HHS Public Access
Author manuscript
World Neurosurg. Author manuscript; available in PMC 2017 June 06.

Published in final edited form as:
World Neurosurg. 2016 June ; 90: 619–620. doi:10.1016/j.wneu.2015.12.010.

Neuroendoscopy for Intraventricular Tumor Resection

Brandon G. Rocque, MD, MS
University of Alabama at Birmingham, Birmingham, AL 35233

In recent decades, the endoscope has become an increasingly important tool in the armamentarium of the neurosurgeon. In pediatrics in particular, intraventricular endoscopy has become a routine part of neurosurgical practice and training. Improvements in image quality, ergonomics of endoscope use, neuronavigation, and a host of other technical factors have contributed to an ever-expanding range of indications for endoscopic treatment of intraventricular pathology. In addition, based in part of the remarkable success of ETV/CPC in treating hydrocephalus in Uganda, North American centers are beginning to expand the use of endoscopic treatment for hydrocephalus as well.[1] The natural consequence of these developments is increasing familiarity of pediatric neurosurgeons with endoscope use and increasing comfort in using the endoscope for more complex undertakings, particularly the resection of intraventricular tumors. However, there are several important factors that must be considered to maximize the chances of successful intraventricular neuroendoscopy.

As with any neurosurgical procedure, patient selection is crucial. The surgeon should pay careful attention to the site of attachment of the tumor to the surrounding structures. Approach and trajectory should be planned such that the surgeon will have good visualization of the interface of tumor with ependyma. For example, subependymal giant cell astrocytomas (SEGA) typically arise from the lateral wall of the lateral ventricle near the level of the intraventricular foramen. Therefore, the optimal approach to a SEGA is often to access the ipsilateral ventricle in the body or frontal horn, directing the scope towards the interface. On the other hand, a tumor based on the lateral wall of the third ventricle may best be approached by accessing the contralateral frontal horn, navigating through the contralateral intraventricular foramen, and thus having a direct view of the lateral third ventricle and tumor.

The surgeon should consider the size of the tumor and the extent of attachment to the surrounding structures. Previous authors have suggested a maximum tumor size for endoscopic resection.[2] However, endoscopic resection of a large tumor with small attachment to the ependyma may as feasible as a small sessile tumor. The size of the ventricles is another important consideration. Traditionally, ventriculomegaly has been considered a prerequisite for endoscopic lesion removal. However, what is likely more important is the size of the ventricles relative to the size of the lesion. Successful endoscopic tumor surgery has been demonstrated in patients with small ventricles.[3] As long as there is sufficient intraventricular space to navigate around the tumor and to view and manipulate the

Correspondence to: Brandon G. Rocque.

tumor from necessary angles, endoscopic tumor surgery can be performed in patients with small ventricles as well as large.

Neuronavigation can be very helpful in establishing a surgical plan for endoscopic tumor resection. Careful preoperative planning is necessary to assure access to the tumor and the tumor/brain interface while protecting critical neural structures. For example, a trajectory to a third ventricle lesion must consider both the position of the lesion and access into the third ventricle through the intraventricular foramen without damage to the fornix. Neuronavigation can be used to plan precise trajectories and guide burr hole placement to assure that the planned trajectory is achievable. This can be of particular importance when targeting lesions in the atrium, posterior, or temporal horns of the ventricles, as standard frontal approaches may not be appropriate for access to these areas. In addition, many neuronavigation systems also provide a method for registering the endoscope as a navigable instrument, allowing the surgeon to determine the position of the endoscope tip in real time while working. This can be very valuable when a tumor has distorted normal intraventricular anatomy.

Perhaps the most important technical consideration for intraventricular endoscopy is maintenance of adequate visualization. One of the keys to good visualization is good irrigation. Irrigation facilitates removal of blood and debris and “maintains a clear medium of image transmission and ventricular patency.”[4] Several methods are available for delivering irrigation during endoscopy. The simplest of these is irrigation via a syringe attached to the endoscope channel. Other methods include the use of a peristaltic pump or more complex systems like a modified centrifugal pump. While irrigation can be crucially important in facilitating successful endoscopy, it can also be a cause of complications. When using irrigation, it is absolutely essential to ensure adequate ventricular outflow. Failure to do so can result in iatrogenic elevation of intracranial pressure that can be catastrophic if not recognized. There are myriad methods for assuring outflow, including use of a separate ventricular catheter that is open to drain, use of a sheath that is larger than the endoscope, allowing backflow of irrigation, or use of one of the endoscope working channels as a dedicated outflow port. If using an endoscope working channel, the surgeon must use caution if an instrument is introduced into that port, as this will substantially change the resistance to fluid outflow.

Maintenance of visualization during endoscopy requires maintenance of hemostasis. This is particularly true during tumor resections, where bleeding from the tumor can quickly obscure the field of view. Many techniques have been described for bleeding control during endoscopy, but the most important factor in maintaining visualization is adequate and safe irrigation. Indeed, much of the bleeding that occurs during endoscopic surgery will stop under the gentle pressure provided by direct irrigation on the bleeding point, allowing platelet aggregation and the clotting cascade to arrest hemorrhage. The surgeon must remain patient through this process. More severe bleeding during endoscopy, the dreaded “red tornado” can very quickly decrease visualization to near zero and arrest all progress. In these cases, careful navigation of the scope closer to an ependymal surface will sometimes allow the surgeon to orient himself and then find the source of the bleeding. Use of electrocautery instruments introduced through the endoscope working channel can be effective.[5] If bleeding cannot be brought under control, then the surgeon must be prepared to abort the procedure and leave an external ventricular drain, or convert to an open craniotomy.

When planning an endoscopic tumor resection, the surgeon must always consider the possibility that conversion to an open approach may be necessary. Hemorrhage that cannot be adequately controlled via endoscopic techniques may require conversion to an open craniotomy for hemostasis. Similarly, the surgeon may make an intraoperative judgment that the tumor cannot safely or effectively be addressed with endoscopic techniques. Therefore, one must always consider the potential need to convert to an open craniotomy during patient positioning, surgical prep, and draping. There are several commercially available systems that can be used to dilate the endoscope tract and provide access to the ventricle once a craniotomy has been performed.

The recent publication in *World Neurosurgery* is an excellent example of the expanding role of endoscopy in pediatric neurosurgery. The authors report on 12 cases over a 9-year period who underwent purely endoscopic resection of solid intraventricular tumors. The most common diagnosis was subependymal giant cell astrocytoma (SEGA). Ependymal, germ cell, and astrocytic tumors accounted for the other cases. In 11 of these cases, they were able to achieve gross total resection with endoscopy alone. Complete resection in one case was not possible due to vascularity of the tumor. There were two cases of tumor recurrence (one local and one distant) and one case of transient elevation of intracranial pressure (from inadequate irrigation outflow), but no permanent morbidity or mortality. While 5 patients had hydrocephalus at presentation, only two underwent ETV at the time of the endoscopic tumor removal. No patient required shunting, as ETV or tumor resection alone was adequate to treat the hydrocephalus.

These cases illustrate the principles of safe and effective neuroendoscopy, and this case series is a significant addition to the literature on endoscopic intraventricular tumor surgery. The authors have demonstrated the feasibility and safety of gross total resection of intraventricular tumors using a solely endoscopic approach. As these techniques evolve, indications for endoscopy will continue to expand, and endoscopy will continue to be a valuable tool for the modern neurosurgeon.

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