads to an increase in

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the ONSD. The reason that lies beneath measuring ONSD rather than papillary edema is the initiation of symptoms. The development of papillary edema may last for hours while it takes minutes for the optical nerve diameter[8].

ONSD can be measured by ultra-sonography (USG) and magnetic resonance imaging (MRI)[9-11]. The optical nerve is surrounded by cerebrospinalfluid and optic nerve sheath diameter (ONSD) measurument with the help of USG imaging is quite an efficient and cost-effective method with very low risk of complications[12-14]. An optical nerve diameter of >5mm during USG imaging is considered as increased ICP[14].

The aim of the present study was to elucidate the comparison of oculer USG and MRI measurement of ONSD in order to detect ICP increase in patients that have undergone cranial tumor surgery. By virtue of this the clinical team could be able to initiate convenient treatment in urgent cases to achieve better survival outcomes.

METHODS

This was an open label, single arm, investigator initiated study conducted with the contribution of our Anesthesia and Rehabilitation and Neurosurgery Department at University of …School of Medicine….., Turkey. The inclusion criteria of the study can be elaborated as: patients over 18 years of age who did not lose consicousness before the elective tumour craniotomy. Subjects with any major cranial anatomical abnormaly or trauma that can could jeapordize USG measurement have also been excluded from the study. Patients with ophtalmic disease and individuals with a scor of Glascow Coma Scale <8 have also been exlcuded.

A total 30 subjects were enrolled but 2 of the individuals had optical nerve involvement and 1 individual had died during intensive care unit stay. Due to this the study population consisted of 27 patients.

Informed consent has been obtained from all the participants and the study has been approved by the …..ethics committe of our institutional review board (Approval Date and Number: 12/07/2019-E.212111).

The ONSD of each patient has been measured 1 day prior to surgery and the day after surgery when the patient has been discharged from intensive care unit for post-operative regular follow up. All the ONSD measurements of these stages have been conducted with the same anesthesiology and rehabilitation spealist who have been trained by the radiology clinic of our university hospital. The pre- and post-operative ONSD measurement of MRI scans have been conducted by the same neurosurgeon. The results of USG and MRI measurements have been compared in order to omit any discrepancies.

The USG measurements have been conducted via Phılıps Lumify probe in supine position with longitidunal and transvers axis 3mm behind the papilla. The MRI scans have been obtained via 1.5T Siemens Avanto Germant device.

In this streamline we assume to have higher survival, lower complication rate and less morbidity compared to unfollowed subjects.

Statistical Aanalysis:
The resulting data were transferred to SPSS (The Statistical Package for Social Sciences) 22.0 database. The data of the study have been processed as mean value, ±standard deviation and percentages. The comparison of USG and MRI in the measurement of optical nerve sheath diameter has been conducted via paired sample test. A *p* value of <0.05 has been accepted as statisticaly significant.

RESULTS

A total of 27 cases between the ages of 18–65 (46,7±14,5 years) have been enrolled in our study. The gender distribution was quite even 55.6% (*n*= 15) of them were women and %44.4 (*n*= 12) of them were male. The mean duration of surgery was 202.2±56.9 hours and the mean time to discharge was 5.04±1.7 days. The baseline demographic propeeties of the study population is denoted denoted in Table (1).

Table 1: Baseline Characteristics:

Age (years), mean±(SD)	46,7±14,5
Gender (male/female)	12/15
ASA (1/2/3/)	9/15/3
Duration of surgery (min)	202,2±56,9
Time to discharge (days)	5,04±1,7

SD: Standart deviation.

The comprasion ONSD measurements in pre and post-operative periods via USG and MRI indicated statistical significance ($p<0.05$) (Table 2). In addition, MRI values were statistically lower than USG values.

The median ONSD of right optical nerve before surgery has been found as 4.6mm (range between 3.4–6.2mm) via USG and 4.1mm (range between 4.1–5.5mm) via MRI (p= 0.02). The median ONSD of left optical nerve before surgery has been found as 4.7mm (range between 3.2–5.7mm) via USG and 4.3mm (range between 3.1–5.4mm) via MRI (p= 0.006) (Table 2).

The median ONSD of right optical nerve after surgery has been found as 4.1mm (range between 3–6mm) via USG and 3.8mm (range between 2.4–6.9mm) via MRI

(p= 0). The median ONSD of left optical nerve after surgery has been found as 4.04mm (range between 3–5mm) via USG and 3.7mm (range between 2.7–5mm) via MRI (p= 0.001) (Table 2).

Table 2: The optical nerve sheath diameter measurement via USG and MRI:

	USG (mean±SD)	MRI (mean±SD)	*P* Value
Right ONSD measurement (pre-operative)	4,6±0,6	4,1±0,6	*0,02
Left ONSD measurement (pre-operative)	4,7±0,5	4,3±0,7	**0,006
Right ONSD measurement (post-operative)	4,1±0,8	3,8±0,8	**0,000
Left ONSD measurement (post-operative)	4,0±0,5	3,7±0,5	**0,001

USG: Ultra-sonography; MRI: Magnetic resonance imaging; ONSD: Measurement of optic nerve sheath diameter; SD: Standart deviation; *: p<0,05; **: p<0,01.

The ONSD over 5mm was accepted as ICP increase. The findings of the study, prior to surgery, 8 patients on ultrasound (USG) and 3 patients on magnetic resonance imaging (MRI) were diagnosed positively based on the examination of the right optical nerve. Similarly, 10 patients on USG and 8 patients on MRI were diagnosed positively based on the examination of the left optical nerve.In terms of post-operative outcomes, other significant findings include: On post-operative period, 7 patients on USG and 1 patient on MRI exhibited values over 5mm according to left optical nerve examination. Additionally, a positive diagnosis was made for one patient each using both USG and MRI according to left optical nerve examination during the post-operative period. These results demonstrate a clear association between ONSD measurements and optic nerve abnormalities in both pre-operative and post-operative periods.

DISCUSSION

The optic nerve sheath is a continuation of the intracranial dura surrounding a trabecular-style subarachnoid space. This area may expand, especially in the anterior retrobulbar section, with increased intracranial pressure (ICP)[15]. There are many studies in the literature stating that ICP can be evaluated noninvasively by measuring the optic nerve sheath diameter (ONSC) [16,17]. However, there are a few studies in which ONSD measurement values obtained by transbulbarsonography and ONSD measurement values obtained by magnetic resonance imaging (MRI) are directly compared, and the results of these studies contradict each other[18-20].

In our study the ONSD measurements in pre and post-operative periods via USG and MRI indicated a difference of statistical significance.

Wolf *et al.*, have published their study the 5mm behind the eye yielded 3.23mm optic nerve diameter and 15mm behind the eye yielded 2.67mm optic nerve diameter (mean). In their measurements of the nerve sheath the same streamline has been achieved as diameters declining from 5.72mm (5mm behind the eye) to 3.98mm (15mm behind the eye). However their USG results (diameters were 2.31mm for the retrobulbar optic nerve and 4.08mm for the sheath) were smaller than MRI which was correlated with our results emphasizing that a difference existed between the two imaging techniques. They have found a statistical significant difference of mean optical nerve and sheath sheath diameter obtained with all three methods (A-scan, B-scan, MRI) (P<0.05). On the other hand they admitted that straight gaze and abduction, the nerve and sheath diameters obtained with B-scan ultrasonography did not differ significantly[21]. In our study the median optical nerve sheath diameter of right optical nerve before surgery has been found as 4.6mm (range between 3.4–6.2mm) via USG and 4.1mm (range between 4.1–5.5mm) via MRI (p<0.02) and the median optical nerve sheath diameter of left optical nerve before surgery has been found as 4.7mm (range between 3.2–5.7mm) via USG and 4.3mm (range between 3.1–5.4mm) via MRI (p<0.006). Wolf *et al.,* have worked with a second radiologist to omit individual discrepancies and found that there was a 3-5% range for nerve and 2-6% range for sheath measurement between the radiologists. This gap was even bigger for the USG as 13% fort he nerve and 9% for the sheath. The coefficient variations for MRI were statisticaly lower than the USG in their study (p<0.001)[21]. On the contrary USG measurements were grater than MRI scans in our study but this could be explained by the fact that our reference point for measurement was papilla. In a previous publication, by Lam *et al.,*[22] they found exactly same diameter values as Wolf *et al.,*[21] however, Lam al did not attain spatial resolution to detect the thinning of the nerve induced by lateral gaze. Ozgen *et al.,* have found the optical nerve diameter as 4.4mm in T1-weighted imaging with a spatial resolution of 507µm[23].

As we have mentioned earlier the intracranial pressure changes are rapidly reflected by ONSD compared to its baseline values[24,25]. The user friendly asset of USG comes from its reproducibility and instructor reliability. According to previous literature examiners with ultrasonography experience have an estimated learning curve of as few as 10 subjects with 3 abnormal scan results. In case of rookies with no experience this case number may rise up to 25[26]. On the other hand the anesthesiology and rehabilitation physician that have conducted USG measurements in this study have been trained by the radiology clinic of our university hospital and has collected data of 27 patients. Quayyum *et al.,* investigated the sensştivity of the USG imaging in 24 subjects and found the sensitivity as 100% (95% CI) and specifity 75% at a cut-off value of 5mm ONSD. The positive predictive value of ONSD for determining ICP was 95.4% and negative predictive value was 100%[6]. According to their research they have declared that ultrasound guided optic nerve sheath diameter is a sensitive and specific test for predicting elevated intracranial pressure[19]. Regarding the data above one can consider that USG can be leveraged as accurate, simple, easy to use and imminent measurement of ICP. There also certain upsides of this technique as the diameter is not influenced by edema, no need to transport patient for MRI and it is cost-effective. The USG is not an invasive procedure and quite easy to learn for the responsible physican.

The MRI has cutting edge precise results for retrobulbar imaging compared to other methods however there are certain downsides as high costs and logistics obstacles that can harm threaten patients' medical condition. HASTE sequences play an important role due to their low variance and short data acquisition time. As a result it ahould be noted that both ultrasonography and MRI have their own advantages and disadvantages[27].

LIMITATIONS OF THE STUDY

One of the main limitations of our study can be elaborated as not having a constant duration of USG and MRI time prior and after the surgery.

The second limitation could be evaluated as a process improvement that the anesthesiology and rehabilitation specialist has been trained by the radiology department of our university hospital, this is a relatively new procedure in our clinic.

CONCLUSION

In this study we did not find a statistical correlation on the measurement of optical nerve sheath diameter with ultrasound and magnetic resonance imaging. We believe that the utilization of ultrasound, a noninvazive procedure by an anesthesiology and rehabilitation specialist will provide better outcomes fornthe monitoring and the survival of the patient. Future studies with larger sample size and trained physicians will provide more datamon this area.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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