Endoscopic applications in Pediatric Neurosurgery

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Neuroendoscopy

- A form of minimally-invasive neurosurgery
- Defined as the discipline of applying an endoscope to the treatment of conditions of the central nervous system
- The endoscope enhances the surgeon’s view by increasing illumination and magnification
- Application of endoscopy to intra-cranial surgery has resulted in well-published positive outcomes for neurosurgical patients with specific pathologies
- Neuroendoscopy follows a general trend in neurosurgery of treating disease with minimally-invasive techniques to reduce approach-related trauma and to improve visualization of the pathology

More interest in minimally invasive techniques??

- Minimally invasive neurosurgery is a term used to describe surgical techniques that require a few small incisions versus a large opening
- The goal of minimally invasive neurosurgical procedures is to:
  - Reduce pain and blood loss
  - Shorten recovery time
  - Shorten hospital stay
  - Reduce scarring
  - Kids go back to school faster!
Endoscopic applications

- Endoscopic third ventriculostomy
- Endoscopic tumor biopsy and removal for intraventricular tumors
- Endoscopic fenestration of arachnoid cysts
- Endoscopic resection of colloid cysts
- Endoscopic simplification of multi-loculated hydrocephalus
- Endoscopic placement of ventricular catheters in shunts
- Endoscopic trans-sphenoidal surgery for sellar and supra-sellar tumors
- Endoscope-assisted microsurgery
- Endoscopic strip craniectomy for craniosynostosis
- Endoscopic choroid plexectomy
- Endoscopic aqueductoplasty
- Endoscopic spinal surgery

History

- L’Espinasse uses a cystoscope to explore the ventricles - 1910
- Mixter performs first third ventriculostomy on 9 months baby with non-communication hydrocephalus using a small urethroscope – 1923
- Few single cases and small series published 1930-1960
- Hoffman, Kelly, Jones and Drake (1970-1990’s) popularized neuro-endoscopy with well published clinical data (ETV literature)
- 1990-2008: Neuro-oncology and trans-sphenoidal applications
 Equipments

Endoscopes: different angles 0, 30, and 70 degrees

Video camera

Light source

Video recorder and monitor

Rigid and flexible instruments (grabbing forceps, scissors, etc.)

Coagulation device (monopolar or bipolar)

Irrigation system

Neuro-navigation

Rigid and flexible endoscopes

Flexible endoscope (for shunts)

Rigid endoscopes

Navigation tool with endoscope
Hydrocephalus

- A disturbance of formation, flow, or absorption of cerebrospinal fluid (CSF) that leads to an increase in volume occupied by this fluid in the CNS

Incidence of congenital hydrocephalus 3 per 1,000 live births

Cerebrospinal fluid (CSF)

- Clear, colorless
- Fills ventricles of brain and sub-arachnoid space that surrounds CNS
- Produced mainly by choroid plexus in lateral, third, and fourth ventricles
- CSF produced at 0.3-0.35ml/minute
- Approximately 500ml/day in young children and adults
Tour of ventricular anatomy

The Ventricular System of the Human Brain

Epidemiology

Epidemiology
Types of hydrocephalus

Communicating:
- CSF over production (idiopathic)
- CSF over production (choroid plexus tumors)
- Less CSF absorption at level of subarachnoid space and arachnoid villi
- Neonatal meningitis

Non-communicating (obstructive):
- Idiopathic aqueductal stenosis
- Tumors (pineal, tectal, brainstem, fourth ventricle)
- Infection
- Hemorrhage
- Post-operative
- Cysts
Endoscopic third ventriculostomy (ETV)

Procedure includes placement of fenestration at floor of third ventricle in patients with obstructive hydrocephalus.

CSF will "BYPASS" flow obstruction, usually at level of Aqueduct of Sylvius.

First attempted ETV in 1923.

Advances and improvements in endoscopic instrumentation in the 1970s and 1980s re-popularized the procedure.

Numerous studies confirmed the high success of ETV and low complication rate.

ETV has numerous potential benefits over standard shunt procedure for hydrocephalus.

Why Third Ventriculostomy?

Shunt troubles:
- Up to 80% lifetime risk of complications
- 10% infection rate, mostly in the first year after implantation
- Can obstruct or break the ventricular catheter, valve, or distal catheter
- Average life of a shunt is about 6-8 years

Quote: “A shunt is not a procedure, it’s a sentence!” - Hal Rekate
Lateral Ventricle Third Ventricle

- Choroid
- Floor of 3rd ventricle
- F. of Monro
- Mamillary bodies

Technique

Endoscopic Third Ventriculostomy (ETV)
Case in point

- 7 yr F presents to ACH with progressive headaches, nausea and gait imbalance
- Exam: + papilledema, upward palsy and unsteady gait

Treatment options?

- Follow tectal tumor with MRIs every six months-one year
- Obstructive hydrocephalus: Permanent shunt? Endoscopic third ventriculostomy?
ETV video - anatomy

ETV video - fenestration
ETV video – Final

MRI cine-CSF flow study

Pre – ETV
Post - ETV
Endoscopic third ventriculostomy (ETV) is a well established treatment for obstructive hydrocephalus in all age groups.

ETV has been shown to be an alternative to conventional shunting in treating obstructive hydrocephalus.

ETV has also been considered as a valid option in selected cases of shunt malfunction and infection.

Overall success rate in selected patients (idiopathic aqueductal stenosis) and tectal tumors is >80%.

ETV is getting more accepted for age < 1 year. Outcomes 50-60% success.
Personal research: ETV outcomes in pediatric population

- **Endoscopic third ventriculostomy for obstructive hydrocephalus in the pediatric population: evaluation of outcome.**


- **Objective:** To identify risk factors for failure and predictors for success in the treatment of obstructive hydrocephalus in the pediatric population with ETV

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**Study outline**

- **Design and methods:** Retrospective review of charts and preoperative anatomical brain MRI and cine CSF flow study

- **Statistics:** Kaplan-Meier estimate of recurrence-free time compared with log rank test

- **Duration of Analysis:** To last clinic visit (success group) or to time of subsequent procedure (failure group)

- **Exclusion Criteria:** Follow-up less than 6 months
Patient population

- 52 pediatric patients underwent 57 ETV procedures (5 re-do) in the period of 5 years
- **Gender:** 28 males (55%) and 23 females (45%)
- **Follow-up:** range 6mo - 74mo
  mean follow-up is 25.6 months
- **Age range:** 3 months - 17 years
  mean age is 8.5 years

Etiology of obstruction

- **Aqueductal stenosis:** 22 (42.3%)
  - Idiopathic 20 (38.4%)
  - Post meningitis 2 (3.8%)

- **Congenital malformation:** 13 (25%)
  - Chiari I malformation 6 (11.5%)
  - Chiari II malformation 5 (9.6%)
  - Dandy-Walker malformation 2 (3.8%)
Etiology of obstruction (cont.)

- Third ventricular mass: 1 (21.1%)
  - Cyst: 5 (9.6%)
  - Pineal tumor: 4 (7.7%)
  - Tectal tumor: 1 (1.9%)
  - Hypothalamic tumor: 1 (1.9%)

- Other: 6 (11.5%)
  - Posterior fossa tumor: 3 (5.7%)
  - Porencephalic cyst: 1 (1.9%)
  - Brain stem tumor: 1 (1.9%)
  - Sturge-Weber disease: 1 (1.9%)

Patient groups

- All 57 ETV procedures were divided into three groups in regard to clinical outcome

  1. Success Group: 36 (63.2%)
  2. Failure group: 18 (31.6%)
  3. Equivocal outcome group: 3 (5.2%)

Definitions:

- Success: Symptoms improve and no subsequent procedure required
- Failure: no improvement of symptoms with need to re-do ETV or shunt
- Equivocal outcome: symptoms improve but may be due to either ETV or shunt both in place
Analyzed factors

1. Gender
2. Age
3. Etiology
4. History of preoperative shunting
5. History of intracerebral infections (shunt infection / meningitis)
6. Preoperative CSF flow MRI study findings

Shunt history at presentation

- **Success group:**
  - no previous shunting 28 (77.7%)
  - previous shunting 8 (22.2%)
  - presented with shunt malfunction 3 (8.3%)
  - presented with shunt infection 5 (13.8%)

- **Failure group:**
  - no previous shunting 6 (33.3%)
  - previous shunting 12 (66.6%)
  - presented with shunt malfunction 6 (33.3%)
  - presented with shunt infection 6 (33.3%)

- **Equivocal group:**
  - no previous shunting 3 (100%)
Patient management

Total patients (N=52)

Success (N=33)  Failure (N=16)  Equivocal outcome (N=3)

Cine CSF flow MRI

(-)  (+)

shunting (N=11)  Redo (N=5)

Failed (N=2)  Succeeded (N=3)

History of pre ETV shunting: Kaplan-Meier curve (p=0.0027)
History of infections: Kaplan-Meier curve (p = 0.1031)

Age: Kaplan-Meier curve (p = 0.843)
Etiology: Aqueductal stenosis (congenital or tumor) Versus All other etiologies (P=0.0157)

Patient with Aqueductal stenosis

Preop (Anatomical)  Preop (CSF flow)  Postop (CSF flow)
Endoscopic applications in pediatric neuro-oncology

- ETV in patients with HCP and pineal or tectal tumors
- ETV in patients with HCP and posterior fossa tumors
- Endoscopic biopsy of pineal lesions
- Endoscopic biopsy/excision of intra-ventricular tumors

Souweidane paper

Endoscopic management of pediatric brain tumors

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Object: Primary endoscopic procedures for children with intracranial brain tumors include endoscopic brain biopsy and endoscopic tumor resection. The minimally invasive endoscopic endonasal transsphenoidal (ETV) endoscopic endonasal approach is shown in a clinical retrospective case study.

Method: Fifty-five patients who underwent endoscopic management of intracranial brain tumors were evaluated from a prospective database. Of those patients, 26 were younger than 21 years of age at the time of diagnosis, with the majority of these patients being younger than 12 years of age. A total of 45 endoscopic procedures were performed in 42 patients. These procedures included 36 endoscopic brain biopsies with 17 patients undergoing both ETV and endoscopic biopsy/excision of the tumor.

Results: In this study, 45 endoscopic procedures were performed in 42 patients. Of these procedures, 36 were endoscopic brain biopsies, with 17 patients undergoing both ETV and endoscopic biopsy/excision of the tumor. The overall success rate of ETV procedures was 85%, with 90% of ETV procedures successful in achieving complete evacuation of the tumor.

Conclusions: Endoscopic brain biopsy/excision of the tumor is an effective and well-tolerated method of sampling of the brain tissue, which is critical for accurate diagnosis. This minimally invasive technique should be considered in situations in which the patient might otherwise need a more conventional procedure, given the high rate of success and low mortality associated with endoscopic management.
Case: Pineal region tumor with obstructive hydrocephalus

History:
15 year male patient with progressive headaches, blurry vision and nausea

Physical examination:
Limited upward gaze and papilledema

Head CT:
Hyperdense pineal region mass with ventriculomegaly involving third and lateral ventricles

MRI brain:
Large enhancing pineal region mass with obstructive hydrocephalus

Total spine MRI:
Two small “drop mets” lesions in lumbar area

Goals from surgery:
1. Treat obstructive hydrocephalus. Avoiding shunt placement will be a great option!
   (Image-guided endoscopic third ventriculostomy)

2. Obtain pineal region tumor tissue diagnosis for further management: surgery, radiation or chemotherapy
   (Image-guided endoscopic biopsy of pineal region mass)
MRI-based image-guided endoscopic third ventriculostomy

MRI-based image-guided endoscopic biopsy of posterior third ventricular pineal region tumor
Postoperative course

Monitoring of ICP’s for 2-3 days → followed by removal of ventricular drain.

Pathologic diagnosis: Germinoma

Patient received Chemotherapy and radiation with excellent response

No further need for any hydrocephalus management

Complete resolution of pineal mass at 9 months – No shunt required

ETV and brainstem tumors

Endoscopic third ventriculocisternostomy for brainstem tumors

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Introduction: The authors retrospectively reviewed the charts of all patients harboring brainstem tumors treated at their institutions, excluding those with local gliomas, who underwent an endoscopic third ventriculocisternostomy. Methods: Endoscopic third ventriculocisternostomy was performed in 11 patients with tumors involving the brainstem: nine patients with diffuse pineal gliomas, two with posterior fossa paragangliomas, one with a von Hippel-Lindau tumor, and one with a posterior polar metastatic lesion. No technical difficulties attributable to the location or size of the tumors or surgery-related complications were encountered. Intracranial pressure relief from hydrocephalus was achieved in all patients, and there was an associated decrease in steroid and anesthetic agent requirements. Only one patient required a shunt for persistent hydrocephalus.

Conclusion: Endoscopic third ventriculocisternostomy can be used in the surgical treatment of patients with brainstem lesions, yielding good results without significant surgical morbidity.

KEY WORDS: pineal glioma, brainstem tumor, endoscopic third ventriculostomy, pediatric neurosurgery
Endoscopic placement of shunt catheters

- Endoscopically placed shunt catheters can assure appropriate location
- Less need for intra-operative ventriculography
- Endoscopic Shunt Insertion Trial (ESIT) represent the notion that endoscopically placed shunts were no more likely to survive than conventionally placed shunts

Endoscopic shunt placement video
Endoscopic trans-sphenoidal surgery for sellar and suprasellar lesions

- More indications in adult population
- Very well accepted approach for most pituitary gland tumors
- Growing interest in management of craniopharyngioma in pediatric population
- Multidisciplinary team approach by neurosurgery and ENT

Endoscopic Pituitary tumor resection images + video x 2
Endoscopic endonasal treatment of pediatric skull base lesions


Fully endoscopic expanded endonasal approach treating skull base lesions in pediatric patients

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Object: The authors reviewed their experience with endoscopic approaches to determine their safety and efficacy in the treatment of pediatric patients with skull base floor lesions, although they were interested in accumulating evidence to support extended use of their approaches, for which no report has been reviewed.

Methods: The authors performed a retrospective review of all endoscopic procedures performed at their institutions between January 2000 and September 2005. The procedures were categorized into a series of anatomic and functional approaches.

Results: Five patients (8-year-old age group) were identified. The surgical goals were individualized and included growth of the brain, removal of lesions, injury to bone structures, or removal of pathological tissue.

Conclusions: The endoscopic approach was the safest, with no or minimal complications. The authors reported the safety and efficacy of this approach.

Endoscopic craniosynostosis repair

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Endoscopic management of complex and multi-loculated hydrocephalus

- Endoscopic fenestration of cysts and loculations to simplify shunting target
- Endoscopic fenestration of septum pellucidum for communication of asymmetric ventricles

Multiloculated HCP

Endoscopic cyst fenestration in the treatment of multiloculated hydrocephalus in children

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Object: The treatment of multiloculated hydrocephalus is a difficult problem in pediatric neurosurgery. Definitive treatment is surgical, yet the approach remains controversial. The authors have therefore reviewed their results with endoscopic cyst fenestration (ECF) in the management of this disease.

Method: A total of 41 cases were compared between the present series and 25 cases of multiloculated hydrocephalus who were treated endoscopically. The group included boys and girls with a mean age of 11.5 months. Multiloculated hydrocephalus was defined as a defect of the lateral ventricles communicating through septicum pellucidum. The endoscopic procedures were performed under general anesthesia using a 20F endoscope and the treatment was based on the size of the septum pellucidum. The fenestration was performed through the septum pellucidum, and the fenestration was performed with the aid of a needle aspiration catheter. The patients were followed up for an average of 23 months. The results showed that ECF was an effective treatment for multiloculated hydrocephalus. Postoperative complications were minimal (3 cases of cholesteatoma and 2 cases of intraventricular hemorrhage), and there were no cases of postoperative ventricular dilatation.

Conclusion: An ECF procedure is recommended in the treatment of multiloculated hydrocephalus because it is safe, simple, and involves no local complications, and is associated with low morbidity and mortality rates.

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Endoscopic Foramen of Monroe foraminoplasty

Case: 11 yr M with third ventricular cyst + Obstructive HCP
Endoscopic cyst fenestration + ETV

Post-op
Conclusions

- Endoscopic neurosurgery is a well accepted form of minimally-invasive neurosurgery for selected group of pediatric patients

- Technological advances in endoscopic instrumentation will help surgeons add new indications and approaches that are less traumatic compared to conventional open neurosurgery and improve visualization of pathologies

Endoscopic CPT® codes

- 62160 Neuroendoscopy, intracranial, for placement or replacement of ventricular catheter and attachment to shunt system or external drainage (List separately in addition to code for primary procedure)
Endoscopic CPT® codes

- 62161 Neuroendoscopy, intracranial, with dissections of adhesions, fenestration of septum pellucidum or intraventricular cysts (including placement, replacement, or removal of ventricular catheter)

- 62162 Neuroendoscopy, intracranial, with fenestration or excision of colloid cyst, including placement of external ventricular catheter for drainage

- 62163 ...with retrieval of foreign body
- 62164 Neuroendoscopy, intracranial, with excision of brain tumor, including placement of external ventricular catheter for drainage

- 62165 Neuroendoscopy, intracranial, with excision of pituitary tumor, trans-nasal or trans-sphenoidal approach
Endoscopic CPT® codes

- 62200 Ventriculocisternostomy, third ventricle
- 62201 ...stereotactic method

References

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- Website of Jho Institute for Minimally Invasive Neurosurgery
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- Website of Seattle Children’s - Department of Neurosurgery
- AMA CPT® 2011: Professional Edition
Thank you!

- Questions?