The Small-Chamber Irrigation Technique (SCIT): A Simple Maneuver for Managing Intraoperative Hemorrhage During Endoscopic Intraventricular Surgery

BACKGROUND: Acute intraoperative intraventricular hemorrhage is a feared event in endoscopic neurosurgical procedures.

OBJECTIVE: To describe the small-chamber irrigation technique (SCIT) for intraoperative endoscopic management of intraventricular hemorrhage.

METHODS: The SCIT was used in intraventricular surgery for hydrocephalus, intraventricular tumors requiring biopsy, arachnoid cysts, and colloid cysts.

RESULTS: Intraventricular hemorrhage was successfully managed endoscopically with a combination of the SCIT, routine irrigation, and coagulation, allowing for completion of the primary procedures.

CONCLUSION: The SCIT is a powerful tool that the neuroendoscopist can use for visualization to achieve hemostasis when performing intraventricular endoscopic surgery.

KEY WORDS: Endoscopy, Intraoperative hemorrhage, Intraventricular, Irrigation, Management

Endoscopic surgery and endoscope-assisted microsurgery are part of the management paradigm for many neurosurgical diseases. Pure neuroendoscopic approaches are predominantly used in the treatment of intraventricular and intracystal pathologies, as well as in transnasal approaches to the cranial base. The majority of endoscopic intraventricular surgery is performed for cerebrospinal fluid (CSF) diversion, but is also frequently used for colloid cyst resection, tumor biopsy, and arachnoid cyst treatment.

Improved technology has given the neuroendoscopist an additional margin of confidence by means of improved visualization: preoperative 1.5-T and 3-T magnetic resonance imaging with constructive interference in steady state/fast imaging using steady-state acquisition sequences, high-definition cameras (2 million pixels), and coupling of navigation to the endoscope system. During the development of these technologies over the past 20 years, multiple large series have reported on complications associated with endoscopic neurosurgery.1-8 Intraoperative hemorrhage is likely the neuroendoscopist’s greatest fear and has been reported in less than 3% of endoscopic intraventricular procedures.2,4,7 Despite the technological advances in visualization, intraoperative intraventricular hemorrhage with ventricular “red-out” remains a daunting entity for the neuroendoscopist.

Intraventricular hemorrhage can complicate an endoscopic procedure in multiple ways. (1) Hemorrhage can be life-threatening in the intraoperative and postoperative periods. (2) The intraventricular blood creates a red-out in which further surgical maneuvers must be halted to prevent inadvertent injury to sensitive neurovascular structures. (3) Blood products that remain within the ventricle can theoretically lead to an increased risk of hydrocephalus development, if not preexistent.9,10 (4) Intraventricular blood usually necessitates placement of an external ventricular drain. (5) Prolonged...
irrigation, used to clear hemorrhage, can extend the length of the case and is associated with electrolyte abnormalities.\textsuperscript{11,12}

Clearly, improved surgical methods and technologies are needed to enable the neuroendoscopist to aptly manage intraventricular hemorrhage. We present an endoscopic method as an option to solve this problem.

**SMALL-CHAMBER IRRIGATION TECHNIQUE**

The small-chamber irrigation technique (SCIT) is a simple maneuver that assists the neuroendoscopist in localizing and treating intraoperative intraventricular hemorrhage. In the setting of red-out, visualization depends on 2 factors: dilution and egress. Larger volumes of CSF and higher red blood cell concentrations require increasing amounts of irrigation to obtain adequate visualization within the ventricle. Dilution is obtained by injecting warm lactated Ringer’s solution in the ventricle through the ports of the endoscope or by removing the endoscope and irrigating directly through the sheath. Neuroendoscopists should be aware that the sheath should be at least 2 French larger than the diameter of the endoscope to allow adequate outflow of irrigant, if the endoscope does not have an irrigation outflow channel. Dilution is of no value unless the bloody CSF is allowed egress through the irrigation outflow channel or the sheath. This process allows for eventual clearance of blood from the ventricular system. Unfortunately, this maneuver will not be successful until bleeding is stopped at the source. In and of itself, irrigation provides no hemostatic effect, but does provide slight visualization as the platelet and clotting cascade proceed in an underwater environment, eventually stopping the hemorrhage. The limiting factor in rapidly correcting intraoperative intraventricular hemorrhage is visualization of the bleeding source.

The volume of a nonpathological lateral ventricle is 15 mL, the third ventricle is 1.3 mL, and the fourth ventricle is 1.4 mL based on computed tomography imaging.\textsuperscript{13} The experienced neuroendoscopist
will note that clearance of bloody CSF from the lateral ventricle can be futile, whereas clearance of the third ventricle is quick and simple due to the small volume within the third ventricle. To localize and treat hemorrhage at its source in the underwater environment of the ventricular system, one must recreate the same effect seen in irrigation of the third ventricle by artificial creation of a “small chamber.”

The steps of the SCIT follow (see Video, Supplemental Digital Content, http://links.lww.com/NEU/A653).

1. When hemorrhage is noted, do not move the endoscope, but hold in position until the assistant begins irrigation (Figures 1A and 1B and 2).
2. Use slow, controlled movements to approach the ventricular wall with the endoscope system (sheath and endoscope together) using generous irrigation. When the endoscope system nears the ventricular wall, light will reflect off of the white brain structures, indicating proximity (Figure 1C).
3. After proximity is achieved, gently withdraw the endoscope 0.5 to 1 cm into the endoscope sheath and maintain this relationship. This creates the “small chamber” (Figures 1D and 3).
4. As the sheath becomes nearly flush with the ventricular surface, the effective volume of CSF requiring clearance of hemorrhage is minimized to 0.2 to 0.4 mL, representing the volume of CSF within the sheath distal to the endoscope irrigation port. This establishes a clear local view of the intraventricular anatomy in the setting of global red-out (Figures 1E and 4). Note: This may be difficult with free-floating vessels, eg, septal vein injury in the setting of chronic hydrocephalus.
5. Carefully navigate the small chamber toward the suspected bleeding site until found.
6. Place an endoscopic hemostasis tool within the working channel (Figure 1E).
7. After determining the bleeding source, decide the best course of action to stop bleeding under direct visualization with the endoscope.
8. Once the bleeding has ceased, based on direct visualization, copious irrigation can be used to clear the remaining red-out from the ventricular system.
9. The planned procedure can then be pursued or aborted in the setting of known hemostasis.

In our experience, this technique has been performed using an endoscope system with an integrated sheath (LOTTA Neuroendoscopy System; Karl Storz GmbH & Co KG, Tüttlingen, Germany). The SCIT can also be performed with a Peel-Away Sheath (Cook Medical Inc, Bloomington, Indiana). In this setting, the sheath is peeled to approximately 10 cm and is not fixed to the skin, allowing for proper dynamic use of the sheath throughout the procedure and if a small chamber is needed. However, in our opinion, a rigid endoscopic sheath can be more easily and more accurately navigated under hemorrhagic conditions.

We used this technique in both adult and pediatric patients for a variety of pathologies at a single academic center in Germany.
One case of arterial hemorrhage occurred while treating an arachnoid cyst (see Video, Supplemental Digital Content, http://links.lww.com/NEU/A653) and 1 major venous hemorrhage occurred while resecting a colloid cyst. Most indications for the SCIT, however, are hemorrhages occurring from tumor feeders while performing tumor biopsies or resections. Coagulation was not necessary in all cases; irrigation under direct visualization using the SCIT was often adequate. In cases of moderate intraventricular bleeding, commonly occurring during endoscopic biopsies, the SCIT was very helpful because the tip of the sheath could be inserted just over the bleeding source, preventing further filling of the ventricles with blood. This technique was used safely in all patients, causing no subependymal damage or damage to deep parenchyma as seen on postoperative imaging. None of the cases in which the SCIT was used to treat intraoperative intraventricular hemorrhage were aborted. Use of external ventricular drains is minimized with this technique because there is minimal risk of continued intraventricular hemorrhage because it is stopped at the source, and all bloody CSF is then replaced with clean irrigation. Our experience with the SCIT has proved it to be an enabling tool in treating intraventricular bleeding during endoscopic procedures.

There are very few published methods of managing arterial or venous intraventricular bleeding during endoscopy. Nagasaka et al. described a technique for hemostasis during endoscopic evacuation of spontaneous intracerebral hemorrhage with the “balanced irrigation, suction, coagulation technique” that requires the Nagasaka multifunctional suction cannula (Fujita Medical Instruments, Tokyo, Japan). Nishihara et al. introduced a transparent sheath for endoscopic neurosurgery and described its application in endoscopic evacuation of intraventricular and intracerebral hematomas. A transparent sheath is likely most valuable in identifying subependymal or intraparenchymal bleeding sources found along the sheath track. Hopf et al., among others, have reported use of the classic teaching of irrigation and time for the management of arterial and venous hemorrhage. Irrigation is the most commonly reported method for hemorrhage management and is usually followed by placement of an external ventricular drain. One case of basilar tip injury during endoscopic third ventriculostomy was managed by leaving the sheath parked within the third ventricle to allow direct egress of hemorrhage, preventing clot formation and increased intracranial pressure. Irrigation and thrombin were injected directly through the sheath to achieve hemostasis (personal communication, Carolyn Carey, MD, 2012). The subsequent pseudoaneurysm was managed endovascularly with good neurological outcome for the child.

A complete literature review regarding the hemorrhagic complications of intraventricular endoscopy has never been performed.

CONCLUSION

Intraoperative hemorrhage is a challenging event during neuro-endoscopic surgery and can be managed in various ways depending on the etiology. The literature provides sparse discussion of techniques, other than irrigation, used by neuroendoscopists to manage hemorrhage. We believe the endoscope to be an immensely valuable tool in neurosurgery, and fear of hemorrhagic complication need not hinder the neurosurgeon in recommending endoscopic treatment. The SCIT is a useful tool for the neuroendoscopist as a means of localizing and treating bleeding as well as visualizing bleeding cessation.

Disclosure

Dr Schroeder is a consultant for Karl Storz GmBH. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

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COMMENTS

The authors clearly and concisely describe a novel, simple technique for the efficient management of hemorrhage during intraventricular neuroendoscopic procedures, a common occurrence that is often difficult to treat efficiently and may lead to aborting the procedure before the goals of surgery are achieved. They successfully used the SCIT to rapidly achieve hemostasis after arterial and venous hemorrhage complicating a wide range of endoscopic procedures, including intraventricular tumor biopsy and resection, as well as arachnoid cyst fenestration. In a relatively small series (12 patients), the authors were able to complete the surgical procedure in all cases without parenchymal injury, and external CSF diversion was rarely required. This is a very promising technique and a welcome new tool available to the neuroendoscopist’s when dealing with intraventricular hemorrhage.

Robert J. Bollo  
Salt Lake City, Utah

The authors report a technique called small-chamber irrigation technique that is used for controlling intraoperative hemorrhage during endoscopic intraventricular surgery. This technique requires the endoscopist to resist the temptation to withdraw the endoscope and create a small chamber to visualize the relevant ventricular anatomy and navigate toward the bleeding source to achieve hemostasis. As hemorrhage is a major concern for any endoscopic surgery, additional strategies to obtain hemostasis are a welcome addition to the surgeon’s armamentum.

Ian M. Heger  
Augusta, Georgia

The paper nicely illustrates a straightforward technique to find and manage the bleeding source in the setting of intraventricular hemorrhage during endoscopic procedures. The video is particularly helpful. I personally plan to try this technique the next time I encounter this situation.

David I. Sandberg  
Houston, Texas