Sonography of the optic nerve sheath beyond the hyperacute stage of intracerebral hemorrhage

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Abstract

Purpose To evaluate the feasibility and utility of serial measuring of the optic nerve sheath diameter beyond the hyperacute and acute stage of intracerebral hemorrhage (ICH).

Methods Four patients with extensive ICH in the left basal ganglia were followed using ultrasound (US) and cerebral CT scans.

Results Optic nerve sheath diameter values assessed beyond the acute stage of ICH showed a high correlation ($\rho = 0.84$, $p = 0.0022$) with midline shift of the third ventricle seen on CT scans.

Conclusions Optic nerve sonography can be useful to evaluate patients with extensive ICH beyond the acute stage and help monitoring clinical evolution in these patients, when ICP monitoring is not feasible.

Keywords Cerebral computed tomography · Intracerebral hemorrhage · Intracranial pressure · Optic nerve sheath diameter

Riassunto

Obiettivi Valutare l'utilità clinica della misurazione seriale del diametro del nervo ottico e dei suoi rivestimenti dopo la fase acuta dell'emorragia cerebrale.

Metodi Quattro pazienti con emorragia cerebrale sono stati sottoposti ad ecografia del nervo ottico e tomografia assiale computerizzata (TAC) del cranio.

Risultati I valori del diametro del nervo ottico e dei suoi rivestimenti correlavano in maniera marcata con lo shift della linea mediana del terzo ventricolo evidenziato alla TAC cerebrale.

Conclusioni La sonografia del nervo ottico con la misurazione del diametro del nervo ottico e dei suoi rivestimenti potrebbe costituire un utile strumento nel valutare l'evoluzione clinica dei pazienti con estesa emorragia intracranica, qualora la misurazione della pressione intracranica non fosse eseguibile.

Introduction

The retrobulbar segment of the optic nerve is surrounded by a distensible subarachnoid space which inflates during an increase of the cerebrospinal fluid (CSF) pressure. Optic nerve sonography (US) has been used to identify intracranial hypertension through the measurement of the optic nerve sheath diameter (ONSD) [1, 2].

Different US studies showed that an increased intracranial pressure (ICP) of different aetiologies leads to enlargement of the ONSD [3, 4].

Two recent sonographic studies conducted in patients with acute intracerebral hemorrhage (ICH) demonstrated a significant enlargement of ONSD already detectable both in hyperacute (within 6 h of symptom onset) [4] and acute

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stage (within 48 h of symptom onset) [5]. However, in the literature there are very little data on ONSD changes in patients with increased ICP secondary to ICH beyond the hyperacute or acute stage [6]. We performed serial US studies to measure ONSD in four patients with extensive hypertensive ICH followed longitudinally beyond the hyperacute and acute stage.

Our aim was to evaluate whether there is a correlation between ONSD values, midline shift [evaluated by means of serial cerebral computed tomography (CT) scans], and optic disc elevation (ODE) beyond the hyperacute and acute stage.

Case description

All patients were admitted to our hospital with aphasia and right hemiplegia. Cerebral CT scans revealed in all cases an hypertensive ICH of the left basal ganglia.

The assessment of ultrasound (US) examinations of the eye was carried out in B-mode using a linear array 10L (4–10 MHz) transducer (Vivid Seven ultrasound system GE, Milwaukee, USA).

Serial measurements of the ONSD were carried out using the same methodology adopted previously by our group [7]. US was also used to evaluate the presence of papilledema: the ODE was gauged between the fundus and the dome of the papilla [7].

The midline dislocation of the third ventricle was measured in CT scan obtained in orbitomeatal projection with a section thickness of 4–8 mm. Midline shift of the third ventricle was obtained by measuring the distance between the external tabula of the skull bone and the middle of the third ventricle on both sides [8].

Spearman's rank correlation coefficient test (non-parametric test) was used to correlate ONSD values of each patient with midline shift on CT scans and with ODE and to correlate ODE values with midline shift.

Clinical characteristics of patients, data on CT findings, and US values are reported in Table 1 and in Fig. 1. In patient 1, two intervals (>30 min) of increased ICP (>20 mmHg) were noted during the first 5 days after admission. In patient 2, the ICP generally remained <20 mmHg; maximal values did not exceeded 18 mmHg. ODE measurable by means of US was not found only in patient 2. ICP assessment was not feasible in patients 3 and 4, who were admitted in a Stroke Unit (and not in a Neurosurgery Department) without possibility of recording ICP values.

A statistically significant positive correlation was found between ONSD and midline dislocation of the third ventricle ($\rho = 0.84$, $p = 0.0022$, patients 1–4), and—although less marked—between ONSD and ODE ($\rho = 0.53$, $p = 0.05$, patients 1, 3, 4). This correlation was not confined to the hyperacute and acute stages of the disease. No correlation was found between ODE and midline shift of the third ventricle ($\rho = 0.24$, $p = 0.357$, patients 1, 3, 4).

Table 1 Clinical characteristics of patients, data on cerebral computed tomography (CT findings), and optic nerve sheath diameter (ONSD) values

Patient age (years), sex	Time since admission (days)	Glasgow coma scale (GCS)	ONSD (mm) (5.4 ± 0.6^a)		ODE (mm)		Midline shift (mm) on CT
			right	left	right	left	
1	0	8	7.3	7.4	0.7	1.3	8
54, M	14	9	7.3	8.0	1.0	1.3	16
	21	10	7.2	7.15	0.9	0.9	8.3
	30	11	6.9	6.9	np	np	6
	41	12	5.9	6.0	np	np	5
2	0	7	6.0	6.1	np	np	7.5
65, M	18	10	6.3	6.3	np	np	11.5
	41	12	5.9	6.0	np	np	5
3	0	8	6.3	6.7	0.7	1.2	6.1
76,F	3	9	6	6.6	0.7	1.2	5.2
	5	10	5.7	6.2	0.7	0.9	4.1
	25	10	4.1	4.6	0.7	0.7	2.1
4	0	9	3.8	5.1	0.7	0.8	4.9
71, M	1	11	3.8	4.8	0.6	0.7	3.5
	20	14	3.8	4.6	0.6	0.7	2

np not present

^a Normal values expressed as mean $\pm$ 1 standard deviation

Fig. 1 **a** ONSD was measured 3 mm behind the papilla (*dotted arrow*) in an axial plane showing the optic nerve in its longitudinal course. **a** (*dashed arrow*) denotes the ONSD: ONSD of case 1 on admission 7.4 mm. **b** By transfer to rehabilitation the ONSD reduced

to 6.9 mm in both eyes without papilledema. **c** Optic disc elevation (ODE) gauged between the fundus and the dome of the papilla (patient 1)

Fig. 2 **a** Midline shift of 16 mm on CT scan in patient with intracerebral hemorrhage on admission. **b** At the last follow-up the CT scan revealed a reduction of the midline shift to 6 mm (patient 1)

Discussion

Our cases showed a positive correlation between ONSD and the midline shift of the third ventricle, which was not confined to the hyperacute and acute stages of the disease.

We decided to assess the ODE, according to a previous study which evaluated both ONSD and ODE in patients with idiopathic intracranial hypertension [9]. The rationale is that the papilledema or ODE is preceded by an elevation of pressure in the subarachnoid space of the intraorbital

portion of the optic nerve [10]. However, we found only a mild correlation between ONSD and ODE, and no correlation between ODE and midline dislocation of the third ventricle, indicating that ODE values may not be accurate indicators of midline shift due to increased ICP in patients with ICH.

Results of this case series confirm and extend previous information on ONSD measurements and increased ICP in patients with ICH [4, 5]. Optic nerve sonography has been demonstrated to be a non-invasive method with an

overall good reliability to detect elevated ICP in patients with spontaneous ICH, and a significant enlargement of ONSD has been demonstrated to be already detectable in hyperacute stage of increased ICP. In this series we showed that ONSD values, which are known to change almost concurrently with rapid ICP variations [5], have a high correlation with midline dislocation of the third ventricle seen on CT scans, which by itself is also related to ICP values [11]. Although our series is limited by the fact that we did not record ICP values in all patients, our results suggest that US may provide indirect information on the presence and amount of midline deviation of the third ventricle, and hence on ICP values in patients with known ICH, when ICP monitoring is not feasible.

Further studies with direct measurement of both ONSD and ICP values are required to evaluate whether US may be considered a reliable and accurate method to longitudinally evaluate patients with increased ICP due to ICH (Fig. 2).

Conflict of interest Piergiorgio Lochner, Cornelia Mader, Raffaele Nardone, Frediano Tezzon, Maria Luisa Zedde, Giovanni Malferrari, Francesco Brigo declare that they have no conflict of interest

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Human and animal studies The study was conducted in accordance with all institutional and national guidelines for the care and use of laboratory animals.

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