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Sonographic assessment of the optic nerve sheath diameter in the diagnosis of idiopathic intracranial hypertension

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ABSTRACT

Objective: Sonographic assessment of the optic nerve sheath diameter (ONSD) is a useful technique in detecting raised intracranial pressure (ICP) in neurocritical care patients. Its utility in idiopathic intracranial hypertension (IIH) is less known. The aim of this study was to evaluate the diagnostic accuracy of ONSD for detecting IIH.
Material and methods: Ultrasound measurement of ONSD was performed in 19 patients with IIH and in 11 patients with different neurological diseases without raised ICP that required undergoing a lumbar puncture. The validity of this technique for diagnosing IIH was established with cerebrospinal fluid manometry values.
Results: Patients with IIH showed significantly enlarged ONSD than those without IIH. The best cut-off point for detecting raised ICP was 6.3 mms, with a sensitivity, specificity and positive likelihood ratio of 94.7%, 90.9% and 10.4, respectively. After a therapeutic lumbar puncture an 87% of cases had a partial reduction of ONSD values.
Conclusion: Sonographic assessment of ONSD seems to be a useful and reliable technique for detecting raised ICP. While the spinal manometry is not replaced in usual clinical settings, transorbital sonography alternatively allows a suitable and harmless screening of patients with suspected IIH. It would be desirable to perform an internal validation of the technique in each hospital in order to get the optimal cut-off point.

1. Introduction

Intracranial hypertension (IH) is a common complication of multiple neurological diseases with raised intracranial pressure (ICP) that can lead to a secondary brain damage, so its early recognition is essential.

Sonographic assessment of the optic nerve sheath diameter (ONSD) has proven to be a reliable test for non-invasive diagnosis of raised ICP in neurocritical patients [1–2]. However, the available information on its value to appraise idiopathic intracranial hypertension (IIH) comes from a single observational study [3] and limited clinical isolated cases [4–9].

The optic nerve is a tubular structure of about 5 cm in length in which its intraorbital segment is evaluable sonographically. Histologically it is surrounded by the same meningeal layers as the brain [10–11]. The optic nerve appears as a hypoechoic linear structure located inside the optic nerve sheath (Fig. 1). Between the sheath and the optic nerve is situated the subarachnoid space, trabeculated and hyperechoic in appearance, whose dimensions are enlarged in IH situations as this raised ICP is transmitted throughout the subarachnoid space to the optic nerve head [11–12].Therefore, the presence of an increased ONSD is an indirect sign of IH because changes in ICP have a direct influence on the perioptic subarachnoid space diameter. However, there is a discrepancy about the optimal ONSD cut-off reported in different published works [1–2,13]. The aim of this study is to evaluate the diagnostic accuracy of ONSD sonographic assessment comparing to spinal manometry, to assess the best cut-off value to predict the diagnosis of IIH and to evaluate the response of ONSD to immediate changes of ICP.

2. Material and methods

2.1. Subjects and setting

We present a diagnostic phase I–II validity study [14] from the data collected between May 2011 and February 2014 in the Laboratory of Neurosonology at the Department of Neurology of La Mancha Centro General Hospital, which was carried out from a consecutive cohort of 30 patients with different degree of suspicion of IH. These patients had attended our department for undergoing a lumbar puncture with cerebrospinal fluid (CSF) manometry (gold standard technique) submitted

Abbreviations: ONSD, optic nerve sheath diameter; ICP, Intracranial pressure; IIH, Idiopathic intracranial hypertension; CSF, cerebrospinal fluid; CSFoP, CSF opening pressure; ODE, optic disc elevation; OND, optic nerve diameter; CCC, concordance correlation coefficient; AION, anterior ischemic optic neuropathy.

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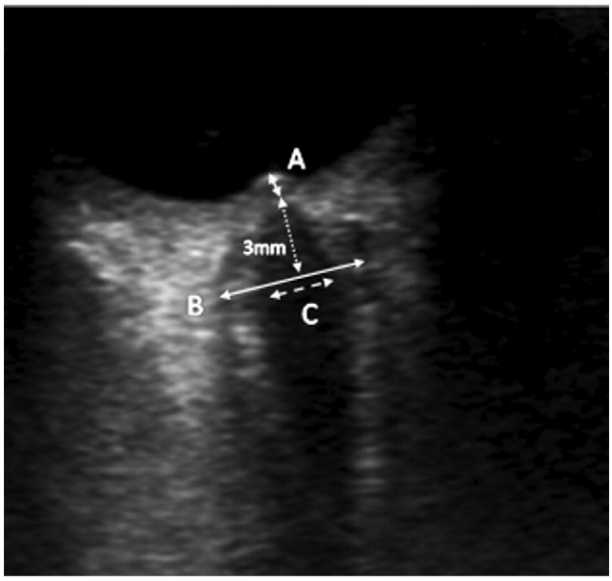

Fig. 1. Transorbital sonography in B-mode of the eyeball and optic nerve. The three basic measurements are shown. A: optic disc elevation (ODE) from its dome to the outer retinal rim or lamina cribosa. B: optic nerve sheath diameter (ONSD). C: optic nerve diameter (OND). B and C were performed 3 mm behind the lamina cribosa.

by their neurologist. After an extensive workup, 19 patients were diagnosed of IIH according to CSF opening pressure (CSFoP). The remaining 11 patients suffered from different neurological disorders without raised ICP in spinal manometry and were, therefore, free of the disease. In all patients, diagnosis was newly established and had to be naive to treatment.

All enrolled patients met the study inclusion criteria: clinical suspicion of possible IH or need to discard it based on clinical data (refractory headache that do not respond to treatment, valsalva associated headache, papilledema, ophtalmoparesis associated to headache, decreased visual acuity or visual blackouts associated to headache), no contraindication to perform a lumbar puncture, no ocular abnormalities that prevent from realization of a transorbital sonography (ie: enucleation of the eye, etc.) and no IH of a secondary etiology. Patients with raised ICP fulfilled the recently updated diagnostic criteria for definite IIH with or without papilledema [15]. The study complies with the principles proposed by the Declaration of Helsinki.All patients accepted the terms of the study and signed a written informed consent.

2.2. Diagnostic methods

A lumbar puncture to exclude raised ICP and a cranial magnetic resonance imaging (MRI) with venous angiography to exclude cerebral venous thrombosis or other intracranial structural lesions were performed in all patients. The lumbar puncture was performed in the lateral position with posterior measurement of CSFoP with legs fully extended, considering a pathological cutoff value of 25 cmH_20 [15].

All patients underwent a transorbital sonography that was performed prior to the lumbar puncture by an expert neurosonologist with ten year's sonographic experience who was blind to clinical patient data and CSFoP. We used a Toshiba AplioXG ultrasound system and a 4.8-11 MHZ linear array multifrequency transducer with the higher spatial resolution setting that the probe allows in a B-mode axial approach to the eyeball. With the patient in supine position, a transverse lengthwise optic nerve approach was performed by placing the probe on the temporal part of the upper eyelid slightly superior to the upper corneal rim using a thick layer of ultrasound gel. Pressure on the eyeball with the ultrasound probe was avoided to prevent pain or vagal reactions. For safety reasons of biomechanical side-effects on sensitive tissues like crystalline, the mechanical index was reduced to 0.2 and the exploration was limited to the minimum possible time. The usually required depth parameter was 4–4.5 cm.

2.3. Measurements

Three parameters were measured on ultrasound examination in each eye (Fig. 1): the optic disc elevation (ODE) from its dome to the outer retinal rim or lamina cribosa, the optic nerve sheath diameter (ONSD) and the optic nerve diameter (OND). The ONSD and the OND were measured 3 mm behind the lamina cribosa because this location is the area more sensible to ICP changes in anatomical studies [16]. The optic nerve appears as a hypoechoic linear structure located inside the two edges of the optic nerve sheath. Between the optic nerve and the optic nerve sheath the subarachnoid space is situated with trabecular and hyperechoic echographic appearance. To measure the ONSD the external edges of the tubular structure formed by the set of the optic nerve and the meningeal sheath should be displayed (Fig. 1). Special attention should be paid to avoid not only artifacts from acoustic shadow produced by the papilla [17],but also curvatures of the optic nerve in order to make the measurement as perpendicular to the longitudinal axis of the eyeball as possible. For this reason, it is useful to ask the patient to direct the horizontal gaze slightly to either side as required. The Color Doppler Image may be useful to visualize the central retinal artery within the optic nerve to highlight areas of curvature that can erroneously increase the ONSD measure [17].OND assessment was performed as the diameter of the visible hypoechoic tubular structure centrally located in the space between the outer edges of the optic nerve sheath.

Each of these measurements was performed three times and means were calculated in each side. A therapeutic CSF removal was performed in patients of IIH group after spinal manometry to achieve a closing pressure of about 15 cmH_2O. A new ultrasound study was performed in these patients 30 min after therapeutic lumbar puncture to verify the changes of ultrasound parameters after correction of the ICP.

2.4. Statistical analysis

We described the principal variables of interest, ONSD, OND, ODE, CSFoP and CSF closing pressure, and the main independent sociodemographic variables, sex and age, in cases with IIH and patients without raised ICP. The mean and standard deviation were used for variables with normal distribution and median and interquartile range for nonparametric variables. The differences in pre and postpuncture measurements in the IIH group were evaluated with the t-Student test for paired data. The differences between the two groups of comparison were made both with respect to the age and relating to the measurements of the variables of interest, using the t-Student test for unpaired data. The differences by sex between groups were established by chi-square test.

The degree of concordance of ONSD, OND, and ODE measures between the right and left eyes were evaluated with the concordance correlation coefficient (CCC or Lin's coefficient). The mean of both sides measurements was used in each of this variables for the final analysis.

The correlation between CSFoP and ONSD measures were evaluated with the Spearman correlation coefficient.

We also assessed the validity of the ONSD measurement as a diagnostic method for detecting raised ICP. The sensitivity, specificity, positive likelihood ratio and positive and negative predictive value for each of the possible ONSD cutoffs values in predicting IH, according to the CSFoP, were calculated. The ONSD cutoff value that best predicted the presence of IH as well as the diagnostic performance of the ultrasound test were determined by a ROC curve (receiver operating characteristic). Finally, we assessed the correlation of ODE with CSFoP measures with the Spearman correlation coefficient.

Analyses were performed using the statistical software STATA SE version 12, considering a significance level of $p < 0.05$.