Management of severe intraoperative hemorrhage during intraventricular neuroendoscopic procedures: the dry field technique

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OBJECTIVE The unexpected intraoperative intraventricular hemorrhage is a rare but feared and life-threatening complication in neuroendoscopic procedures because of loss of endoscopic vision. The authors present their experience with the so-called “dry field technique” (DFT) for the management of intraventricular hemorrhages during purely endoscopic procedures. This technique requires the aspiration of the entire intraventricular CSF to achieve clear visualization of the bleeding source.

METHODS More than 500 neuroendoscopic intraventricular procedures were retrospectively analyzed over the last 24 years for documented severe hemorrhages, which were treated by the application of the DFT.

RESULTS The technique was required in 6 cases, including tumor resection/biopsy, cyst resection, and intraventricular lavage. Additionally, the technique was applied as part of the planned strategy in 3 cases of endoscopic tumor removal. The hemorrhage was stopped in all cases and no associated postoperative deficits occurred.

CONCLUSIONS Although severe hemorrhages are rare, the neurosurgeon needs to be aware of them and has to establish strategies for their management. Most hemorrhages can be stopped by constant irrigation and coagulation. In the other rare cases, the DFT is a safe, reliable technique and can be easily incorporated into endoscopic surgery.

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KEYWORDS neuroendoscopy; dry field technique; intraventricular hemorrhage; complication management; surgical technique
traventricular procedures from the Department of Neu-

The authors retrospectively analyzed their database to share

The analysis of more than 500 neuroendoscopic intra-


tive bleeding source. The hemorrhage should now stop af-

EROSION OF THE FORAMEN OF MONROUS

Mortiz Arndt University, in Greifswald, Germany, between January 1993 and March 2003; from the Department of Neurosurgery, Hannover Nordstadt Hospital, in Hanover, Germany, between April 2003 and September 2008; from the Department of Neurosurgery, Johannes Gutenberg University, in Mainz, Germany, between October 2008 and November 2010; and finally, from the Department of Neurosurgery, Saarland Medical School, in Homburg, Germany, between December 2010 and March 2018.

Records were examined retrospectively for severe bleeding events in which the DFT was applied. Those procedures included third ventriculostomy, tumor biopsy/resection, cyst fenestration/resection, aqueductoplasty, aqueductal stenting, septostomy, hematoma clot removal, and catheter removal/placement. The procedures were mainly performed with the GAAB I and later with the GAAB II neuroendoscopy set (Karl Storz Co.).

In the experience of the authors, neuroendoscopists have to be aware of potential hemorrhage during biopsy or fenestration procedures. The risk might be lower when the specific region is coagulated beforehand. Nonetheless, a small amount of hemorrhage may occur during the tissue penetration. This may not cause impaired vision and can be flushed out by short irrigation. The authors recommend lactated Ringer’s solution at 36°–37°C over saline to reduce the risk of postoperative feverlike episodes. The surgeon has to provide a sufficient outflow of the irrigation fluid to avoid life-threatening intracranial pressure (ICP) increase. Prolonged hemorrhage caused by smaller blood vessels can be stopped by patient irrigation and optional coagulation. The potential thermal damage to adjacent tissue has to be considered.

The DFT

However, if the hemorrhage cannot be controlled by these methods, the DFT should be considered. The steps of the DFT are as follows. First, a transparent sucking device—for example, a pediatric suction device provided by the anesthesiologists—is introduced in the working channel and the complete CSF is carefully aspirated. In the next step, the trocar is carefully placed over the presump-

TABLE 1. Summary of all patients with unexpected severe intraventricular hemorrhage during intraventricular neuroendoscopic procedures

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Pathology</th>
<th>Initial Symptoms</th>
<th>Surgical Procedure</th>
<th>Outcome</th>
<th>Add’l Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62, F</td>
<td>Hemangioma of side ventricle</td>
<td>Organic mental disorder</td>
<td>Tumor resection</td>
<td>Symptom free</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>60, F</td>
<td>Intraventricular hemorrhage</td>
<td>Comatose</td>
<td>Clot removal, ventricular lavage</td>
<td>Unchanged</td>
<td>EVD</td>
</tr>
<tr>
<td>3</td>
<td>61, M</td>
<td>Colloid cyst</td>
<td>Headache, memory disturbance</td>
<td>Cyst resection, septostomy</td>
<td>Symptom free</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>48, M</td>
<td>Plexus papilloma of 3rd ventricle</td>
<td>Seizure</td>
<td>Tumor resection</td>
<td>Symptom free</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>48, F</td>
<td>Glioblastoma of thalamus</td>
<td>Hydrocephalus, memory disturbance</td>
<td>Tumor biopsy, ETV</td>
<td>Improved</td>
<td>VP shunt after 1 mo</td>
</tr>
<tr>
<td>6</td>
<td>56, M</td>
<td>Colloid cyst</td>
<td>Headache, depression</td>
<td>Cyst resection</td>
<td>Improved</td>
<td>EVD</td>
</tr>
</tbody>
</table>

Add’l = additional; ETV = endoscopic third ventriculostomy; EVD = external ventricular drain; VP = ventriculoperitoneal.

The analysis of more than 500 neuroendoscopic intraventricular procedures revealed only 6 cases with extensive hemorrhage that could not be managed by constant irrigation and coagulation, hence the DFT was applied. The average duration of irrigation was approximately 12 minutes, with up to 34 minutes in the case of a colloid cyst. Pathologies and procedures are summarized in Table 1. Tumor resection or biopsy was scheduled in 3 cases and achieved after the unexpected severe hemorrhage was controlled by the DFT. The patient suffering from a glioblastoma required an additional shunt procedure after 1 month due to the blockade of the foramen of Monro and died in the following months. The patient with an intraventricular hemorrhage remained comatose. The 2 patients suffering from a colloid cyst improved and showed no signs of cyst recurrence in the follow-up. No hemorrhage-associated transient or permanent deficits occurred. During the application of the DFT no collapse of the ventricles was noted. No complications associated with postoperative pneumocephalus were observed. An example of the DFT and postoperative CT scans is demonstrated in Fig. 1.
The DFT was also applied in 3 cases of tumor resection as part of the preoperative strategy. As a high vascularization was expected, the DFT was applied to support intraoperative hemostasis. In one case of astrocytoma at the wall of the frontal horn, the patient was positioned to have the tumor at the highest point. CSF was partially aspirated, so the biopsy could be performed under clear vision (Fig. 2). Another patient suffered from a subependymoma, and in this case the CSF was aspirated to achieve complete tumor resection using an ultrasound aspirator (Soering Co.) under clear vision. In both cases the postoperative course was uneventful (Fig. 3). A third patient suffered from hydrocephalic symptoms. The MRI showed a tumor at the left basal ganglia occluding the foramen of Monro. The exophytic part of the tumor was resected using the DFT due to high vascularization (Video 1).

**FIG. 1.** Case 6. Example of intraoperative hemorrhage management. The patient, pretreated with a shunt, was scheduled for an endoscopic resection of a colloid cyst (A and B). After cyst fenestration, the mucoid part was aspirated (C and D). After removal of the cyst walls, an intraoperative hemorrhage occurred during the last steps of cyst wall resection (E and F). As the hemorrhage was persistent under constant irrigation after more than 30 minutes, the CSF was completely aspirated and hemostasis was achieved using the DFT (G–I). Final inspection and postoperative CT scans obtained 24 and 72 hours after surgery (J–L) showing complete hemostasis. Figure is available in color online only.

The histopathological analysis revealed a meningioma. The patient recovered and showed only partial facial nerve palsy after 3 months’ follow-up.

**Discussion**

There are several reports about the management of intraoperative hemorrhage during neuroendoscopic procedures. It is common sense that there is a stepwise escalation of the bleeding management: first irrigation, then cauterization, and lastly, more invasive methods are recommended. The most common recommendation is the conversion to a microsurgical approach. This conversion is most commonly performed by extending the craniotomy, opening the dura, and following the trajectory of the endoscopic approach with the help of retractors. The aspiration of the intraventricular CSF is also necessary. This surgical technique might be the easiest to be adopted. However, some limitations have to be considered. Visualization of the surgical field through the microscope might be limited and the origin of the hemorrhage may not be visualized. Therefore, more invasive retraction might be necessary and causes additional damage to the brain tissue. The minimally invasive as-
pect of the endoscopic approach is abandoned with this technique.

Additional strategies have been developed. Cappabianca et al. applied a small cotton pad through the working sheet and forced it into a position as a tamponade under endoscopic view. After a short period of pressure, hemostasis should be achieved.

Special tools were developed to manage the hemorrhage endoscopically. Nagasaka et al. introduced a multifunctional suction cannula (Fujita Medical Instruments) and the “balanced irrigation, suction, coagulation technique.” Nishihara et al. developed a transparent working sheath for the evacuation of intraventricular and intracerebral hematoma. Such a working sheath is considered helpful when the bleeding source originates along the approach and is usually covered by the working sheath.

Another minimally invasive technique for hemorrhage management is the so-called “small-chamber irrigation technique.” In short, the endoscope is withdrawn 0.5–1 cm into the endoscope sheath under constant irrigation and placed over the bleeding zone. This creates a small chamber in which the hemorrhage can be stopped by irrigation or coagulation. Of course, the surgeon has to resist the temptation to withdraw the endoscope and has to be confident with the intraventricular navigation, even under impaired vision.

The presented DFT may raise some concerns about potential side effects. A collapse of the ventricle systems has thus far not been observed. This is a limited cases series of only 9 patients, although a ventricle collapse is a rather rare observation in neuroendoscopic procedures. Furthermore, potential postoperative subdural hematoma was not observed in our case series. Feverlike symptoms are not unusual after intraventricular endoscopic procedures and might occur more often after extended irrigation. However, these symptoms show spontaneous relief after a few days. A similar report about the application of the DFT in a case series of 5 pediatric and 2 adult patients did not find any technique-related complications.

Conclusions

Severe hemorrhages are rather rare complications, and every neurosurgeon has developed his or her own strategies to manage them. That is why we want to share our experience with the neurosurgical community and offer alternative, purely endoscopic strategies to the more invasive conversion to microsurgical approaches. We believe that the DFT is a quick and safe method for bleeding management, even for less experienced neuroendoscopists. Overall, it does not require changing the instruments, and provides a broad overview of the anatomical structures and thereby orientation within the ventricular system. It can also be considered for endoscopic tumor resection from the beginning, when the tumor appears to be highly vascularized and bleedings are strongly suspected.

References

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Disclosures
Joachim Oertel and Henry Schroeder are consultants for Karl Storz Company.

Author Contributions
Conception and design: Oertel, Schroeder, Senger. Acquisition of data: Oertel, Csokonay, Schroeder, Senger. Analysis and interpretation of data: Oertel, Senger. Drafting the article: Oertel, Linsler, Csokonay, Senger. Critical revising the article: Oertel, Linsler, Schroeder, Senger. Reviewed submitted version of manuscript: Oertel, Linsler, Schroeder, Senger. Approved the final version of the manuscript on behalf of all authors: Oertel. Study supervision: Oertel

Supplemental Information
Videos

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