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Complications of brain tissue pressure monitoring with a fiberoptic device

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Abstract

Seventy-five patients with intracranial hypertension whose Glasgow Coma Score (GCS) was 8 or below and in whom intracranial pressure (ICP) was monitored were examined for complications of this procedure. In 20 of the 75 patients we used only an intraparenchymal fiberoptic ICP monitoring transducer, while, in the remaining 55 patients, who required CSF drainage, a ventricular drainage set (VDS) was used in addition to ICP monitoring. The duration of monitoring with the ICP transducer alone was approximately 5.1 ± 2.6 das (min. 1, max. 13) and that of ICP monitoring with VDS was 6.2 ± 3.1 days (min. 1, max. 13). In 8 cases a total of 9 complications were experienced (12 %). These complications were infection in 3 cases (4 %), epidural hematoma in 2 cases (2.7 %), disconnection in 2 cases (2.7 %) and contusion in 2 cases (2.7 %). Although none of the 44 patients who were monitored for less than 5 days experienced infection, 3 of the 31 patients monitored for longer than 5 days did experience infection (9.7 %) ($p < 0.05$). None of the 20 patients who underwent ICP monitoring only experienced infection. However, 3 of the 55 patients in whom the ventricular drainage set was implanted in addition to the transducer for ICP monitoring experienced infection ($p < 0.05$).

Owing to its minimally invasive nature, low complication rate, and accuracy in monitoring the parenchyma pressure, the Camino fiberoptic intraparenchymal monitor has become the system of choice in our clinic.

Keywords: Complications, fiberoptic device, intracranial pressure monitoring.

1 Introduction

Effective treatment of intracranial hypertension by hyperventilation, osmotic agents and barbiturate therapy has been supported by the regular use of ICP monitoring in most neurosurgical centers [10, 17, 30, 34]. Judicious use of the data from ICP monitoring can save lives and alter the outcome in patients with severe head injuries [7, 17, 25, 27, 28].

An ideal system for measuring intracranial pressure should be accurate, free of risk to the patient, and simple to use [11, 16, 18, 28]. The intracranial pressure monitors currently in use include ventricular catheters, subarachnoid screws and bolts, various subdural and epidural monitors, and fiberoptic devices [9, 11, 13, 20, 22, 36, 31]. All these monitoring techniques have significant drawbacks. The risks are directly related to whether the system is opened or closed and to the extent of invasiveness of the system being used [20, 28]. The reported risks include infection, brain damage, occlusion, hemorrhages and disconnection [1, 11, 16, 23].

In this study, we reviewed the intraparenchymatous ICP monitoring system used in our intensive care units (ICU) between 1991 and 1995 with special reference to any complications.

2 Materials and methods

This study involves 75 patients who were admitted to the Department of Neurosurgery, University of Uludag, School of Medicine between 1991 and 1995. All the patients had GCS 8 or below. 20 of the patients were female and 55 were male. Their ages ranged from 2 to 82 years (mean age was 38.5). In 20 (26.6 %) of the cases ICP monitoring only was performed, and in 55 (73.4 %) a VDS for drainage, was

inserted in addition to ICP monitoring. Initially, all patients underwent ICP monitoring with a fiberoptic ICP device (Camino, San Diego, Calif.), and a VDS (Medtronic, Calif.) was implanted in patients with an initial ICP of over 20 mmHg.

The ICP monitor was applied under local anesthesia in the operating room. The transducer was introduced at a point 10 cm posterior to the glabella and 3 cm lateral to the midline on the left or right, depending on which hemisphere was more severely affected. The same point on the right or left frontal part was used for patients who required VDS application. None of the patients had their hair cut, but it was scrubbed gently for 8–10 minutes with povidon iodine solution at a concentration of 10 %. Then Bacitracin solution (50000 IU/500 cc) was used as a cleaning agent. CSF samples were obtained from all patients with VDS during the operation for insertion, for direct microscopy and for isolation of the agent. CSF samples were obtained from patients who had only ICP monitor by lumbar puncture, except in the case of patients with a high ICP intracranial mass effect. All patients were kept under observation in the ICU, and underwent cranial CT to check for early complications.

In cases with a GCS of 8 or below a standardized protocol was followed [5]. When ICP was below 20 mmHg the VDS was turned off. When it was above 20 mmHg, after revision of all parameters the VDS was turned on and drainage of CSF began and was maintained until the ICP fell below 20 mmHg. In some cases a few drops was enough to reduce the pressure.

Continuous CSF drainage was not performed in any of these cases. In the patients whose ICP could not be decreased but went on increasing despite all the medical agents (mannitol, furasemide), administered, cranial CT was performed. Whenever CT revealed any abnormality requiring surgery the patients underwent an operation. Otherwise, patients were given highly dosed barbiturate therapy.

In cases with an ICP below 20 mmHg for 24 hours, ICP monitoring was discontinued an the VDS was removed. At this point second samples were obtained for direct microscopy and culture during intraventricular catheter withdrawal. The distal portion of the ventricular catheter was sent for culture antibiogram. In all patients new ICP transducers and VDS were used.

3 Results

The reasons for monitor insertion are shown in Table I. Patients were followed by ICP monitoring for an average of 5.1 ± 2.6 days (min. 1, max. 13) and by VDS for an average of 6.2 ± 3.1 days (min. 1, max. 13). The average GCS score of patients was determined as 6.

Table I. Reasons for insertion of monitor

	Case	%
Intracerebral hematoma	23	31
Contusion	27	36
Subarachnoid hemorrhage	10	13
Epidural hemorrhage	8	11
Intracerebral hematoma	4	5
Hydrocephaly	2	3
Intracerebellar tumor	1	1
Total	75	100

Eight patients experienced complications. Details of these patients and the complications are shown in Table II.

Acinetobacter baumanii, Alcaligenes and Candida albicans were isolated in CSF cultures of 3 patients (4 %) diagnosed with meningitis. In cases where an infection developed the duration of monitoring was 9 days (5, 9, 13 days). These patients received appropriate antibiotics.

Control CT of the 4 patients in whom the ICP could not be reduced despite CSF drainage and mannitol revealed epidural hematoma below the penetreting point of the transducer in 2 and brain edema in 2. The 2 patients diagnosed with epidural hematoma underwent operations, and the other two were started on highly dosed barbiturate therapy.

None of the 44 (60 %) patients who were monitored for less than 5 days experienced infection. Three (9.7 %) of the 31 (40 %) patients who were monitored for 5 days or more did experience infection ($p < 0.05$).

Although none of the 20 patients who undergone ICP monitoring only experienced infection, 3 of the 55 patients who had ventricular drainage in addition to ICP monitoring developed infection ($p < 0.05$). In 2 cases where the transducer was disconnected during transportation a new transducer was used for replacement.

Table II. Complications and the data on patients effected

Case	M/F	Age	Primary Disease	GCS	Steroid usage	Type of monitor	Ventriculostomy	The duration	Complication	Micro-organism	Result
M.S.	M	35	Contusion	4	–	Intra-parenchymal	+	ICP 5 days VDS 5 days	Disconnection Infection	Alcaligenes	Relief
M.D.	F	33	Contusion	6	–	Intra-parenchymal	–	ICP 3 days VDS 5 days	Disconnection	–	Exitus
C.D.	M	65	Intracerebral hematoma	5	+	Intra-parenchymal	+ +	ICP 13 days VDS 13 days	Infection	Candida albicans	Exitus
E.K.	F	27	Intracerebellar tumor (postop.)	8	+	Intra-parenchymal	+	ICP 3 days VDS 9 days	Infection	Acinetobacter Baumanii	Relief
H.K.	F	8	Contusion	6	–	Intra-payrenchymal	+	ICP 3 days VDS 4 days	Contusion	–	Exitus
G.C.	F	24	Contusion	3	–	Intra-parenchymal	+	ICP 7 days VDS 7 days	Epidural hematoma	–	Exitus
M.K.	F	45	Contusion	5	–	Intra-parenchymal	+	ICP 5 days VDS 5 days	Epidural hematoma	–	Exitus
A.T.	M	72	Intracerebral hematoma	8	+	Intra-parenchymal	+	ICP 3 days VDS 4 days	Contusion	–	Relief

GCS = Glasgow Coma Scale; ICP = intracranial pressure; VDS = ventricular drainage

4 Discussion

Comatose head injury patients, patients with subarachnoid or intracranial hemorrhage, children with Reye's syndrome, surgical patients tending to brain edema or ventricular obstruction and patients being evaluated for occult hydrocephalus can all be considered reasonable candidates for ICP monitoring [1, 2, 7, 8, 11, 17, 23, 26]. In our clinic patients whose ICP was thought to be high were monitored regardless of the cause of their hypertension. ICP monitoring and aggressive medical management of elevated ICP may improve the morbidity and mortality rates of patients with severe head injury. Nevertheless, debate continues on the risk-to-benefit ratio and the cost effectiveness of these techniques [8, 11, 16, 20].

Though monitoring techniques have been developed in recent years, none of the methods currently in use for monitoring ICP is ideal, each having advantages and disadvantages [11, 22]. A fiberoptic ICP monitor has various advantages: it is solid state, is effective in the subdural intraparenchymal and intraventricular compartments, and is easily inserted. It also allows direct measurement of brain tissue pressure in patients with compressed or dislocated ventricles and can be disconnected for transport without losing its calibration [3, 11, 16, 22, 30].

This system has two disadvantages. First, it must be used along with ventriculostomy when CSF drainage is clinically required [8, 11, 16, 22]. In our study, ventricular drainage was performed in 55 patients who required CSF drainage in addition to ICP monitoring. The second disadvantage is that it cannot be recalibrated unless it is withdrawn [8, 11, 22].

Owing to its minimally invasive nature low complication rate and its accuracy in monitoring the parenchyma pressure, the fiberoptic intraparenchymal monitor has become the initial system of choice in our clinic [16]. With this system of monitoring the ICP values are highly reliable: a drift of up to 1–2 mmHg/day is reported in the literature, but this is considered not to have clinical significance. However, the reliability of ICP values can be assessed and discussed over a long period of use of the monitor [19]. For a short duration of monitoring the drift is relatively small, but by the 5th day the cumulative drift becomes significant. Based on this finding, it is concluded that the fiberoptic device should probably be replaced after approximately 5 days [8, 11, 16]. This may have the additional desirable effect of lowering the incidence of infection. In our patients we did not change any of the transducers except the two that had become disconnected, but we changed the VDS on the 5th day in patients who were dependent on the CSF drainage.

The most common complication in ICP monitoring is infection, which can include local skin infection, osteomyelitis, meningitis, ventriculitis, encephalitis, empyema, abscess or any combination of these disorders [1, 16, 27]. The infection rates have been reported in the literature as approximately 1.5–15 % [6, 16]. This rate increases up to 26 % with intraventricular catheters [1]. None of the 20 patients in whom ICP monitoring only was performed experienced infection.

In the experience of the Traumatic Coma Data Bank (TCDB), there was no significant increase in the risk of CSF infection attributable to monitoring accomplished with a Richmond bolt or Camino intraparenchymal monitor [16]. In our cases the infection rate was determined as 4 %.

The infection rate is found to be related to the type of the monitor, the duration of its use, steroid usage and the primary illness of the patient: intraventricular monitoring, monitoring for longer than 5 days, steroid usage, intracerebral hematoma, open depressed fractures and ventriculostomy all increase the infection rate [1, 4, 16, 18, 21, 23, 24, 27, 29]. The data on our three patients who experienced infection are shown in Table II. An ICP transducer was used with a VDS in these patients.

The literature is inconsistent about the length of time ventricular catheters can safely be left in place. Some authors state that ventricular catheters should be left in place as long as needed, while others state that they should be removed and a new catheter inserted after a given time [1, 4, 6, 12, 14, 16, 21, 22, 27, 32].

Infections were most commonly associated with staphylococci [1, 21, 24]. The other microorganisms include Acinetebacter baumanii, Alkaligenes and Candida albicans.

Prophylactic antibiotic usage is still controversial. Some of the authors advocate the prophylactic use of antibiotics, while others conclude that antibiotics have not significantly influenced the development of infection, or the type of organism likely to be recovered [1, 12, 16, 18, 21, 24, 27, 32]. However, all our patients were given prophylactic antibiotics during monitoring (third-generation cephalosporins 2 g/day).

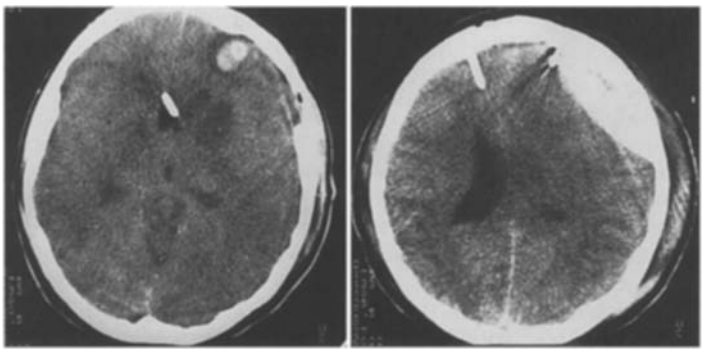

Figure 1. The epidural hematoma that occurred at the point of penetration by the transducer.
Figure 2. The contusion seen at the entry point of the transducer to the brain parenchyma.

When placing the transducer we prefer operation room conditions, although this is still controversial [21, 32].

The second complication is brain injury with hemorrhage. This occurs during penetration of the transducer into brain, because the tip of the transducer penetrates 12–14 mm into the brain [16, 30]. The incidence of hemorrhage is below 0.5 %. In 2 of our patients an epidural hematoma was observed at the transducer penetration point. The incidence of hemorrhage and brain injury that occurred during VDS placement in those of our patients who required CSF drainage was 1–6 % [16]. In 2 of our patients a contusion (Figure 1) was seen at the transducer penetration point (Figure 2). Brain injury is especially significant in intraventricular monitoring [30].

Theoretically, hemorrhage associated with ventricular catheters can be due to overdrainage with rupture of bridging vessels [16]. This hemorrhage seen in our patients occurred at the point of penetration by the transducer within 6 hours of placing the catheter. This suggested that the hemorrhage occured when the transducer penetrated the dura mater. Our findings at operation confirm this.

The third complication is disconnection. In the literature such complications are reported to be unimportant, and they can be prevented with trained staff and nursing [22, 27]. In 2 of our patients disconnection was observed. This complication occurred during nursing, not transportation. The transducers were replaced with new ones.

It is reported in the literature that the removal of hair by shaving does not lower the risk of surgical wound infection and may not increase the risk [15, 33]. In our clinic hair is not removed in any of the patients unless there is some special reason.

Finally, increased ICP should be managed in accordance with the values of ICP. It should always be kept in mind that none of the monitoring techniques are completely devoid of risk. Because of easy placement and low complication rate, we advise the intraparenchymal fiberoptic monitoring technique that we use routinely.

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