Review Article

Neurosurgical Endoscopy

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INTRODUCTOIN

Neurosurgical endoscopy is a field that is becoming more widely used for the diagnostic and therapeutic purposes of many different conditions. The technological development of optical and mechanical instrumentation, in addition to stereotactic or ultrasound-guided procedures, provides new modes of treatment that are less invasive and, therefore, less traumatic for the patient.

The development and recent advances of endoscopic neurosurgery and its application to the brain and spine pathology is summarized in this article.

HISTORICAL LANDMARKS

Dandy[1] was the pioneer of neuroendoscopy using a cystoscope as a ventriculoscope to visualize the lateral ventricle. In 1922, he described the use of the ventriculoscope for fulguration and avulsion of the choroid plexus. The successful management of obstructive hydrocephalus was presented by Mixer[2] in 1923, when he mechanically perforated the thinned floor of the third ventricle under endoscopic guidance. Putnam[3] developed the technique of endoscopic coagulation of the choroid plexus for treating hydrocephalic patients. Fukushima et al[4] used the first flexible endoscope in neurosurgery and performed biopsies of ventricular tumors.

During the ensuing 40 years, both open craniotomy and endoscopic procedures were attempted in the management of communicating hydrocephalus. Scarff[5] further refined the procedure of endoscopic cauterization in a series of 26 patients resulting in the control of the progression of hydrocephalus in 67%.

Little interest in neuroendoscopy followed until 1970. This lack of interest undoubtedly relates to the more effective, simple, low risk management of hydrocephalus by a ventriculoperitoneal shunt. However, with the further development of endoscopic optics, cameras, monitors, and instrumentation for tissue dissection, these former procedures were "recovered" and yielded similar or improved results over the ventriculoperitoneal shunt[6,7,8,9]. Griffith[10] controlled intracranial hypertension by endoscopic choroid plexus cauterization and more than half their patients experienced normal head growth. Hirsh[11] and Sainte-Rose[12] reported an increasingly larger series of patients with demonstrated obstructive hydrocephalus which were managed by third ventriculostomy. More than 60% of these patients currently are shunt-independent.

The successful biopsy and excision of intraventricular or cystic neoplasm, colloid cyst of third ventricle, in a small series of patients has been described[13,14,15]. Zamorano et al[16] described an extensive series of tumor biopsies and dissections in which the rigid endoscope was coupled with a frame stereotactic system. In 1991, Manwaring et al[17,18,19] described a frameless stereotactic guidance technique involving magnetic field guidance through both the rigid endoscope and fiberscope. Mayer and Brock[20], Dikman and Detweiler[21], and Rosenthal and Dikman[22] successfully used the endoscope in selected patients to manage symptomatic bulging discs. Hüwel[23] demonstrated effective communication of loculated cysts in association with hydromyelia.

NEUROENDOSCOPES

Four types of endoscopes have been developed and used in craniospinal procedures: rigid, flexible fiberscope, videoscope and optically guided instruments[24].

Rigid neuroendoscope: This type of neuroendoscope is currently the most extensively used endoscope in neurosurgery. The advantages of this instrument, compared with the fiberscope, include not only image quality but also the degree of miniaturization, its tolerance of handling and sterilization, and its straight design. It is easily adapted to frame and frameless stereotactic systems. Another significant benefit of the rigid neuroendoscope is easy image orientation.

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The disadvantages of rigid neuroendoscope include inability to steer and operate around corners and the necessity to continually reposition a holder for the neuroendoscope.

The rigid neuroendoscope has been used routinely as an adjunct to the ventriculoperitoneal shunt, by gaining access to the ventricular system with a peel-away sheath introducer. The neurosurgeon can introduce the endoscope inside the peel-away sheath introducer and guide the sheath as a conduit under direct endoscope visualization. The tip of the sheath can then be positioned in an optimal site within the ventricular cavity, away from the choroid plexus and the parenchyma. Upon removal of the endoscope, the proximal catheter is measured in length to the exact depth of the guided peel-way sheath.

Fiberscope: The principle advantages of fiberscope in neurosurgery are flexibility, steer ability and ease of holder positioning. As the tip, with its instrument channel, is steerable, the neurosurgeon can inspect around the corners without deforming vital neural and vascular structures, and can do biopsy, dissect, and vaporize tissue. This type of endoscope is also an effective adjunct to microscopic craniotomy when inspection around corners at the conclusion of dissection may insure the completeness of the dissection[25].

The fiberscope diameters range between 0.5 and 5 mm. The flexibility of the thinnest fiberscope (0.75 mm) is ideal for intraluminal inspection of a proximal shunt catheter and dissection of choroid plexus from within and away from catheter perforation.

The 2-mm flexible fiberscope can be inserted through a dorsal myelotomy in the cord of a patient with separated or non-communicated hydromyelia. The fiberscope can than be used to mechanically perforate membranes and place a single syrinx peritoneal shunt[26].

The 4 to 5 mm range fiberscopes provide excellent intraventricular and intracystic access.

TV-control: All endoscopes can be used under direct visual control but the attachment of a high-resolution camera to the eyepiece allows simultaneous vision by the surgical team and videotape recording.

Endoscope guiding system: Both stereotactic and ultrasound systems have been used for guiding the introduction of the rigid endoscope or cannula. Non-guided punctures, based only on anatomical landmarks can also be performed, especially in patients with very large ventricles or cysts.

Instruments: Both rigid and flexible grasping and biopsy instruments are available that will pass through a 1-mm instrument channel in a rigid or flexible fiberscope. Endoscopic microscissors are also available and are used for excision through the rigid endoscopes.

ENDOSCOPIC PROCEDURES

Simple blunt or mechanical perforation of a cyst membrane or creation of a third ventriculostomy as described by Jones, Stening, and Brydon[8] is frequently a satisfactory method of a longterm fenestration[12,17]. Mechanical perforation can also be achieved by using a 2-French Fogarty balloon catheter. The dissection procedure must be undertaken on the electrically conductive environment of clear cerebrospinal fluid. Both the monopolar and bipolar radiofrequency energy can be effective for dissection in the electrically conductive cerebrospinal fluid environment. The contact laser energy has been shown to be effective for tissue dissection in the cerebrospinal fluid environment.

Manwaring[19], and Heilman and Cohen[27] described a refinement of the urologic Bugbee wire that allows both incising and tissue vaporizing action with monopolar radiofrequency energy.

Both YAC and KTP lasers have been used with contact fibers in the endoscope cerebrospinal fluid environment effectively dissecting tissue. Argon and Holmium lasers have been used less often. Contact fibers consist of either bare, bluntly cut probes or sculptured tips. Compared with radiofrequency dissection, laser tissue dissection has a theoretically further benefit.

Endoscopic guidance systems: Various guidance systems to endoscopic intracranial dissection have been used. These include C-arm lateral fluoroscopic X-ray such as that used in transsphenoidal approach to the pituitary surgery, ultrasound through the yet-open anterior fontanelle or through the small craniotomy, sterotactic frame coupled with rigid endoscope or rigid guide tube for fiberscopes and new techniques of frameless stereotaxis[9,16,18].

Intraoperative sonography through an open fontanelle or through a small craniotomy allows real-time assessment of the position of the endoscope tip and its trajectory. Many parenchyma pathological conditions are not well visualized by ultrasound, but ventricular and cystic lesions are well seen.

Coupling the rigid endoscope with a frame stereotactic system allows precise orientation before a surgical dissection or biopsy commences. Furthermore, because direct endoscopic visualisation is achieved, the greater degree of surgical effectiveness or safety is reasonable compared with that of blind frame stereotaxis. Some small tumors may then be completely excised with the andoscope alone[15,16,28,30]. For other lesions, the neurosurgeon may use the microscope to complete the procedure.

Frameless stereotactic systems have the significant benefit over conventional frame stereotaxis. Mechanical arm, infrared, acoustic microphone and magnetic field systems have been described[16,18,24]. The surgeon can preoperatively plan a guide path for initial burr hole placement and subsequent excursion along a tract to the surgical target. Such preoperative planning minimizes the risk of transgressing vital structures or blood vessels.

The neuroendoscopic surgical procedures described frequently in the literature to date include the following:

Diagnostic procedures:

1. Ventriculoscopy
2. Cisternoscopy
3. Biopsy in the intraventricular, intracystic, or cisternal spaces

Therapeutic procedures:

1. Ventriculoperitoneal shunt
2. Excision of encysted shunt catheter
3. Third ventriculostomy
4. Septostomy of the septum pellucidum
5. Fenestration or membranectomy
6. Aqueductoplasty
7. Foraminoplasty
8. Evacuation of intraventricular hematoma
9. Evacuation of chronic subdural hematoma
10. Intraventricular tumor excision
11. Fenestration of loculated hydromyelia
12. Partial excision of a lumbar disc
13. Adjunct postcraniotomy inspection

The endoscope is particularly effective in the management of cerebrospinal fluid compartmentalization following inflammation-induced hydrocephalus[17,31]. Small intraventricular or cystic parenchymal tumors were removed entirely in the limited reported series[9,14,15].

The neuroendoscopy has an increasing role to assist microsurgical craniotomy[10,27] in addition to spinal and spinal cord pathology[21,22].

COMPLICATIONS OF NEUROSURGICAL ENDOSCOPY

The principle challenges to safe endoscope dissection are the control of bleeding and orientation. Minor bleeding, particularly venous in origin, is seldom a problem. Continuous irrigation with lactated Ringer`s solution or mock cerebrospinal fluid is usually the only requirement. The venous bleeding often accumulates downward to form a clot on the floor of the cyst cavity or the ventricle. After bleeding stops, the clot can often be removed by suction. No effective method for control of arterial bleeding has yet been developed, because of the lack of an adequately miniaturized instrument that can coapt the walls of a blood vessel, while applying heat (bipolar forceps). Until such a development, the neuroendoscopist must be content to dissect only areas where no major vessels are hidden beneath the tissue. The heating by contact laser or radiofrequency energy will shrink vessels before they are incised, however, if a major artery is bleeding, little treatment can be offered. A craniotomy set should be available in case unexpected and uncontrolled bleeding occurs.

Opacification of the working environment in front of the distal lens of the endoscope, because of minor bleeding, old blood (chronic subdural hematoma) or tumor, or cyst fluid, is readily managed by continuous irrigation. The fluid passed through the instrument channel must go out through the peel-away sheath without significant resistance. The sheath may remain at the top of the endoscope, otherwise significant intracranial hypertension can ensue.

Disorientation because of the featureless appearance of brain tissue or the lack of recognizable anatomic landmarks in the presence of pathology will be overcome after some experience. Furthermore, the variable magnification effect of the monoscopic endoscope makes some vessels and nerves unrecognizable that would otherwise be easily seen under a microscope at craniotomy.

FUTURE CAPABILITY OF NEUROSURGICAL ENDOSCOPY

The future capability of therapeutic neuroendoscopy appears promising. With refinement of the tools of hemostasis and tissue debulking in the cerebrospinal fluid environment, simple biopsy will probably be replaced by more complete excision of neoplasms and evacuation of hematomas. In addition, frameless stereotactic guidance will probably extend the present capability for lesion of tracts and nuclei in functional neurosurgery. Implantation for neurotransmitter replacement or for local chemotherapy delivery may also be more precise with endoscopic visualization. The sophistication of neuroendoscopic neurosurgery to be capable to operate around the corners may allow effective management of skull base lesions currently approached through extensive craniotomies.

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