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
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
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
Listen to mom talking about fine motor skills!


ETV outcomes in pediatric population

- 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

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%)
  - Chairi 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 to 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 tumor biopsy and endoscopic tumor resection. The noninvasive treatment of hydrocephalus with endoscopic third ventriculostomy (ETV) using a subpial technique reduces the morbidity of a traditionally invasive endoscopic approach.

Method: Forty-five pediatric patients underwent endoscopic management of intracranial brain tumors from January 2000 to December 2009. The average age at the time of diagnosis was 5.5 years (range, 2 days to 15 years). The mean length of stay was 2 days.

Results: Of 45 patients, 10 had lesions involving the upper brainstem or cerebellum, 12 had lesions involving the upper brainstem or cerebellum, and 12 had lesions involving the upper brainstem or cerebellum. In the rest of the group, the procedures included ETV for hydrocephalus (9 patients) or both endoscopic tumor biopsy and endoscopic tumor resection (8 patients). Nine patients underwent procedures for the treatment of hydrocephalus. In 9 of 11 patients, hydrocranial imaging confirmed complete removal of the tumor.

Conclusions: In children with brain tumors, endoscopic procedures can be used effectively and safely without the sampling of the tumor and, in select cases, its excision. This minimally invasive technique should be considered in situations in which the patient might otherwise avoid a more conventional procedure, given the high rate of success and low morbidity associated with endoscopic management.

Keywords: endoscopy • brain tumor • subdural cyst • hydrocephalus
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

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**Surgical planning**

**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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Objective: The authors retrospectively reviewed the charts of all patients harboring brainstem tumors treated at their institution, excluding those with local disease, who underwent an endoscopic third ventriculocisternostomy.

Methods: Endoscopic third ventriculocisternostomy was performed in 14 patients with tumors involving the brainstem: nine patients with diffuse pineal masses, two with posterior fossa tumors, one with a Cushing’s syndrome, and one with a pineal region tumor. No technical difficulties attributable to the location of the tumors or surgery-related complications were encountered. Immediate symptomatic relief of hydrocephalus was achieved in all patients, and there was no associated increase in intracranial or cerebrospinal fluid pressure. Only one patient had a recurrence of their tumor.

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

Key Words: pineal glioma • brainstem tumor • endoscopic third ventriculocisternostomy • 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 tumors. Although the procedures were associated with a higher risk of complications compared to those for adults, the authors observed that the treatment approach was well tolerated by all of their pediatric patients, and that the endonasal endoscopic approach allowed for a better disease-free outcome for their pediatric patients.

Methods: The authors conducted a retrospective review of all endoscopic procedures performed on children from January 2000 to September 2005. The procedures were categorized into a series of endonasal endoscopic approaches.

Results: Thirty-five patients aged 14 years or younger were identified. The surgical goals were dictated by the location of the tumor and the extent of the tumor, and included resection of the tumor, decompression of the neural structures, and removal of the tumor. The endoscopic endonasal approach was associated with a lower risk of complications compared to other approaches, and resulted in a better disease-free outcome for their pediatric patients.

Conclusions: The endoscopic endonasal approach appears to be safe, effective, and well-tolerated by pediatric patients. The authors recommend the endoscopic endonasal approach for the treatment of skull base lesions in children, and suggest that further studies be conducted to determine the long-term outcomes of this approach.

Endoscopic craniosynostosis repair

[Diagram of cranial bones and surgical approach]

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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 surgery, but the approach remains controversial. The authors have therefore reviewed their results with endoscopic cyst fenestration (ECF) in the management of this disorder.

Methods: This study included 16 patients with multiloculated hydrocephalus who were treated endoscopically. The group included 10 males and 6 females, with a mean age of 11.5 months. Non-surgical hydrocephalus was expanded in this study because it is a different entity that could be better evaluated separately.

Results: Ventriculoperitoneal shunting was the most common surgery (19 patients), followed by intraventricular shunting (6 patients), peritoneoventricular shunting (1 patient), and multiple ventriculostomies (1 patient). Multiloculated or multicystic ventricles were evaluated in all patients. The etiology of the hydrocephalus was congenital (15 patients) and acquired (1 patient). The 15 patients with congenital hydrocephalus were divided into 2 groups: Group A (11 patients) included the patients with congenital hydrocephalus of the hydrocephalus of the age that was less than 4 months and Group B (4 patients) included the patients with congenital hydrocephalus of the age that was more than 4 months. The mean follow-up period of Group A was 18 months and of Group B was 24 months. The mean follow-up period of the entire group was 20 months. The overall improvement in the clinical condition of the patients was assessed in all patients. The mean follow-up period of the entire group was 20 months. The overall improvement in the clinical condition of the patients was assessed in all patients. The mean follow-up period of the entire group was 20 months. The overall improvement in the clinical condition of the patients was assessed in all patients.

Conclusions: ECF procedure is recommended in the treatment of multiloculated hydrocephalus because it is of definite, simple, endoscopic localization, and associated with low mortality and morbidity rates.
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
Endoscopic CPT® codes

- 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

- Principles of neurosurgery, by Rengachary and Ellenbogen, Chapter: Neuroendoscopy. Teo et al.
- Website of Jho Institute for Minimally Invasive Neurosurgery
- Website of NewYork-Presbyterian Hospital - Department of Neurosurgery
- Website of Seattle Children’s - Department of Neurosurgery
- AMA CPT® 2011: Professional Edition
Thank you!

- Questions?