OPTIC NERVE ULTRASOUND: A BEDSIDE TOOL IN INTRACRANIAL HYPERTENSION

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INTRODUCTION

Bedside measurement of the optic nerve sheath diameter (ONSD) is being proposed as a reliable non-invasive tool to detect increased intracranial pressure (ICP). Intracranial hypertension is a life threatening condition, defined as sustained ICP > 20mmHg. It is very common in neurointensive care units and can be secondary to acute traumatic brain injury (TBI), subarachnoid hemorrhage, intracerebral hemorrhage, brain tumors and malfunctioning of ventriculoperitoneal shunts. If untreated, brain ischemia and brainstem herniation can be the final complications [1].

The gold standards for ICP measurement are the invasive intracranial devices [2,3], which may not be widely available or can be contraindicated due to coagulopathy or thrombocytopenia [4]. In addition, they can lead to complications such as hemorrhage [5] in 1.1–5.8% of the cases [4], malfunction [5] in 6.3–40% [4] or infection [6] in 0–15% [4], with a significantly increased risk of bacterial colonization after 5 days of placement [7].

Considering the availability of the optic nerve ultrasound (ONUS) in many medical centers, its feasibility, reproducibility, non-invasive properties, and also its significant correlation with the invasive measure of intracranial pressure (ICP), it may allow both earlier diagnose and

management of intracranial hypertension. This is especially important when ICP monitoring is not available or before its placement.

SEARCH STRATEGY

A PubMed search for articles published until September 2016 was performed using the terms "optic nerve sheath diameter" [Mesh] AND ("ultrasound" [Title/Abstract]). Additionally, the reference lists of the articles were searched. Two reviewers independently screened articles' titles and abstracts. Articles with at least an abstract in English or Portuguese were searched.

RATIONALE

Ontogenetically, the optic nerve is part of the central nervous system and the sheath around it is in fact a continuation of the dura mater. The subarachnoid space extends along the optic nerve within the sheath. As cerebral spinal fluid (CSF) pressure varies, the optic nerve sheath diameter (ONSD) changes [8,9] in few seconds [10,11]. A rise in ICP is therefore transmitted to the optic nerve head, eventually resulting in swelling of the optic disc and papilledema [12]. While the distension of the retrobulbar optic nerve sheath takes seconds, the development of papilledema can take hours to many days [13].

It is not expected a purely linear correlation between ONSD and ICP measurements for higher or lower (<10 mmHg) ICP values, as in these cases the ONS reaches its maximum distensibility or adheres to the optic nerve, respectively [10]. This is due to the biologic characteristics of the ONS.

TECHNIQUE

An ultrasound machine with a 13–6 MHz probe is used to perform the ONUS examination. The patient should keep his eye closed and a linear-array probe is placed against his upper eyelid, angled slightly caudally and medially (Fig. 1). The optic nerve is, after some adjustments, visualized as a linear hypoechoic structure with defined margins, posterior to the globe (Fig. 2).

The ONSD is hence measured 3 mm behind the retina (Fig. 2).

The optimal ONSD criterion for the detection of ICP >20 mmHg varies according to the study evaluated. Morettiand collaborators identified the ONSD cutoff of 0.52 cm [14], while Hassler W et al described a 0.5 cm cutoff, after 38 measurements in a study of 15 patients [15]. Geeraerts and collaborators identified a 0.59 cm cutoff [16]. Such discrepancies emphasize the importance of internal institutional validation of sonographic ONSD criteria prior to the routine clinical use of this modality.

Differences in equipment and operator technique can result in systematic differences in measurements, as highlighted by Ohle R and collaborators [13]. These authors believe that the 0.48 cm sonographic cut-off is likely to be a more accurate criterion for the detection of an acutely distended optic nerve sheath in the setting of intracranial hypertension. The number of measurements in the same patients, anatomy, absolute values of ICP and interval between ONSD and ICP measurements may have influenced the results of each study, and may explain the different findings in these studies as well [17].

The probe must always be placed gently on the closed eyelid, avoiding direct contact to the cornea or sclera (which can result in corneal abrasions) and preventing nausea and vomiting as a vasovagal response. Excess acoustic power can, in theory, damage the retina. For this reason, only probes and settings approved by the FDA are recommended for ocular imaging.

Careful angulation of the transducer during real-time imaging is important to clearly demarcate the margins of the optic nerve sheath and distinct the optic nerve from linear hypoechoic artifact (acoustic shadow). Both the lamina cribrosa [18] and the dura mater [19] can produce acoustic shadows behind the globe, depending of the transbulbar sound direction and the incidence of the ultrasound beam on them. The frequency of these artifacts increases if the probe has a frequency of <7.5 MHz [17, 20, 21]

ADVANTAGES AND UTILITIES OF THE METHOD

Many life-threatening conditions can be diagnosed by ultrasound operators at bedside, such as ruptured ectopic pregnancy, aortic aneurysm and cardiac tamponade. Intracranial hypertension may become part of this list, and the measurement of the ONSD has been developed and suggested for this purpose [22,23,24,25].

A systematic review of six studies, including 231 patients, evaluated the performance of ultrasonography of the ONSD for assessment of intracranial hypertension and found a good diagnostic accuracy [1].

The method can play an important role in emergency and critical care routines. The management of intracranial hypertension may start earlier if the ultrasonography of ONSD suggests high ICP. This is of critical importance when ICP monitoring is not available or before its placement [1]. It can help physicians to decide if a transfer to a tertiary medical centers is necessary or if placing an invasive device is required.[1]. Moreover, during long transportation periods it can be useful to better monitor acutely ill patients and to eventually suggest a more aggressive medical treatment [1].

Ultrasonography of ONSD is reproducible, with a median intra-observer reliability of 0.2 mm (0.1–0.5 mm) [26] and a median inter-observer reliability varying from 0.2 to 0.3 mm [26,27,28]. The learning curve for experienced sonologists may include as few as 10 subjects with three abnormal scan results. The number of scans needed may be closer to 25 if the sonologists are beginners. [29]. In addition, the equipment is widely available, and the cost is low [30].

LIMITATIONS

As happens with other propedeutic tools, some limitations must be considered to avoid diagnostic and management errors. The occurrence of artifacts and the measurement of small dimensions may be the most challenging aspects of ONUS to inexperienced and untrained operators, leading to inconsistent results. Supervised measurements of normal and distended optic nerve sheaths are extremely important before an operator can independently perform ONSD measurements.

Another point to be considered is that the ONUS is a qualitative, not a quantitative method. It is able to show that intracranial pressure is raised but not to how much it is, as a permanent linear correlation of ONSD and IP is not expected. Unlike the invasive methods, ONUS shows punctual information. As many measurements as necessary must be performed to give an idea of the evolution of the whole process.

Interpretation of ultrasonography of ONSD should be combined with a set of clinical and radiological signs [1]. ONUS does not substitute the invasive devices but plays an important role as a complementary tool in clinical practice.

CONCLUSIONS

Many studies presented robust data to, at least, consider the ONUS as a reliable tool to rule out raised ICP [21]. It is evident that larger ones are needed to confirm the accuracy and real-life feasibility of this method. Institutions intending to use this technique as a clinical tool in a more heterogeneous group of patients at risk for intracranial hypertension should be careful before adopting criteria from previously published material [10,11,15,31,32,33].

FIGURES

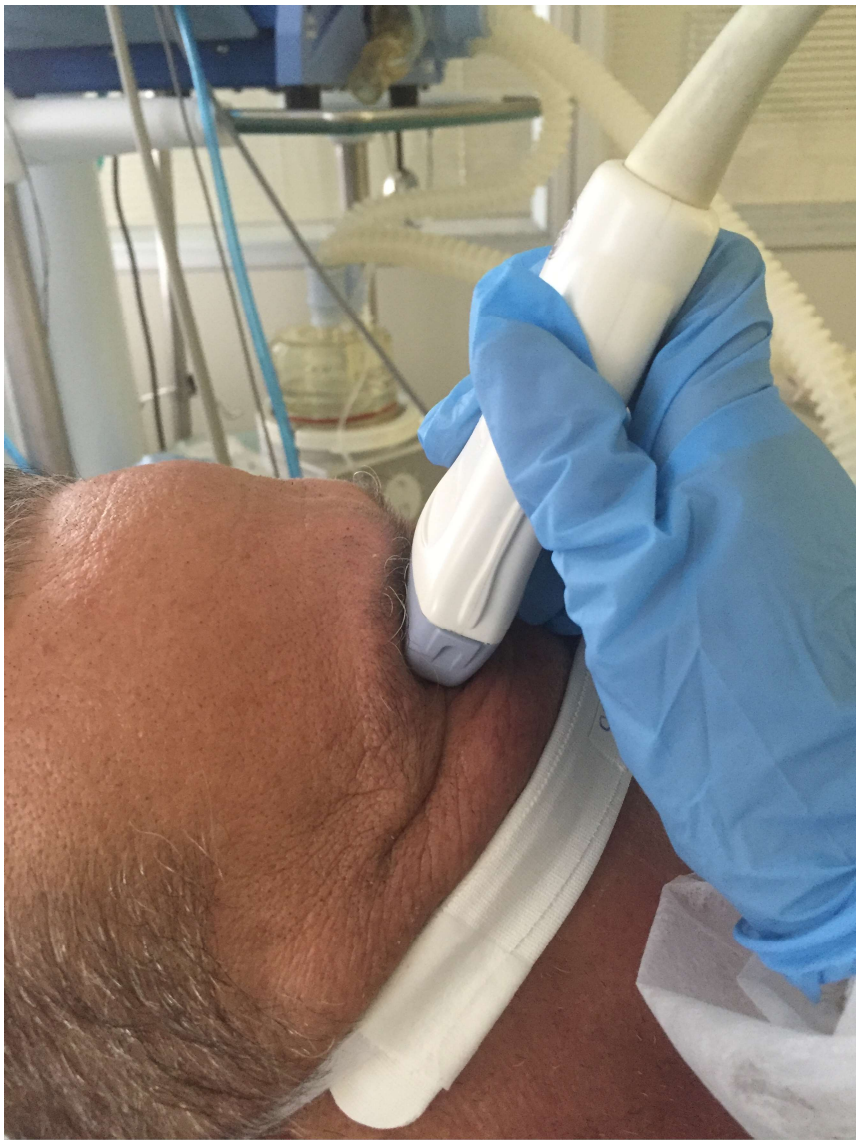

FIGURE 01

A Linear-array 13–6 MHz probe placed against the upper eyelid, angled slightly caudally and medially.

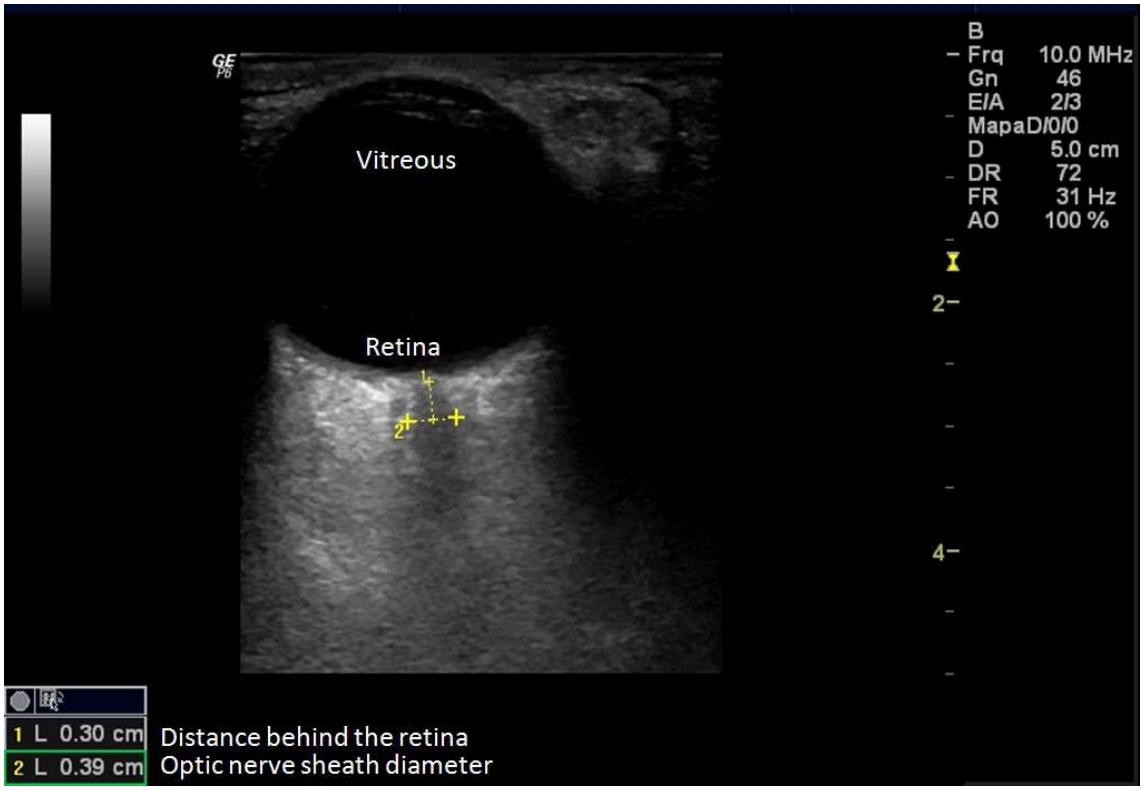

FIGURE 02

Measurement of the optic nerve sheath diameter: The ONSD is the linear hypoechoic structure with defined margins, posterior to the globe. It is measured 3 mm behind the retina.

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