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An Indigenous Intracranial Pressure Monitoring System: A Devise for Succour

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Abstract

Introduction: Intracranial pressure (ICP) monitoring system is an important tool in managing traumatic brain injury (TBI) patients. However, in developing countries like India, intraparenchymal ICP monitoring systems are not feasible and intraventricular monitoring is not preferred due to high infection rates as well as difficulty in placement in the absence of ventriculomegaly. We tried to evaluate the feasibility and utility of indigenous, low-cost subdural ICP monitor in TBI patients.

Materials and Methods: This prospective observational study over 12-month of the period included patients aged 18 years or more with a Glasgow coma score (GCS) of less than 12 following a head injury, who were admitted within 12 h of the injury. ICP was measured in these patients when there was no definitive operable finding on computed tomography head. Patients having ventriculomegaly and/or coagulopathy were excluded. Soft sterile silicon (6 FG) was placed subdurally after making a small burr hole and connected to a central venous pressure manometer, sterile saline used as coupling agent. The total cost of consumables was around INR 1125. Based on serial ICP recording (up to 72 h), patients were grouped as high ICP (>20 cm H_2O) Group H (N = 12) and normal ICP (<20 cm H_2O) Group N (N = 7). The outcome was assessed at 6 months with GCS.

Results: A total of 19 patients were analyzed, 14 (74%) were severe head injured (GCS - 3-8) and 5 (26%) patients sustained a moderate head injury (GCS - 9-12); all were male with a mean age of 34 years. 14 (73.6%) patients had high ICP, all of whom were subsequently operated. Median GCS was 5 (range 4 - 6) at 6 months follow-up in the operated Group H and median GCS of 6 (range 4 - 7) in the non-operated Group N.

Conclusions: Our indigenous and cheap subdural ICP monitoring system is feasible, easy to use and may be an attractive alternative in resource-constrained setting.

Key words: Head injury, Indigenous intracranial pressure monitor, Intracranial pressure

INTRODUCTION

Monitoring of intracranial pressure (ICP) plays an important role in managing a variety of acute and chronic intracranial pathologies. While there are several techniques described to monitor ICP, the ventricular catheter remains the most accurate. The earliest descriptions of ICP monitoring date back almost 100 years.[1] Most significant advances in this area, however, have occurred over the last three decades.[2-6] With technological refinements, the process of monitoring has become more elegant, reliable, and safe. Lundberg,[3] in 1960, introduced continuous monitoring of ICP in clinical neurosurgery, and today, it has become an integral part of neurosurgical intensive care. Intracranial hypertension following traumatic brain injury (TBI) can lead to potentially catastrophic consequences. Fatality may not result from the primary insult rather progressive brain damage may develop over time due to raised ICP.[7] ICP monitoring is a vital part of the neurosurgical armamentarium in most of the advanced trauma centers around the world, but these equipment come at the cost of increased health care and patient's expenses. In developing countries like India, intra-parenchymal.[8-10] ICP monitoring systems are not easily feasible and intraventricular monitoring is not

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preferred due to high infection[11] rates and so also difficulty in placement in the absence of ventriculomegaly. We designed a prospective observational study to evaluate the indications, feasibility and utility of an indigenous, low-cost, subdural ICP monitor in TBI patients, in a resource constrained setting.

MATERIALS AND METHODS

After institutional ethical clearance, this study was conducted jointly under the Department of Anaesthesiology and Critical Care and Department of Neurosurgery, Gauhati Medical College and Hospital (GMCH) from October 2012 to September 2013. For this prospective observational study 19 adult patients aged more than 18 years, admitted under the Neurosurgery Department, GMCH, having head injury (Glasgow coma score (GCS) < 12) of <12 h duration with no definitive/doubtful operable finding on baseline plain computed tomography (CT) head were enrolled into it, after obtaining written informed consent. Clinical and CT scan characteristics were analyzed from them. The patients, with unstable vital parameters having ventriculomegaly or coagulopathy, were excluded from this study. ICP monitors were installed aseptically using a sterile soft silicon catheter of 6 FG size as an intracranial catheter. Under all aseptic and antiseptic precautions, a frontal burr hole was made at Kocher's point (1-2 cm anterior to the coronal suture in mid-pupillary line or 11 cm posterior from the glabella and 3 cm lateral from midline). The catheter was placed subdurally and progressed anteriorly by approximately 3-4 cm. The external end of the catheter was tunneled under the scalp for 3-5 cm and was sutured to the skin. It was then connected to a central line central venous pressure (CVP) manometer (graduated from −4 cm to +34 cm and attached to a three-way tap), sterile saline was used as a coupling agent. Zeroing was done at the level of the external auditory meatus when the head was in neutral position and 30° elevated. ICP was marked by the movement of a latex rubber flash ball (red) in the manometer, on saline and at the same time the pulsatile movement of the ball was also observed. If the ICP was more than 20 cm of water for more than 5 min then intracranial hypertension was established. Intracranial hypertension was defined as any sustained increase in ICP of more than 20 cm H_2O for 5 min or more, with head elevated to 30° and neck in neutral position, provided vital parameters were stable and papillary light reflex was present (patients on mechanical ventilation included). Based on serial ICP recordings 2 hourly interval up to 72 h, patients were either grouped as high ICP (Group H) consisting of patients with ICP value of >20 cm of water and normal ICP (Group N) group comprising patients with ICP of <20 cm of water.

Cost of Consumables

Silicon catheter (INR 800), CVP manometer (INR 250), sterile saline (INR 15), nylon suture (Rs. 60). The total cost of consumables are INR 1125. We tried to perform the same using Fogarty catheter but high-cost factor (approximately USD 25) and availability remained a problem. Approximate cost of a standard intraparenchymal catheter is INR 15,000 in our place plus the high-cost of the monitor.

RESULTS AND OBSERVATIONS

A total of 19 patients were prospectively analyzed over the period of last 12-month duration. All the patients were male except one, a mean age was 36 and 34 years in Group H and N.

In Group H, 8 patients had effaced basal cisterns on CT. All 12 patients in this group were operated within 24 h of injury.

Compared to Group N, Group H showed significantly higher mean ICP in the first 24 h and all these 12 patients had to be operated within first 24 h of admission ($P = 0.0001$).

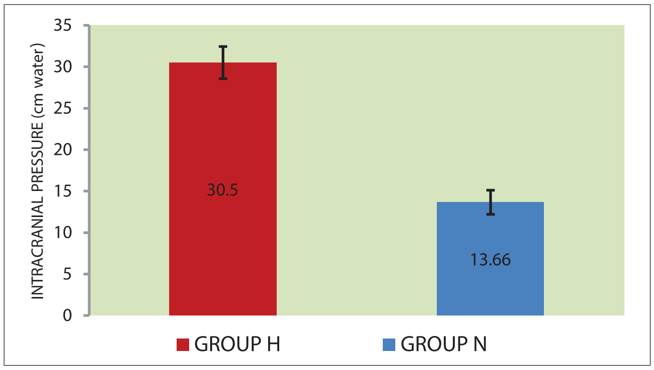
ICP monitoring in Group N and postoperatively in Group H revealed a higher mean ICP in Group H compared to Group N, but they were comparable ($P = 0.068$).

Two patients in Group N had delayed high ICP (after 24 h but within 72 h) and were also operated then. Rest of the patients Group N was managed conservatively and had an excellent recovery. Group H patients had good functional recovery at 6 months follow-up with a median GCS of 5 (range 4 - 6) in comparison to a median GCS of 6 (range 4-7) in the non-operated Group N. Procedural complications noted in Group H were blocked catheter in three patients, dampened tracing in two patients, infection and acute subdural hematoma in one patient each. A major limitation encountered in our study was inability to drain cerebrospinal fluid (CSF) and absence of ICP reading higher than 34 cm at manometer. (Table 1, Graphs 1 and 2, Figures 1 and 2)

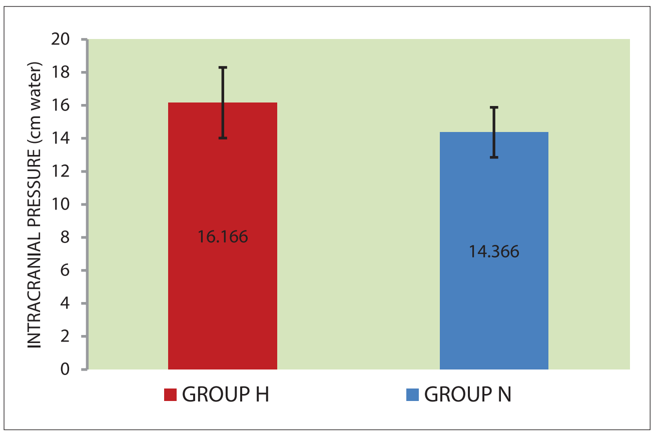
Table 1: Group characteristics

Parameters	Group H	Group N
Number of patients (%)	12 (64)	7 (36)
Age (years)	36±6	34±5
Weight (kg)	68.5±7.5	66.2±5.6
Sex (M/F)	12/1	7/0

In Group H, 8 patients had effaced basal cisterns on CT. All 12 patients in this group were operated within 24 h of injury. CT: Computed tomography



Graph 1: Mean ICP during first 24 h in group H and N



Graph 2: Mean ICP in next 48 h after craniotomy in Group H compared to Group N

Figure 1: Clinical photograph of a patient with subdural ICP monitoring catheter in situ

DISCUSSION

In our study, we found that the neurological outcome in follow-up at 6 months was comparable between the two groups. Moderately or severely head injury patients with initial abnormal CT findings, but that does not mandate operative intervention, are the ones that need the maximum attention as the ICP may be high on immediate recordings or there may be delayed rise in ICP with subsequent clinical deterioration, which can take away the benefits that early surgery could have given to such patients. Narayan *et al.*[12] have analyzed their experience with ICP monitoring in 207 patients over a 4-year period. Patients with either high-density or low-density lesions on CT at admission had a high incidence (53- 63%) of intracranial hypertension (ICP persistently over 20 mm Hg). In contrast, patients with normal CT scans at admission had a relatively low incidence of ICP elevation (13%). Gallbraith and Teasdale[13] found that traumatic intracranial hematomas in whom the surgeon was undecided about the need for surgery, indicates that all patients with ICP's above 30 mm Hg eventually deteriorated and required surgery. This rarely happened in those patients with an ICP below 20 mm Hg. Patients in the 20-30 mm Hg range were about evenly divided into two groups between the surgical and nonsurgical groups. This study exemplifies the value of ICP monitoring as an early-warning system that allows appropriate measures to be taken before actual neurological deterioration occurs. This and many other studies have shown the benefits of ICP monitoring in avoiding surgery when the initial CT scan was normal. High ICP may be a very early event after TBI, but in most cases, especially when contusions and edema develop over time, ICP will worsen over succeeding days. In our study, regular ICP monitoring helped diagnose delayed rise in intracranial hypertension in two patients who had normal ICP previously.

Stocchetti *et al.*[14] describes the incidence and severity of elevated ICP after TBI and attempts to document its time course. 201 TBI patients in whom ICP was monitored prospectively for more than 12 h were evaluated. ICP was measured, digitalized, and analyzed after manual filtering. The number of episodes of high ICP and the mean ICP value for every 12 h interval were calculated. When

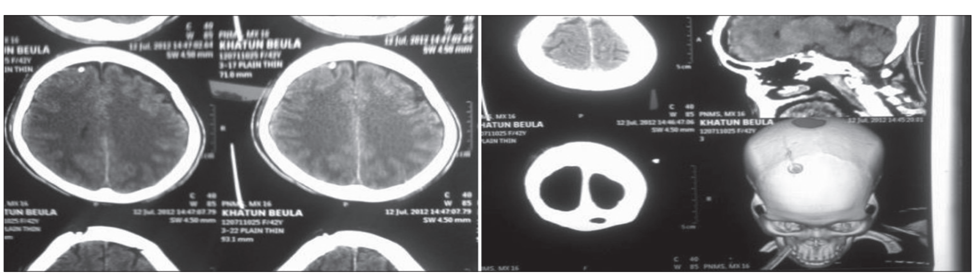


Figure 2: NCCT head of a patient with severe head injury with cerebral edema, point of frontal burr hole and tip of subdural catheter seen

monitoring was concluded, the highest mean ICP collected in every patient was identified. A total of 21,000 h of ICP monitoring were recorded. Active treatment to prevent or reduce high ICP was used in 200 patients. High ICP was documented in 155 cases. Half of the patients had their highest mean ICP during the first 3 days after injury, but many showed delayed ICP elevation, with 25% showing highest mean ICP after day 5. In these cases, high ICP was significantly worse and required more intense therapies. The question that this study raises is whether or not CT scanning can identify a group of patients who could just benefit from early surgery without going through initial ICP monitoring and thus preventing the delay that sometime occurs because of initial low ICP values. Initial post trauma ICP could only be measured maximally in our study population up to 24 h as patients having persistently raised ICP were operated within 24 h period. Potential limitations of our study include a small study population, non-randomisation of the study population. Major problems encountered in our study was inability to drain CSF in few patients and absence of ICP reading higher than 34 cm at manometer. Our study may not be applicable in all settings and in all populations.

CONCLUSIONS

Unconscious head injured patients with a normal looking CT head does not exclude raised ICP. Our indigenous and cheap ICP monitoring system is feasible, easy to use, and safe, provides adequate information for a diagnostic decision. It may be considered as an acceptable alternative to the costlier standard methods, especially in resource-constrained settings.

Implications

Based on neuro-critical care protocol, we have started to manage severely head injured patients based on CPP which is easily measured by calculating mean arterial pressure (arterial line needed) and subtracting ICP (after conversion to mm Hg).

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