Case Report

Perioperative monitoring of intracranial pressure using optic nerve sheath diameter in paediatric liver transplantation

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ABSTRACT

An elevation of intracranial pressure (ICP) secondary to cerebral oedema is a major contributor to morbidity and mortality in acute liver failure (ALF). We present a case of ICP monitoring with ocular ultrasonography in a 2-year-old child with ALF for liver transplantation. Since invasive ICP monitoring was risky considering the level of coagulopathy, optic nerve sheath diameter (ONSD) monitoring was done by ultrasound. A value of 4.5 mm was chosen as the cut-off for an ICP >20 mmHg in this child and was checked at regular intervals during the surgery. Ultrasonographic ONSD assessment can be a useful modality in liver transplant recipients, with severe coagulopathy and high ICP. In our specific patient scenario, ocular ultrasound proved to be a valuable safe and noninvasive monitoring tool in this paediatric patient.

Key words: Acute liver failure, intracranial pressure monitoring, ocular ultrasound, optic nerve sheath diameter, paediatric liver transplantation

INTRODUCTION

An elevation of the intracranial pressure (ICP) secondary to cerebral oedema is a major contributor to morbidity and mortality in acute liver failure (ALF).[1-4] The American Association for the Study of Liver Diseases recommends ICP monitoring in ALF patients with high-grade hepatic encephalopathy (HE).[4] Although direct measurement of ICP using an intraventricular catheter has been known to be a gold standard method for evaluating ICP, it is a highly invasive technique. The clinical use of ICP monitoring using an intraventricular catheter in patients with ALF is limited by associated coagulopathy as it may be associated with a high potential for the development of haemorrhagic complications.[5] Despite the risks associated, perioperative ICP monitoring may be beneficial for guiding the administration of targeted therapy (i.e., mannitol, hypertonic saline, hyperventilation and reverse Trendelenburg positioning) to prevent brain herniation. Recently, ultrasonographic measurement of optic nerve sheath diameter (ONSD) has been increasingly used for the assessment of high ICP.[6] Although ONSD has also been used in adult liver failure patients, there is not much literature on the perioperative use of ONSD in paediatric liver transplantation. Here, we present a case of ICP monitoring with ocular ultrasonography in a 2-year-old child for liver transplantation.

CASE REPORT

A 2-year-old male child (weighing 13 kg), diagnosed as ALF, was referred to our institution and was admitted in the Paediatric Intensive Care Unit. The aetiology of ALF was hepatitis A, with a history of jaundice for 20 days and altered sensorium for 2 days. On presentation, the child had HE Grade 3 and was electively intubated. The right internal jugular vein was cannulated, and 5.5 Fr central venous catheter was

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inserted for venous access. The child was hypotensive with a systolic blood pressure of 70 mmHg, and a right radial arterial catheter was inserted. Noradrenaline infusion at a rate of 0.3 mcg/kg/min was started. As urine output was nil for 5 h, a 10 Fr haemodialysis catheter was inserted in the right femoral vein, and continuous renal replacement therapy was started with an ultra-filtrate of 15 ml/h. The child was posted for liver transplantation next morning and preoperative workup started. His preoperative laboratory parameters were a prothrombin time of 80 s, an international normalised ratio of 7.0, activated partial thromboplastin time of >120 s, a total bilirubin level of 24.6 mg/dL, with a direct bilirubin of 16.1 mg/dL, an aspartate aminotransferase level of 179 U/L, an alanine aminotransferase level of 219 U/L, a haemoglobin level of 9.6 g/dL, a platelet count of 153000 and a serum creatinine level of 0.3 mg/dL. The child also underwent a computed tomography scan of the head, which did not show any features suggestive of cerebral oedema. Various anticerebral oedema measures, such as head-up position, hyperventilation to keep PCO_2 around 30–35 mm Hg, avoiding hyperthermia and keeping body temperature around 35.0°C, were instituted in the Intensive Care Unit itself.[4,7] Since the child was already in HE, there was a high risk of development of cerebral oedema. This was one of the chief concerns to the anaesthesia team before the surgery. Since invasive ICP monitoring was very risky considering the level of coagulopathy, it was decided to monitor the optic nerve sheath diameter by ultrasound. Majority of studies done in paediatric ONSD monitoring by ultrasound have suggested that an ONSD value >4 mm in children under 1 year and >4.5 mm in older children should be considered abnormal.[8-10] A value of 4.5 mm was chosen as the cut-off for an ICP >20 mm Hg in this child. The baseline preoperative optic nerve ultrasound examination was performed in the operation theatre, which was 3.7 mm for both eyes. This, along with the subsequent measurements of ONSD was done by the same anaesthesiologist. For measuring the ONSD, a linear ultrasound probe (Venue 40, GE healthcare) with a standard vascular preset at a frequency of 7 MHz was placed on the superior and lateral margin of the orbit on the closed eyelid; an image of the globe with the retina and the optic nerve was obtained, and the diameter of the optic nerve sheath was identified 3 mm below the retina [Figures 1 and 2]. General anaesthesia was induced with intravenous fentanyl and inhalation (through the pre-existing endotracheal tube) of isoflurane. The maintenance of general anaesthesia was achieved via a balanced anaesthetic technique with isoflurane, along with continuous infusions of fentanyl (2 mcg/kg/h) and atracurium (0.5 mg/kg/h). Due to the nature of surgery and the large volume fluid shifts anticipated, it was decided to do ONSD monitoring every two hourly [Table 1] during intraoperative phase. The surgery extended for about 12 h, and during that duration, the ONSD remained within the cutoff criteria. The surgery went off relatively uneventful and the child was shifted to liver transplant Intensive Care Unit at the end of surgery. It was decided to monitor ONSD by ultrasound, every 4 hourly in the postoperative period also [Table 2]. The patient's trachea was extubated after 36 hours. The renal and neurological status also improved gradually and the child was discharged to home on the 15th day.

DISCUSSION

The use of ultrasound to measure the optic nerve diameter is a well-described technique in literature for more than a decade. Conventionally, ICP has been measured invasively with either an intraparenchymal probe or an intraventricular catheter. Both techniques

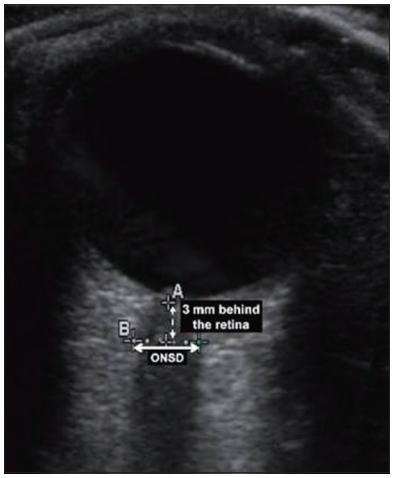

Figure 1: Ultrasound image showing optic nerve sheath diameter

Table 1: Intraoperative optic nerve sheath diameter values

Phase of Surgery	Time (h)	ONSD right eye (mm)	ONSD left eye (mm)
Before induction	0	3.7	3.7
Dissection phase	2	3.9	3.8
Dissection phase	4	3.9	3.8
Dissection phase	6	3.9	3.9
Anhepatic phase	8	4.0	4.0
After reperfusion	10	4.0	4.0
Neohepatic phase	12	3.9	3.8

ONSD – Optic nerve sheath diameter

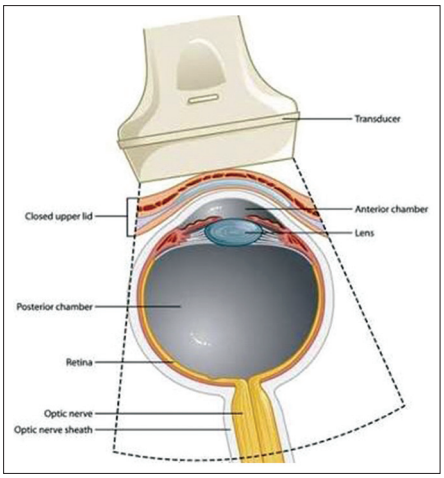

Figure 2: Ocular ultrasonography

Table 2: Postoperative optic nerve sheath diameter values in Intensive Care Unit

Time (h)	ONSD right eye (mm)	ONSD left eye (mm)
0 (ICU)	3.9	3.8
4	3.8	3.8
8	3.8	3.9
12	3.7	3.9
16	3.8	3.8
20	3.8	3.9
24	3.9	3.9
28	3.7	3.8
32	3.8	3.7
36 (before extubation)	3.8	3.7

ONSD – Optic nerve sheath diameter; ICU – Intensive Care Unit

carry the risk of infection or bleeding, even in the noncoagulopathic patient population. The noninvasive monitoring of an elevated ICP with optic nerve ultrasonography can, therefore, be advantageous in patients with signs of an increased ICP in the setting of acute fulminant liver failure. The optic nerve sheath is contiguous with the dura mater and its contents are contiguous with the subarachnoid space. Thus, raised ICP leads to an increase in the optic nerve sheath diameter. A-mode sonography was first used for visualisation of the optic nerve sheath; however, it was not until 1994, when Hansen *et al*. used B mode sonography, when the approach to measurement was standardised. Sonographic studies of cadaveric optic nerves together with the work of Hansen *et al*. established that the greatest degree of distension of the sheath occurred 3 mm behind the optic globe. This location has become the standard measurement point. Based on these considerations, noninvasive measurement of ONSD has been increasingly attempted for monitoring ICP in many clinical settings. Especially, ultrasonographic ONSD assessment has proven to be useful for monitoring high ICP in patients with brain injury, idiopathic intracranial hypertension and spontaneous intracranial haemorrhage. Further studies are most certainly needed to assess whether perioperative ICP monitoring with optic nerve ultrasound will alter management and improve outcomes, particularly in ALF patients undergoing liver transplantation. In addition, because of the noninvasive nature of ultrasound technology and the minimal examination time for acquiring accurate measurements, the safety of optic nerve ultrasound in comparison with other more invasive modalities is maximised, with no reports of adverse events from the brief use of ultrasound for measuring ONSD.

CONCLUSION

There is limited information available about the usefulness of ultrasonographic ONSD assessment in paediatric liver transplant recipients, who may experience severe coagulopathy and high ICP during liver transplantation. In our specific patient scenario, optic nerve ultrasound proved to be a valuable safe and noninvasive monitoring tool for ICP monitoring.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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