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Ultrasound in Emergency Medicine

ACCURACY OF OPTIC NERVE SHEATH DIAMETER MEASUREMENT BY EMERGENCY PHYSICIANS USING BEDSIDE ULTRASOUND

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☐ **Abstract—Background: Ultrasound (US) measurement of the optic nerve sheath diameter (ONSD) has been utilized as an indirect assessment of intracranial pressure. It is usually performed by trained ultrasonographers. Objectives: To evaluate whether or not emergency physicians (EP) are capable of measuring the ONSD accurately by US. Materials and Methods: A retrospective measurement of ONSD was conducted on computed tomography (CT) scans of the head or facial bones. These patients had undergone ocular US performed by EPs prior to CT scanning. The CT scan measurements of ONSD read by a board-certified radiologist were compared with that of the US read by a registered diagnostic medical sonographer. A difference in measurements of the ONSD ≥ 0.5 mm between the two modalities was considered as significant for this study. Results: The ONSD measurements were performed with CT scan and compared to that of the US. Of the 61 patients studied, 36 (59%) were male and 25 (41%) were female. The average age was 56 ± 17 years. All but 3 patients had ONSD measurements that were between 5 and 6 mm. Discrepancy in measurements of the ONSD between US and CT for both groups fell within our predetermined value (0.5 mm) for the majority of cases. None of the measurements were above 6 mm. The intraclass correlation coefficient was 0.9 (95% confidence interval 0.8846–0.9303). Conclusion: Emergency physicians were capable of accurately measuring the ONSD using bedside US. Prospective studies with a larger sample size are recommended to validate these findings. Published by Elsevier Inc.**

☐ **Keywords—emergency physician; ocular ultrasound; optic nerve sheath diameter; CT scan; ICP**

INTRODUCTION

Bedside ultrasound has gained tremendous popularity in most emergency departments (EDs), and it has been integrated as a core element of resident training. Bedside ocular ultrasonography has been used for detection of ocular trauma, retinal detachment, intracranial pressure (ICP), and vitreous hemorrhage in the ED (1–7). Ultrasound measurement of optic nerve sheath diameter (ONSD) has been validated as an indirect assessment of the ICP when performed by formally trained ultrasonographers. Measurements of ONSD by magnetic resonance imaging (MRI) have been shown to correlate with direct ICP measurements (8–10). Our group has recently shown that ONSD measured by computed tomography (CT) was comparable to ONSD measurements by MRI (11).

In terms of its embryonic development, the optic nerve is a part of the central nervous system rather than a

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peripheral nerve. It is derived from an outpouching of the brain (diencephalon) during embryonic development. The optic nerve migrates to the orbit and is ensheathed in all three meningeal layers (dura, arachnoid, and pia mater), known as the optic nerve sheath (12–14). The optic nerve sheath is contiguous with the subarachnoid space, and cerebrospinal fluid flows freely between the cranium and orbit within the subarachnoid space. Increased pressure within the cranium is transmitted to the optic nerve sheath and may be detected by increased size of the ONSD (12,15,16). The normal ONSD is < 5 mm, and anything above 6 mm is considered to reflect a clinically significant increase in ICP (8,9). Measurements between 5 and 6 mm require clinical correlation.

Intracranial pressure is traditionally measured using invasive procedures such as lumbar puncture and ventriculostomy. The most simple and longest-standing method of measuring ICP is to perform a lumbar puncture and to observe the opening pressure. This indirect and imprecise procedure is still commonly used. It has significant disadvantages and inaccuracies. Ventricular catheterization remains the gold standard for ICP measurement today. Both procedures are associated with a high risk of infection, which limits the duration of such monitoring, and with technical difficulties in cannulating a compressed or deviated ventricle in situations of raised ICP (17–19). Bedside ultrasound offers a simple, fast, and indirect assessment of the ICP by measuring the ONSD noninvasively (4,8,20–22). The correlation between the ONSD and direct measurement of the ICP was shown recently (23). MRI measurements of ONSD have been used to detect increased ICP indirectly (8–10). Likewise, bedside ultrasound (US) of the ONSD has been frequently used in recent years to detect ICP (24–27). We have recently shown the correlation of ONSD measurement by CT and MRI, an imaging modality that has been correlated to direct ICP measurement. A correlation between ONSD measurements by CT and by US performed by emergency physician has not been demonstrated, to the best of our knowledge.

This partly retrospective study investigated whether or not emergency physicians (EPs), after a short introductory course on ocular ultrasonography by an EP who is a registered diagnostic medical sonographer (RDMS), are capable of measuring the ONSD as accurately by US as CT scan measurement of ONSD by a board-certified radiologist.

MATERIALS AND METHODS

We conducted a retrospective measurement of ONSD on CT scan of patients from the ED and compared the measurements with that of the US. These patients required CT scan of the head or facial bones for medical reasons. These patients had undergone ocular US examination after obtaining a verbal consent. The ocular US, as part of US curriculum, was performed by EPs on all patients evaluated in the ED prior to the CT scan. Participating EPs had received a structured didactic/cognitive training US education comprised of lectures, videotape review, and structured reading from ultrasonography textbooks and journal articles on ONSD US provided by an EP who is an RDMS. Participating physicians did five practice ocular scans under supervision initially. Out of all physicians who had the above training, two attending physicians, four postgraduate year (PGY) level 2 and one PGY level 1 residents performed the ocular US examination for the study. A waiver to review the CT scans was obtained from the institutional review board for this study. The readily available LOGIQ e Ultrasound machine from General Electric (GE Healthcare, Little Chalfont, UK) with a high-frequency 7.5–10-MHz or higher linear array ultrasound transducer was used for imaging. The scans were reviewed for technical adequacy by RDMS. Subjects were put in supine position (head of bed 0°). The probe was placed lightly over each closed eye after covering each eye with Tegaderm (3M, St. Paul, MN), over which the ultrasound gel was applied. Eye structures were imaged while asking the subjects to look forward with closed eyes to align the optic nerve directly opposite to the probe. The ONSD was measured 3 mm behind the optic disc in both transverse and sagittal planes. The average of the three measurements was recorded. A distance (depth) of 3 mm behind the globe was chosen for two reasons. First, the ultrasound contrast is greatest/the results more reproducible, and secondly, because changes in ONSD with ICP are greatest at this level (5,6,28,29). In the absence of complete visualization of the entire optic nerve, the largest viewed diameter was taken as the maximal ONSD (Figure 1A–C). Prior experience of EPs ranging from very limited to quite extensive experience with US was not controlled for in the study. The ONSDs on the US were read by the RDMS EP retrospectively. The results of the ONSD measured by US were compared with the measurements from CT scan of the head or facial bones read by a board-certified radiologist (Figure 1D–F). Measurements of ONSD on CT scan were performed using an electronic caliper on a Sectra Workstation, Pictorial Archiving and Communication System (PACS; Sectra Imtec AB, Teknikringen 20, SE-583 30 Linkoeping, Sweden). The same radiologist also reviewed the scans for additional abnormalities within the orbit. A discrepancy of 0.2–0.7 mm in ONSD measurements has been reported (30,31). For our study, we considered a difference in ONSD measurements of ≥ 0.5 mm between the two modalities as a significant discrepancy.