Comparison of Complications in Patients Receiving Different Types of Intracranial Pressure Monitoring: A Retrospective Study in a Single Center in Switzerland

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OBJECTIVE: Intracranial pressure (ICP) monitoring has become “state of the art” in the management protocol for unconscious or sedated patients with intracranial pathologies; however, all current monitoring systems have significant drawbacks. We analyzed the complications of these monitoring devices as well as the risk factors for those complications.

METHODS: We reviewed a total of 288 patients with ICP monitoring, i.e., 173 external ventricular drainage (EVD) and/or 123 intraparenchymatous catheters (IPCs). Placement of the IPC or EVD was performed by a standardized protocol according to fixed anatomical landmarks. Infections were diagnosed from positive cerebrospinal fluid cultures, positive devices cultures, and/or fever; hemorrhages were diagnosed by postprocedure computed tomography.

RESULTS: Sixteen patients (9.2%) with an EVD and 1 patient (0.8%) with an IPC system experienced an infection (P < 0.01). Factors associated with a greater risk for infections include subarachnoid hemorrhage (10 patients, 9.4%), intraventricular hemorrhage (7 patients, 8.6%), and concomitant catheters (6 patients, 3.5%). Mean monitoring time was 3.9 days (range 1–17 days), with the greatest incidence of infections between day 5 and 11. Intracerebral hemorrhage was seen in 2 patients with EVD and in 1 patient with IPC (P < 0.01). None of these patients needed surgical evacuation of the blood clot.

CONCLUSIONS: EVD is an indispensable device in neurosurgery. Unfortunately, it has a significantly high complication rate, mostly in relation to infections. Therefore, the indication of the device used to monitor ICP must be evaluated carefully. The antimicrobial-impregnated external catheter and silver-coated catheters might decrease the problem of infection.

INTRODUCTION

Intracranial pressure (ICP) monitoring has become “state of the art” in the treatment of traumatic brain injuries (TBIs), and it is part of the guidelines and management protocol for unconscious or sedated patients. It determines not only the need for treatment but also the efficacy and endpoints of ICP-decreasing strategies. ICP monitors currently in use include ventricular catheters and fiberoptic intraparenchymatous devices. Subarachnoid screws and bolts, in addition to various subdural and epidural devices, are used less frequently.

An ideal monitoring system for measuring ICP should be reliable and free of risks for the patient; however, the literature shows that all current ICP-monitoring techniques have significant drawbacks. The reported complications include infection, brain damage, hemorrhages, catheter occlusion, or disconnection and seem to be directly related to the extent of the invasiveness of the system. The most frequent reported complication in the literature is infection.

Putting aside all these complications, the different devices all have their own advantages. Intraventricular catheters not only allow the continuous monitoring of the ICP and dynamic changes that occur within the cranium, and therefore provide information...
on the intracranial compliance but, moreover, these devices also allow in a very simple way to lower ICP by just draining cerebrospinal fluid (CSF) in patients with intracranial hypertension, especially when caused by hydrocephalus. Furthermore, the intrathecal application of drugs through an intraventricular catheter becomes very simple. In contrast, intraparenchymatous catheters measure ICP continuously, are easy to insert, and may cause less brain damage because of their small size and minor invasiveness.

During the last year, changes have occurred in the management of head trauma patients in our intensive care unit, and the aim of our study is to analyze the complications of brain tissue—monitoring devices and intraventricular catheters as well as the risk factors related to those complications.

MATERIALS AND METHODS

In this retrospective study, we included a total of 288 patients admitted to the Centre Hospitalier Universitaire Vaudois intensive care unit and Neurosurgery Department from 2003 through 2008 who had undergone ICP monitoring (external ventricular drainage [EVD] or Intraparenchymatous catheter [IPC]). For this retrospective study, the patient’s data from our hospital electronic files, the laboratory studies, and the radiographic studies were reviewed. The cohort was divided according to the pathologies found on the head computed tomography (CT) scans or magnetic resonance imaging at admission. In our cohort, we found 180 TBIs and 108 cerebral vascular accidents. The reported TBI lesions were epidural hematoma, intraparenchymatous contusion/hematoma, diffuse axonal injury, acute subdural hematoma, subarachnoid hemorrhage (SAH), intraventricular hemorrhage (IVH), and diffuse edema. The cerebral vascular accidents included aneurysmal SAH, IVH, intracerebral hemorrhage, ischemic stroke, and cerebral veins thrombosis.

Monitoring devices were placed routinely in the operating room and sometimes as a bedside procedure in the intensive care unit. In our institution, the indication for ICP monitoring follows well-described standard guidelines. Classically, we use EVDs for patients with IVH, severe SAH with early hydrocephalus, intracerebral hemorrhage with signs of hydrocephalus, or in any case in which it is useful to drain CSF to reduce ICP. The IPCs remain the gold standard to easily monitor the ICP, especially in cases of severe TBI. In our department, we choose to insert intraparenchymal monitoring for patients with Glasgow Coma Scale ≤ 8, pathologic brain CT scan, and no indication to drain CSF.

Placement of the external catheter via ventriculostomy was performed by a standardized protocol, according to fixed anatomical landmarks: patients were placed in a supine position, the hair shaved, and their head elevated approximately 20°. Skin disinfection was performed according to the usual practice. The positioning of the burr hole was verified by anatomical landmarks, i.e., the Kocher’s point, situated about 13 cm posterior to the nasion just frontal of the coronal suture and approximately 3 cm lateral to the sagittal sinus. After we drilled the burr hole and coagulation of the dura, the dura itself was incised and a corticotomy with bipolar cautery was performed. The ventricular catheter then was inserted orthogonally to the brain parenchyma. The optimal endpoint was defined as the ipsilateral foramen of Monroe with a maximum insertion depth of 6 cm. The catheter was tunneled subcutaneously as far as possible from the skin incision and connected to an ICP monitoring and a gravity-dependent drainage system.

Monitoring device malpositioning and other intracranial lesions, like hemorrhage, attributable to the insertion of the monitoring device were defined on postprocedure CT scan. In every case, the malpositioning required the replacement of the device. In our study, infections (meningitis, ventriculitis) were diagnosed from positive CSF cultures, positive devices cultures, and fever. None of these patients suffered from previous infection before insertion of the monitoring. Suspicion of infection was based on fever, positive device cultures, but negative CSF cultures. There was no evidence of other sites of infection in this group.

The type of monitoring device used included 173 EVD and 123 intraparenchymatous monitors. Some patients benefited from more than one device during their hospitalization, and we take into account each one separately. In this study, concomitant catheters means that some of our patients had 2 or more catheters at the same time (i.e., 2 or more EVDS), and multiples catheters means that they received more than one catheter while they were in hospital but not at the same time (i.e., replacement of a malfunctioning catheter).

This retrospective study was approved by the Ethical Commission for clinical research of the faculty of biology and medicine and by the Medical Director of the Centre Hospitalier Universitaire Vaudois to have access to the patients’ files. The comparative analysis was performed using χ² test and Student t test. The level of statistical significance (2-sided) was set at P < 0.01.

RESULTS

Complications and ICP Monitoring

Taking the 173 EVDs of our study into account, a total of 24 complications were found (13.9%). These 24 complications included 16 infections (positive CSF cultures, fever, and positive monitor cultures, i.e., 62.5% of the reported complications with EVD). The remaining complications were 2 suspicous of infections (negative CSF cultures, fever, positive monitor tip cultures, i.e., 12.5% of the reported complications with EVD). Two patients (8.3%) suffered an intraparenchymatous hemorrhage attributable to the placement of the monitoring system, and 4 cases (16.7%) presented a malpositioning of the device.

In the group of the 123 IPCs, we found a complication rate of 2.4%. Only one patient suffered from an infection. Intracerebral hemorrhage attributable to the placement of the monitor was reported in 1 case, and 1 device was broken in the intensive care unit. The comparison between the complication rates of intraventricular monitoring systems with 24 complications compared with the intraparenchymatous device with 3 complications is statistically significant (P < 0.01) (Table 1).

Infections

The relation between infections and monitoring system showed that 16 patients (9.2%) with an EVD developed an infection, whereas only 1 patient (0.8%) with an intraparenchymatous monitoring system suffered from an infection (Table 2). This difference is also statistically significant, P < 0.01. The
microorganisms found in these 17 patients are summarized in Table 3.

### Risks Factors for Infections
In our cohort, we found some factors that seem to be associated with a greater risk for infections. Those factors include SAH, IVH, concomitant catheters, and/or multiple catheters. Ten patients with SAH (9.4%) and 7 patients with IVH (8.6%) developed an infection during their hospitalization. For this part of our study, we took the 19 patients with infections and suspicion of infections. Some of the patients had more than one of these factors, and we count each one separately. We also found 3 infections in the 6 patients with concomitant catheters (50%) and 3 infections associated with multiple catheters (14.3%) (Table 4).

### Relation Between Monitoring Duration and Infections
In our total of 296 ICP monitoring in 288 patients, the duration of monitoring ranged from 1 to 17 days (average of 3.9 days). The majority of the devices were present during the first 5 days. Among the 17 infected patients, we found an increased incidence of infections during the first 11 days. The greater incidence was found between days 5 and 11 of monitoring. (Figure 1 and Figure 2).

### Hemorrhage Attributable to Catheter Insertion
Another complication included an intracerebral hemorrhage resulting from the placement of the catheter. CT scan revealed bleeding of this kind after the insertion of the device in 2 patients with intraventricular monitoring and in 1 patient with an intraparenchymatous device (Table 5). There was no significance (P > 0.01) for this complication. None of these patients needed surgical evacuation of the blood clot.

### DISCUSSION

#### Complications and ICP Monitoring
In our study, we found a greater rate of complications with EVDs (13.9% EVDs; 2.4% IPC), and this difference between EVDs and IPCs is statistically significant. In our review of the literature, this observation also seems to be predominant.3,4 Our results show also that infections are, by far, the most represented complication, especially in the EVDs group. Two decades ago, Clark et al.5 showed some major infection-related complications such as infected bone flap, brain abscess, subdural empyema, ventriculitis, meningitis, and superficial wound infection. Others complications, such as hemorrhages, monitor failures, and malpositioning of the device, were less prevalent. Technical complications are the second most-reported complication.4

#### ICP Monitoring and Infections
The difference that we observe between the infection rate with EVDs (9.2%) and the one with IPC (0.8%) is statistically significant and confirms the dominant trend found in our review of the literature that EVDs are more subject to infections. The incidence of external ventricular drainage-related infections in most studies...
is reported within a range of 0%—27%. Our rate of infections (9.2%) coincided with this range.

Lozier et al. found in 288 extraventricular drains with CSF infection that the most common microorganism was coagulase-negative staphylococcus followed by Staphylococcus aureus and Klebsiella. Acinetobacter represents the fourth most common infecting organism. Some others studies reported the same conclusions about the microorganism being involved in CSF infections. In our retrospective study, we also found coagulase-negative staphylococcus to be the most frequent microorganism.

Risk Factors and Infections

Lozier et al. reviewed several studies published from 1941 through 2001 to determine the risk factors for ventriculostomy-related infections. They found that the major risk factors were as follows: the presence of IVH on admission, SAH, or cranial fracture with CSF leak. Moreover, they noted that craniotomy, ventriculostomy irrigation, concomitant systemic infections, and duration of catheterization are further risk factors for infections. Some others risks factors, e.g., corticosteroids, multiple catheters, and tumor, remain very controversial. In our retrospective study, we also found coagulase-negative staphylococcus to be the most frequent microorganism.

Relation Between Monitoring Duration and Infections

Kanter et al. show that the percentage of monitoring devices that subsequently became infected tended to decrease after day 6, remaining at 0 after day 11. This decrease in the infection rate over time suggests that infection is introduced at the time of monitor insertion. In conclusion, they proposed to use a single ICP monitoring as long as necessary, with reinserter of a new monitor only if a malfunction occurs or if daily surveillance cultures demonstrate an infection. Holloway et al. and more recently Lo et al. arrived at the same conclusion with an increased risk of infection over the first 10 days. In their results, the authors reported that patients in whom catheters were replaced before 5 days did not have a lower infection rate than those in whom catheters were exchanged at more than 5-day intervals.

The majority of our devices are used during the first 5 days, and we observed an increased risk of infections after the fifth day. Compared with the number of monitors used, the infection rate seems to correlate with the duration of monitoring, but we have to temperate this finding by the small number of infected monitors.

Hemorrhage Caused by Catheter Insertion

The risk of hemorrhage by EVDs generally is reported between 2% and 19%. Gardner et al. reported that 19.7% of EVDs were associated with larger hemorrhages and concluded that EVDs have a significant risk of associated hemorrhage. Anderson et al. looked at complications in children with head trauma. They found a hemorrhage rate of 17.6% with EVDs and 6.5% with fiberoptic intraparenchymal device. In our study, the risk of hemorrhage is lower than in these studies (1.2% EVDs and 0.8% IPCs). The difference between EVDs and IPCs is not statistically significant and we cannot agree with these observations.

Current Management of ICP Monitoring

The antimicrobial—impregnated external catheter (BACTISEAL; Codman Neuro, a division of DePuy Synthes, Raynham,
Massachusetts, USA) is one of a new kind of monitoring device that uses the combination of clindamycin and rifampicin to protect against coagulase negative staphylococci. The recent systematic review and meta-analysis of the literature show that the use of antimicrobial-impregnated EVD catheters seems to be related with a lower rate of infections and could be beneficial for the prevention of CSF infection.27-29

Soleman et al.25 report that there seems to be no benefit in using antibiotics-impregnated catheters in the treatment of intracranial ventriculitis and support only their prophylactic use. In their comparison between antibiotic-impregnated and standard extraventricular drainage devices, Pople et al.26 found no significant difference in the number of infections in these groups and that the duration of time to suspected infection was prolonged. The cost-effectiveness of this new type of devices is also a legitimate question after their emergence. Edwards et al.27 in their cost-consequence analysis of antibiotic-impregnated shunts and EVDs, show that the use of these devices can reduce mortality, hospital stay and costs, principally as the result of decreased infections.

Recently, the silver-impregnated catheters also seem to be very encouraging in the prevention of EVDs-related infections.30-32 The comparison between antibiotic-impregnated versus silver-coated EVDs is a hot topic in the recent literature, and a significant difference in the infection rates between the 2 devices has now been shown. Compared with the antibiotic-impregnated catheters, the silver-coated EVD is in fact the only one that showed Class I evidence of decreasing CSF infection.29

CONCLUSIONS

According to our study, the infections are certainly the major complication for ICP monitoring and they seem to be well correlated with the use of EVDs and the presence of some factors such as SAH, IVH, multiple catheters, and concomitant monitors. In our study, the duration of monitoring plays a role in the apparition of infections with an increase after 5 days of drainage. A good indication for ICP monitoring seems to be the first step in the good care of head trauma patients.31 The occurrence of some complications remains, unfortunately, unpredictable. It is the duty of the medical staff to observe patients clinically, looking for signs of infections and instigating specific treatment as quickly as possible to minimize the risk of mortality. It is also clear and well-known that a good and standardized intraoperative protocol is the most efficient prevention of postoperative infections.22-25 The increase of new ICP monitoring devices such as antimicrobial-impregnated catheters or silver-impregnated catheters seems to be effective in reducing infections, but remain controversial.

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REFERENCES


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