

Endoscopic Third Ventriculostomy

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Overview

- History
- Development
- Tools
- Technical Points
- Outcome Analysis
- Complications
- Future Directions

Resources

- Hellwig et al. Endoscopic third ventriculostomy for obstructive hydrocephalus. *Neurosurg Rev* 28:1-34, 2005.
- Drake J. Endoscopic third ventriculostomy in pediatric patients: The Canadian Experience. *Neurosurgery* 60:881-886, 2007.
- Farin et al. Endoscopic third ventriculostomy. *J Clinical Neuroscience* 13:763-330, 2006.

Introduction

- Endoscopic third ventriculostomy is a technique to treat obstructive hydrocephalus
 - Involves making a hole in the floor of the third ventricle to bypass the aqueductal obstruction
 - Involves using an endoscope, single port, multiport, rigid or flexible
 - Considered minimally invasive neurosurgical procedure

History

- Key and Retzius clarified the physiology of CSF circulation, production, and reabsorption in 1875
- Dandy began treating hydrocephalus with fulguration of the choroid plexus
 - 24/25 first children treated died of complication
- L'Espinasse (a urologist) introduced a cystoscope into the ventricle to fulgurate choroid plexus in 1904
- Dandy refined this method calling it “ventriculoscopy”
 - He described the topographical anatomy of the lateral ventricle, choroid plexus, and third ventricle

History

- Mixer in 1923 performed the first ETV in a child with congenital hydrocephalus
 - The floor of the third ventricle was perforated using a urethroscope and probe
 - Mixer proposed ETV as a treatment of obstructive hydrocephalus
 - Popularity waned because of high mortality, large cumbersome instruments, preference for choroid fulguration
- Putnam and Scarf developed a coagulation endoscope in 1934
- Scarf published that out of 20 children, 3 died immediately, 7 survived without decreased ICP, and 10 had permanent improvement in ICP

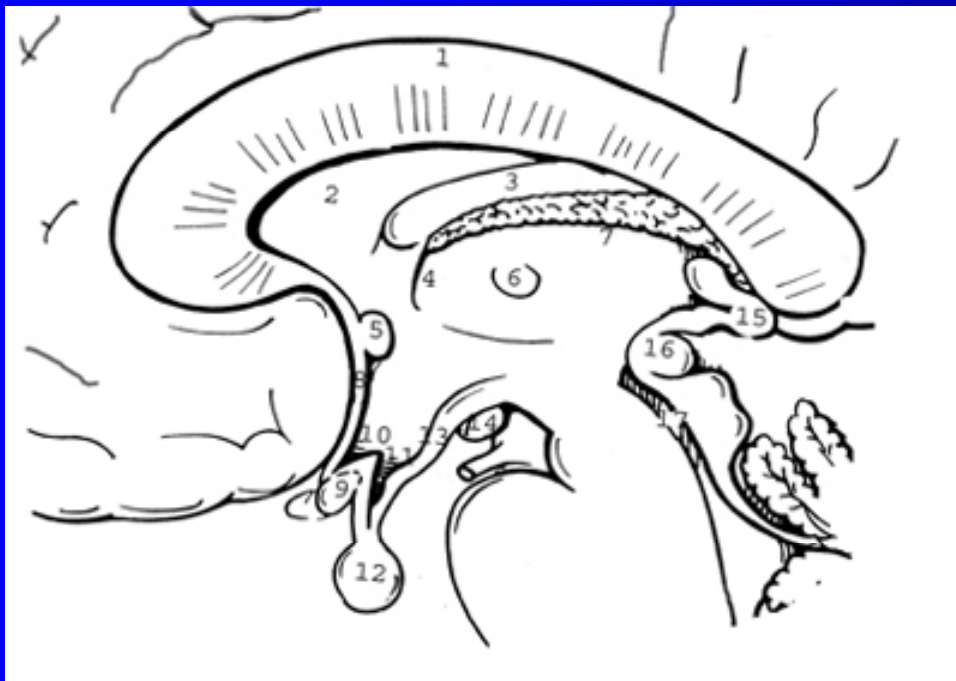
History

- In the 1950s, ventricular shunts and valves were developed. This led to less interest in ETV.
- Mid 1980's minimally invasive neurosurgery became popular leading to a renewed interest in ETV and neuroendoscopy.

Operative Technique

- General Anatomy
- Endoscopic Anatomy
- Tools
- Technique

Anatomy of the Third Ventricle

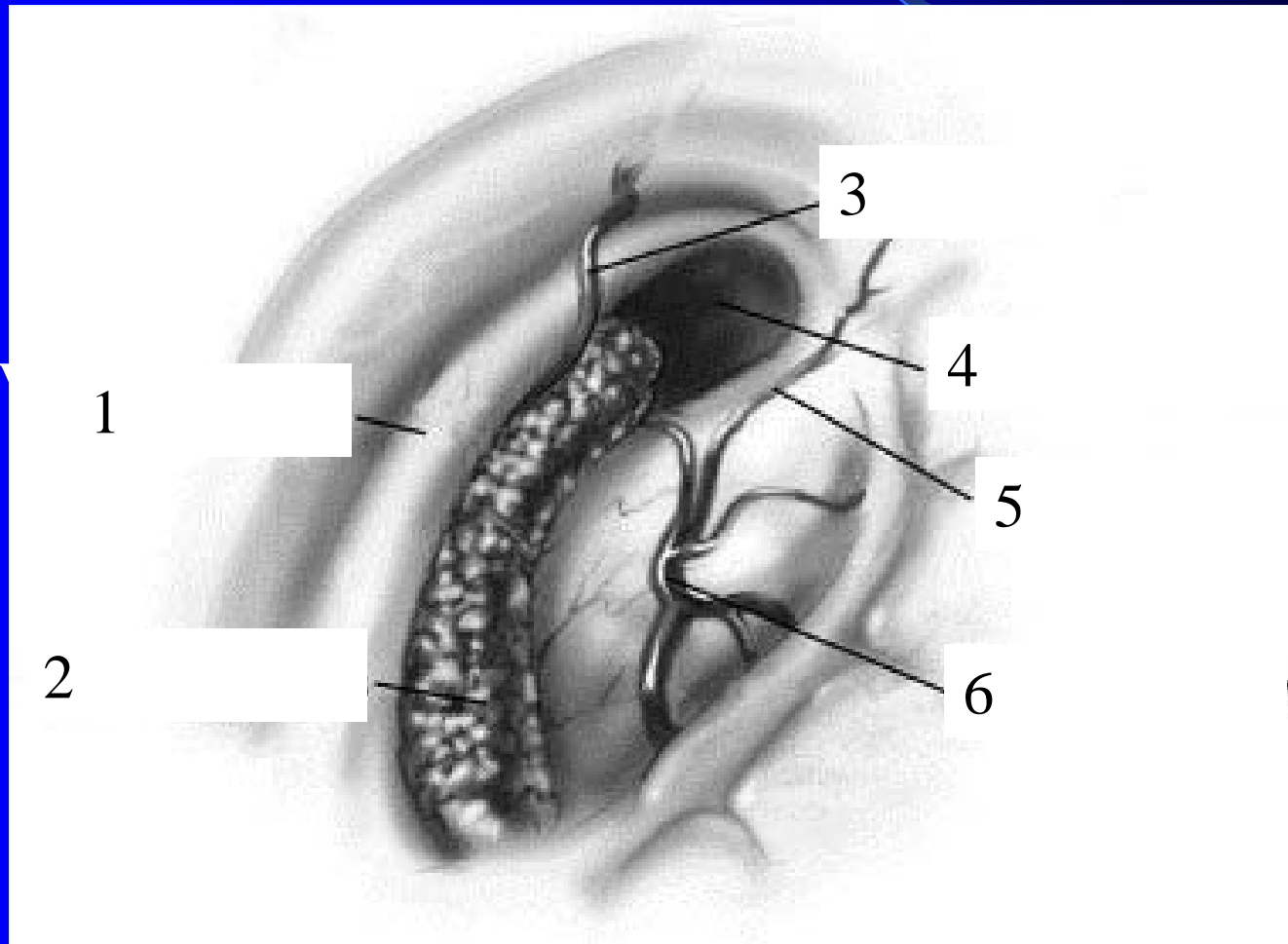


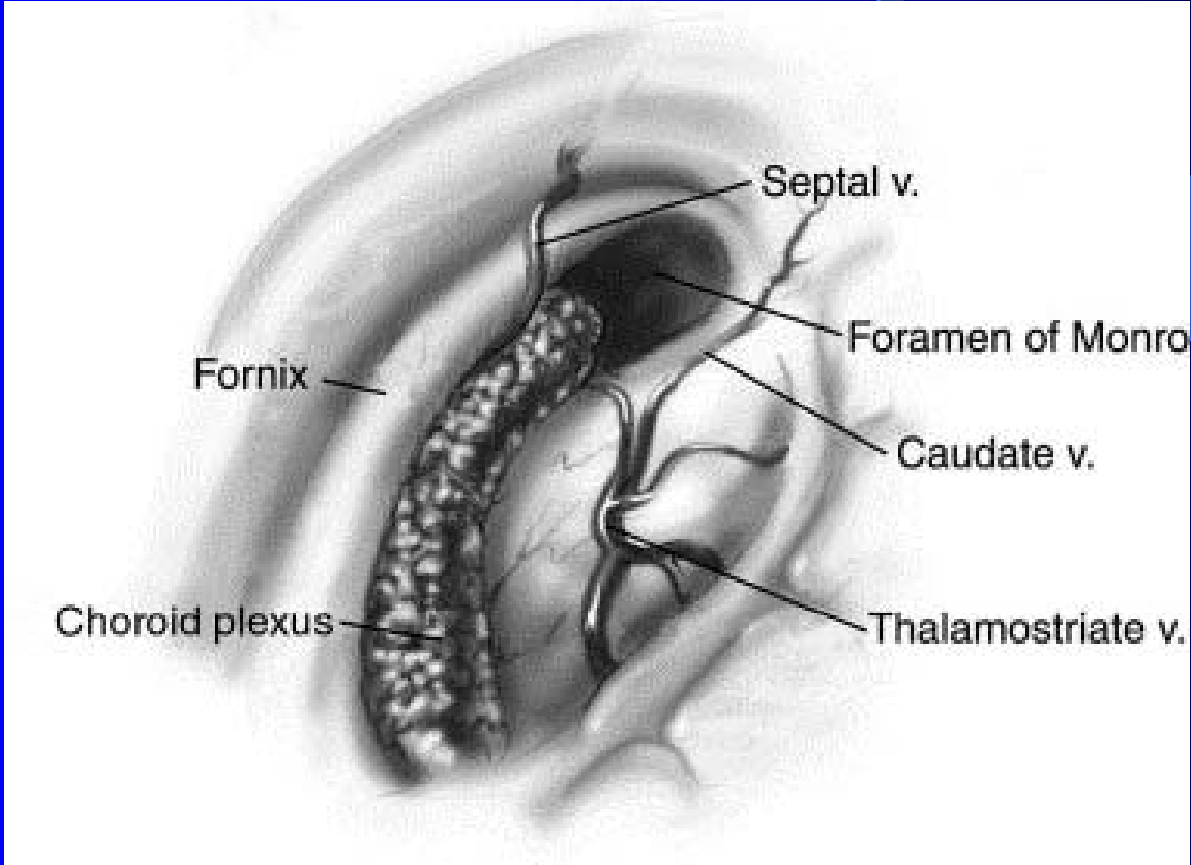
- 1: CC
- 2: Septum pellucidum
- 3: Fornix
- 4: F of M
- 5: AC
- 6: MI
- 7: Choroid
- 8: LT
- 9: OC
- 10: Optic recess
- 11: Infundibular recess
- 12: Pit Gland
- 13: Tuber Cinereum
- 14: MB
- 15: Pineal
- 16: PC
- 17: Aqueduct

Can you name the structures?

Anatomy of the Lateral Ventricle

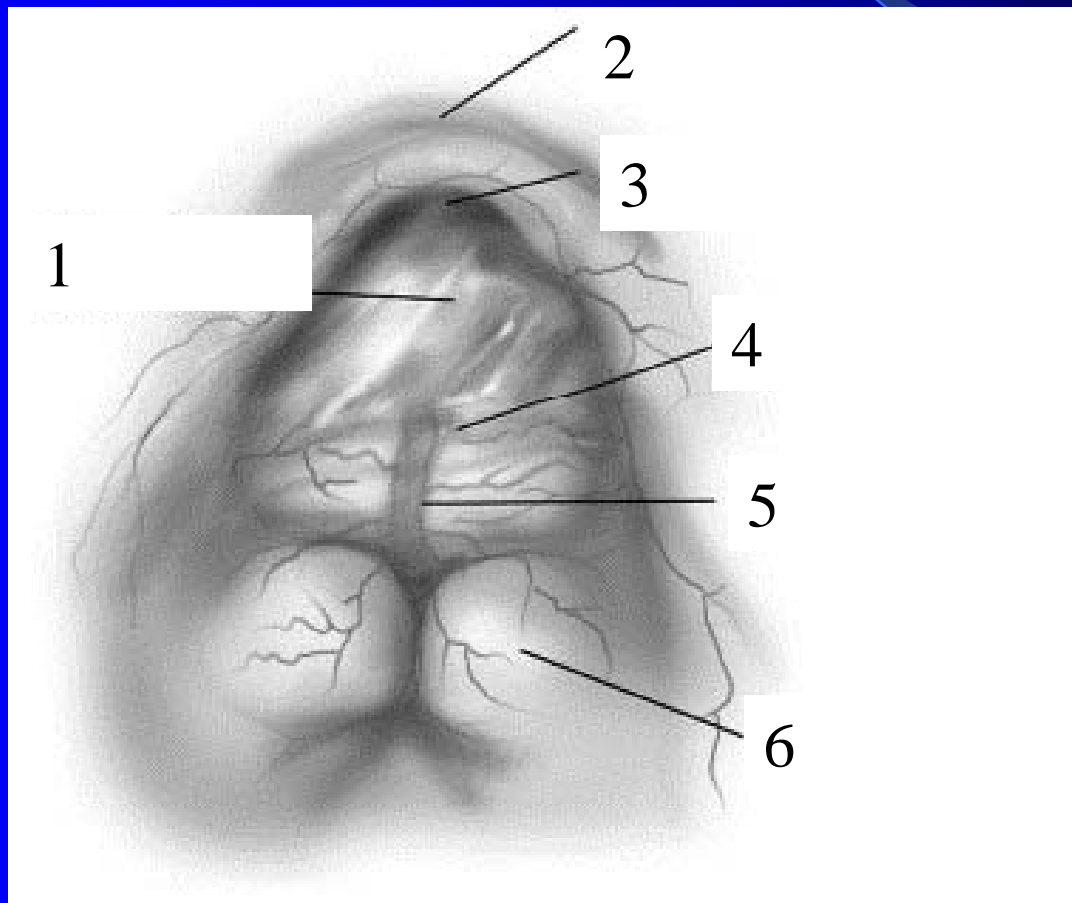
1. Fornix
2. CP
3. Septal V
4. F of M
5. Caduate V
6. TS V

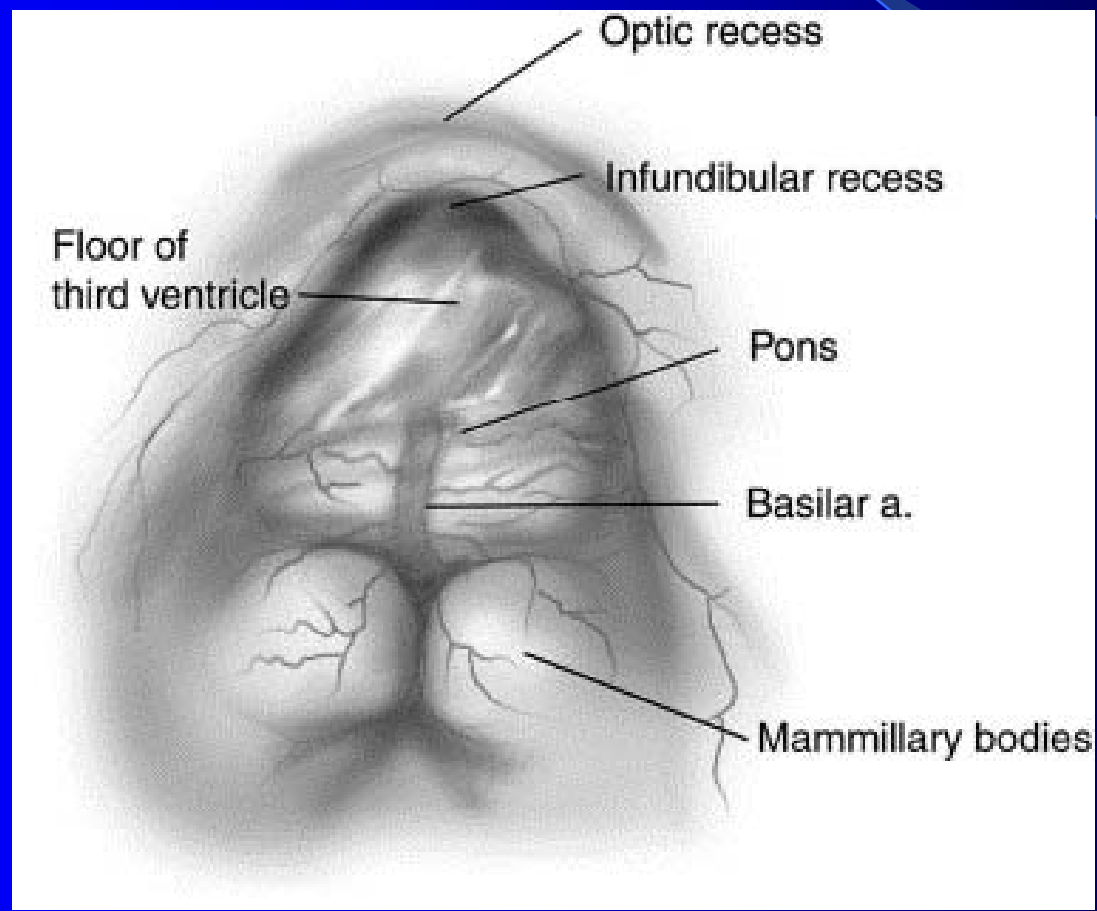




Anatomy of the Floor of the 3rd Ventricle

1. Floor
2. O R
3. I R
4. Pons
5. Basilar
6. MB

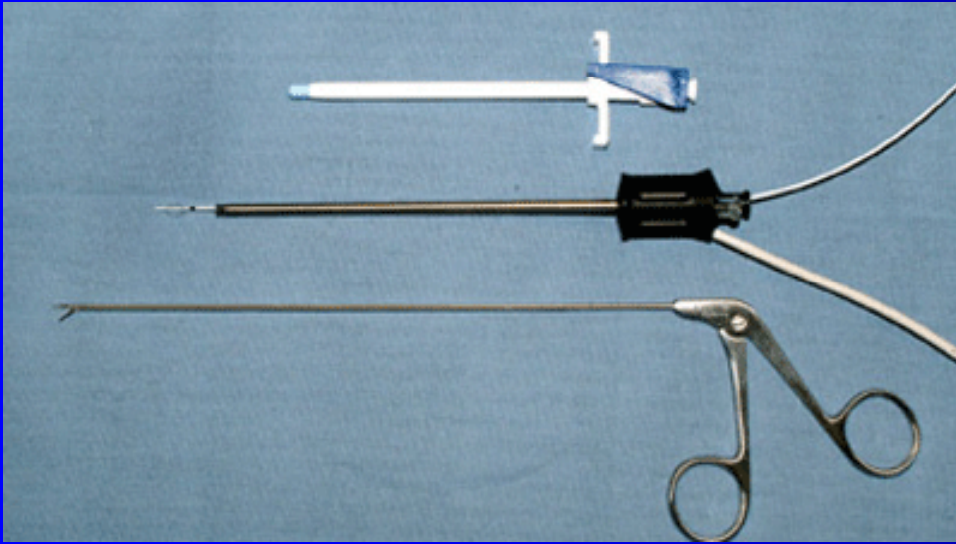




Anatomy of the Floor of the 3rd Ventricle

- Lateral Walls: anterior 2/3 of the thalamus and hypothalamus. These are joined together by the massa intermedia.
- Posterior anatomy: pineal body, habenular commissure, posterior commissure, and the cerebral aqueduct
- Anterior anatomy: In the AP direction
 - Optic Recess
 - Optic Chiasm
 - Infundibulum
 - Infundibular recess
 - Tuber Cinereum
 - Mamillary Bodies

Technique: Tools



Working instruments

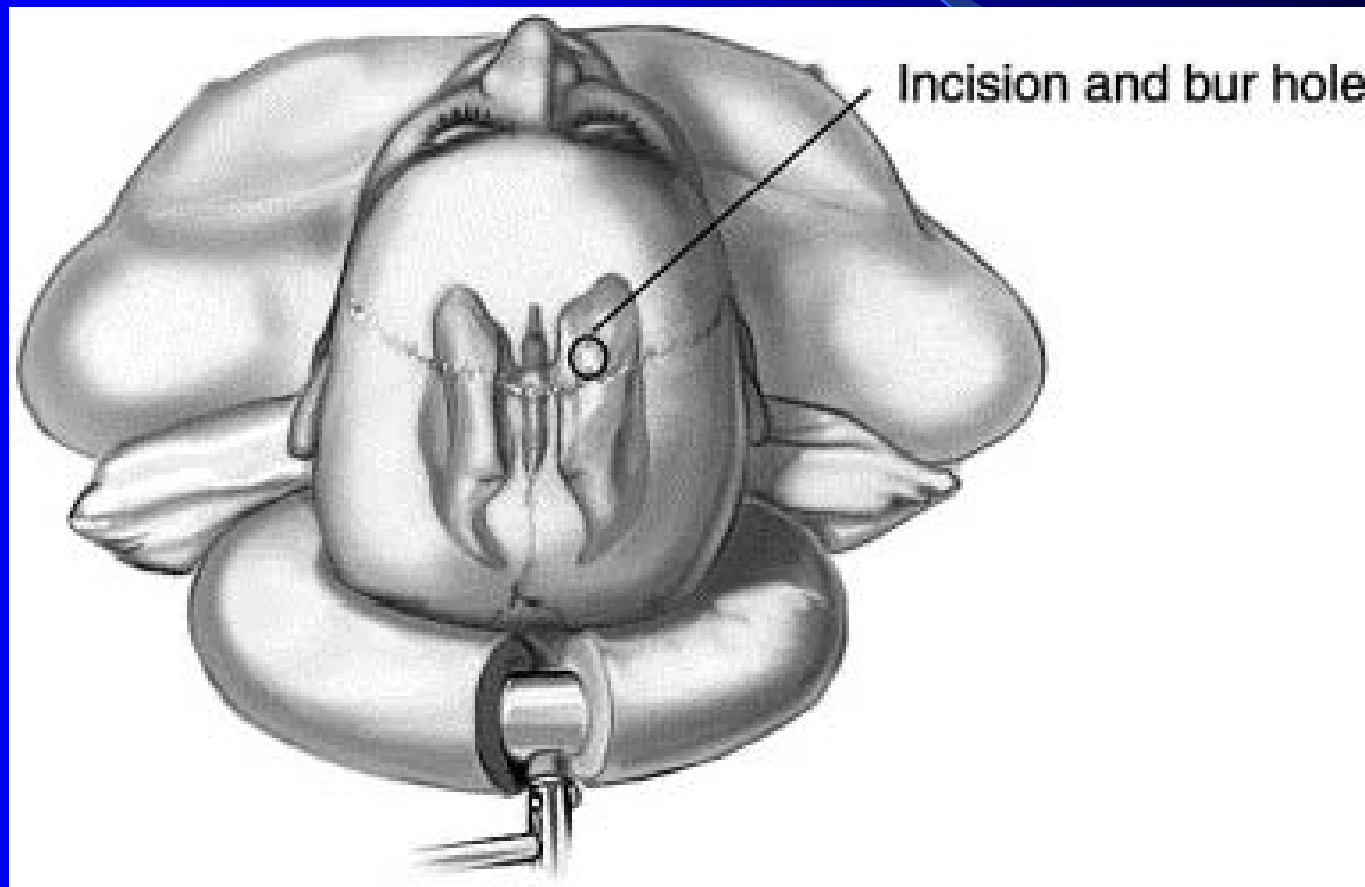
1. Grasping forceps
2. Biopsy forceps
3. Scissors
4. Bipolar coagulation
5. Cutting probe



Basic Operative Technique

- Determine entry point and enter ventricular system
- Finding and entering the Foramen of Munro
- Inspecting the floor of the third ventricle
- Perforating the floor of the third ventricle
- Enlarging the perforation (approx 5 mm)
- Inspecting the pre-pontine cistern

Technique: Targeting



Technique: Targeting

- Non Stereotactic Method – Freehand Method
 - Preoperative MRI evaluation of neurovascular structures below floor
 - Burr hole at coronal suture and mid-pupillary line, approx 2-3 cm lateral to midline
 - Aim endoscope medially toward medial canthus of ipsilateral eye and toward the contralateral EAM in the AP plane

Technique: Targeting

- Stereotactic Method - Neuronavigation
 - Allows for optimal burr hole position
 - Safest trajectory in cases of large or atypical ventricles
 - Helps to reduce traction on foramina of Monro-related structures
 - Kelly et al., described stereotactic third ventriculostomy in 1986
 - Target Point: Point in the midline between dorsum sella and the basilar artery
 - Entry Point: Foramen of Monro (side of entry). Extend line to skin for skin entry point

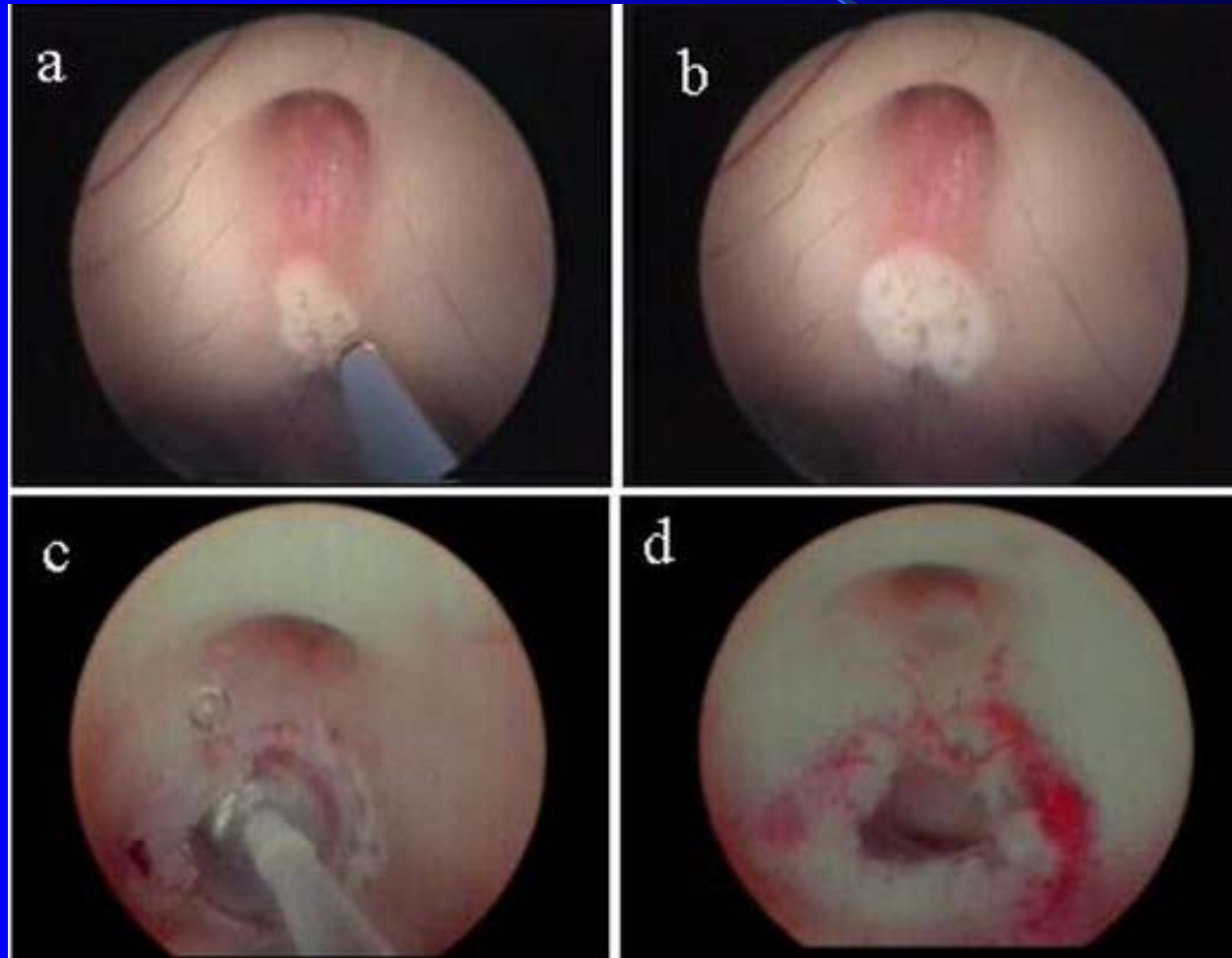
Technique: Introduce Endoscope

- Create burr hole and pass a 14 French peel away sheath into lateral ventricle
- This can be done freehand or with a rigid fixation arm system
- Introduce endoscope through the sheath and navigate through the Foramen of Monro
- Identify structures on floor of 3rd ventricle

Online Video

The background is a solid blue gradient. A thin, light blue curved line starts from the top left and arcs towards the right. A larger, semi-transparent blue triangular shape is positioned on the right side, pointing towards the center of the slide.

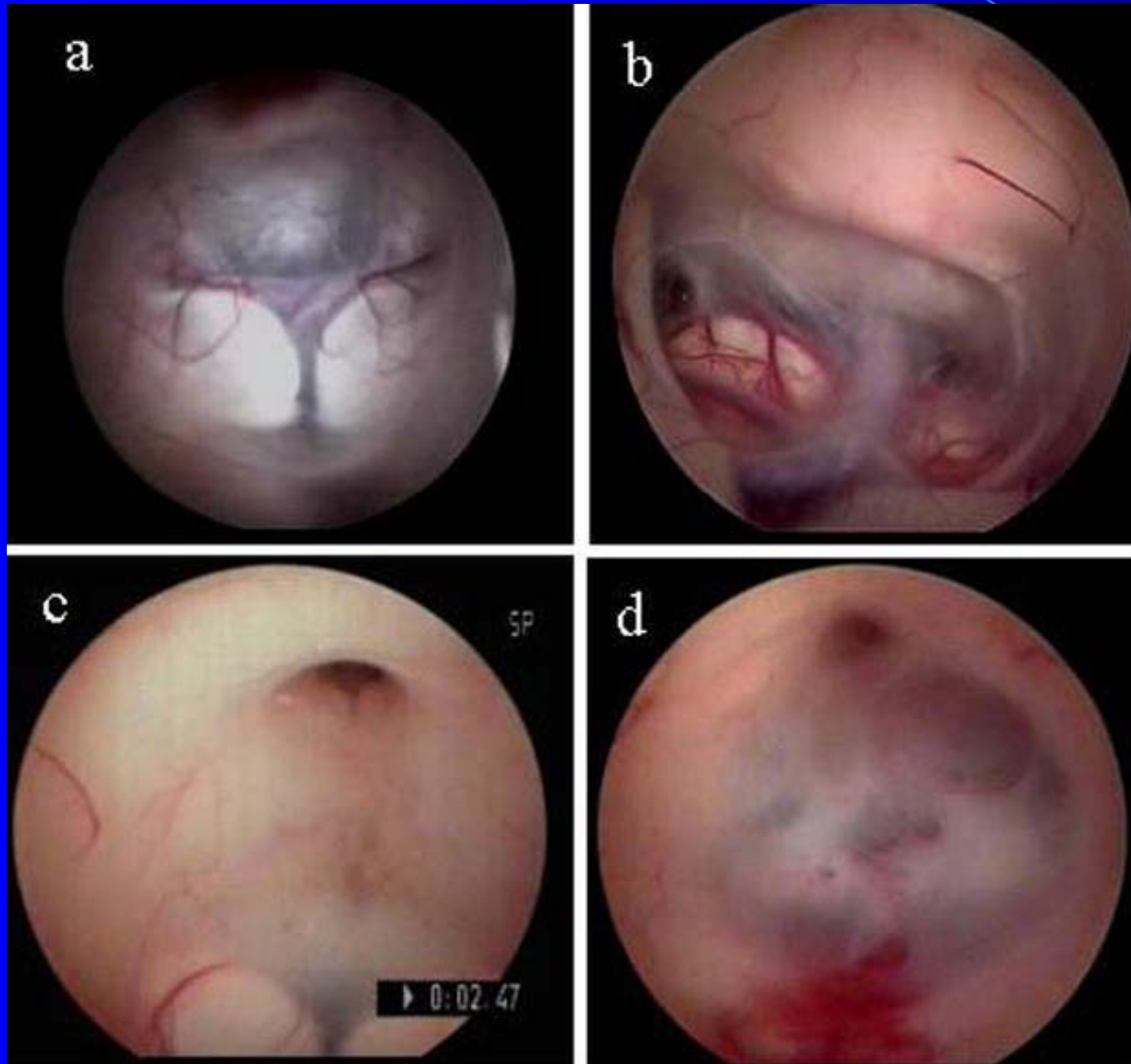
Technique: Fenestration



Technique: Fenestration

- Multiple methods exist for perforating the floor including:
 - Blunt probe
 - Laser probe
 - Ultrasonic contact probe
 - Electro-coagulation and cutting probes
- Dilation of the fenestration is achieved using a Fogarty balloon catheter

Variants of the Floor



Can you tell
the difference
between AB
and CD?

Key Points

- Longstanding hydrocephalus or increased ICP can alter the anatomy of the floor.
 - Upward ballooning of the floor
- Must explore the pre-pontine space and open membrane of Liliequist for a successful ETV.
- Liliequist extends from the upper border of dorsum sellae to the anterior edge of mamillary bodies.

Patient Selection- Indications

- ETV is the treatment of choice for aqueductal stenosis caused by anatomic, inflammatory, and some neoplastic etiologies.
- Preferred treatment for congenital AS, less successful in patients with acquired AS

Indications

- Primary Aqueductal Stenosis
 - Most common indication
 - Multiple studies available for review
- Isolated Lateral Ventricle with hydrocephalus
 - ETV in combination with septal fenestration
- Idiopathic Stenosis of foramen of Magendie and Luschka
 - Several case reports reporting successful management of hydrocephalus

Indications

- Isolated 4th Ventricle
 - 4th ventricular obstruction combined with functional occlusion of the aqueduct
- Dandy Walker
 - Case reports of performing ETV and placing a stent from the 3rd ventricle to the posterior fossa cyst. Successful in two patients, failed in one.
- Intraventricular Hematoma
 - Used in patients with supratentorial IVH as a method to aspirate clot
 - Also used to treat patients with cerebellar hematomas with obstructive HCP

Indications

- Intraventricular Tumors
 - Used to relieve HCP and perform tumor biopsy
 - McArthur et al., reported long term control of HCP and tissue diagnosis in 55/66 (83%) of patients.
- Pineal and Tectal Tumors with HCP
 - One step procedure to include ETV and biopsy
 - Risk: Case reports of germinoma recurring along ventriculoscope tract
 - Wellon et al., reported 13 patients with tectal plate gliomas and HCP. All underwent ETV with symptoms resolved at 31 months

Indications

- Posterior Fossa Tumors
 - Saint Rose et al., performed ETV prior to posterior fossa surgery. They found that this significantly reduced risk of postoperative HCP.

Indications

- Post-infectious/post hemorrhagic HCP
 - Less successful
- Slit Ventricle Syndrome
 - Case reports
- Communicating Hydrocephalus
 - Indications not clearly defined or understood
 - Some reports of improved symptoms, thought to be due to a functional obstruction
 - Case reports

Complications

- Vascular Injury: basilar artery injury
- Bradycardia
 - Incidence as high as 41%
- Respiratory Arrest
- Diabetes Insipidus
- Pneumocephalus
- Subdural hygromas, hematomas
- Death: subarachnoid hemorrhage, late failure of ETV (from post-op to 7 years later)

Measurable Outcomes in Literature Review

- Shunt Independence- Success and Failure
- Change in ventricular size
- Patency of stoma

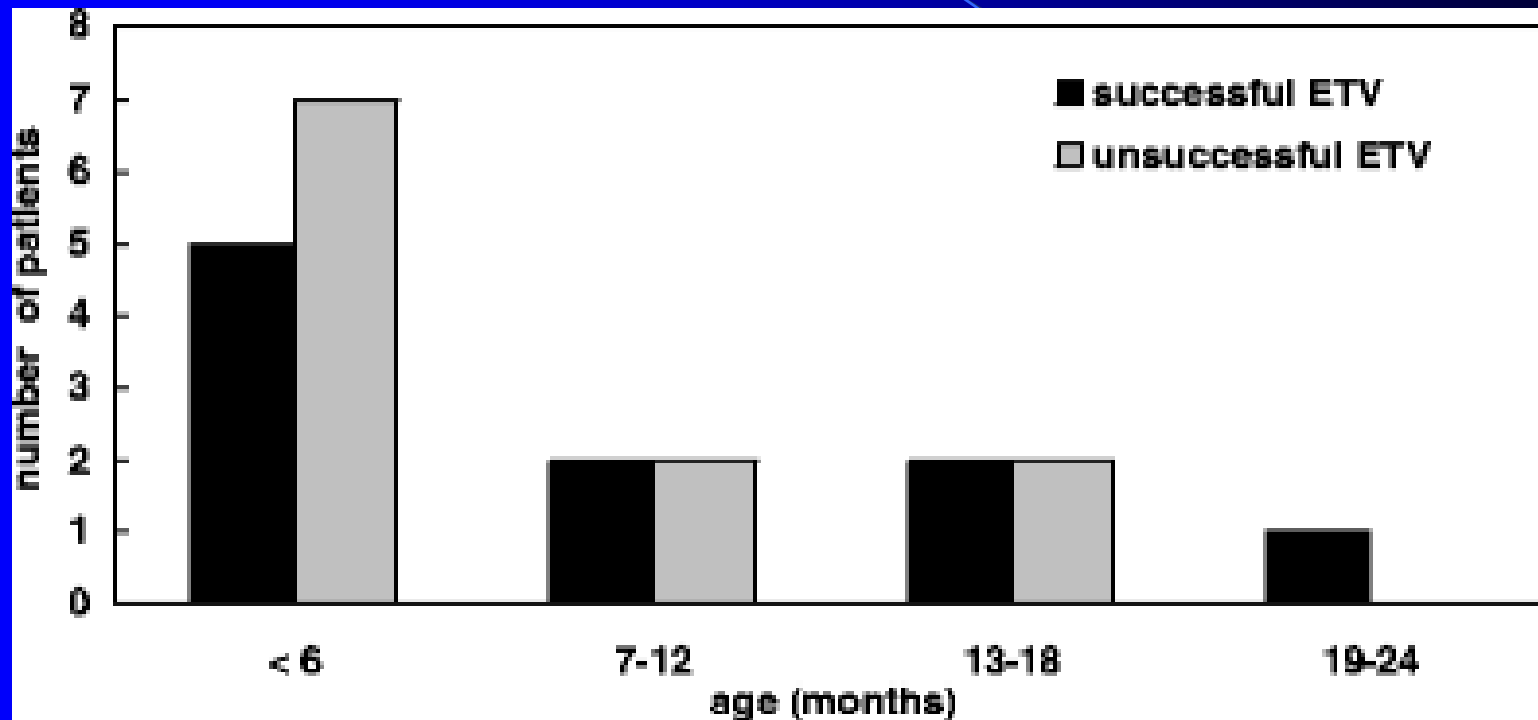
Infant Outcomes

- *Baldauf et al., Child Nervous System, 2007.*
- ETV under age 2 is controversial because of high failure rate and technical difficulties
- Methods
 - 21 patients
 - Mean age 6.7 months, range 9 days to 15 months
 - 8 aqueductal stenosis, 4 congenital anomalies, 3 post hemorrhagic, 3 tumor related

Infant Outcomes

- Results

- ETV successful in 9/21 (43%) patients with mean follow-up of 26.2 months
- ETV successful in 37.5% of patients under age 1
- ETV unsuccessful in 12 patients with mean follow-up of 3.3 months



- Failure of ETV in infants has been studied by repeat ETV
 - 1) reclosure of the ventriculostoma;
 - 2) narrowing of the ventriculostoma; and
 - 3) patent ventriculostoma with new arachnoid membranes in the basal cisterns below the floor of the third ventricle, not present at the time of the first ETV

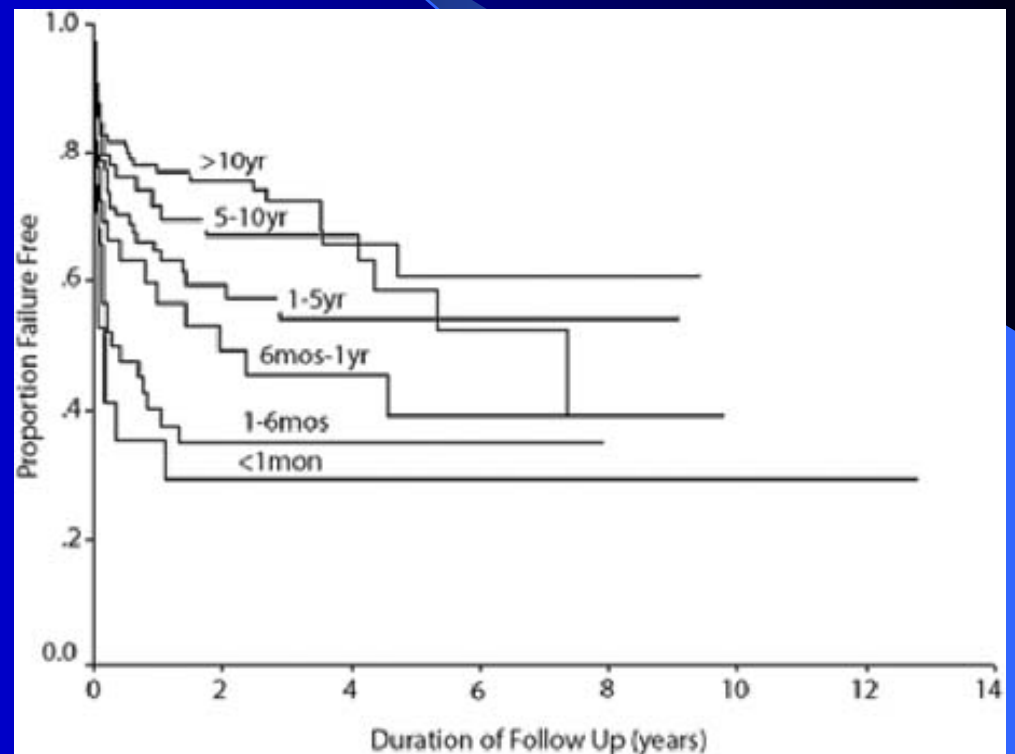
Wagner et al, J Neurosurg, 2005

Pediatric Outcomes: Large Canadian Experience

- *Drake et al, Endoscopic Third Ventriculostomy in Pediatric Patients: The Canadian Experience, Neurosurgery, 2007*
- **Methods**
 - 15 year period, 368 patients
 - The Hospital for Sick Children, Toronto
- **Results**
 - Average age 6.5 years
 - 57% were male patients
 - 34% due to aqueductal stenosis
 - 29% due to tumor
 - 22% had been previously shunted

Pediatric Outcomes

- Success Rates
 - 1 and 5 year success rates were 65% and 52%
 - Only age had significant effect on outcome
 - Younger patients had higher failure rates



Pediatric Outcomes

- Complications

TABLE 1. Complications

Complication	Percentage of patients
Cerebrospinal fluid leak	3.6%
Meningitis	2.8%
Hemorrhage	1.4%
Hypothalamic injury	1.4%
Cranial nerve injury	1.4%
Seizure	1.4%
Other ^a	1.4%
Total	13.6%

^a Two cases of rapid delayed deterioration and death 2 years and 3.5 years after endoscopic third ventriculostomy (10).

Adult Outcomes

- *Feng et al. ETV in the management of obstructive hydrocephalus. J Neurosurg, 2004.*
- **Method**
 - Retrospective analysis
 - 58 patients in one institution between 1999-2003
 - Mean age 35 years old
 - Mean follow-up 24 months

Adult Outcomes

- Results

- At one month, 45/58 (77.6%) patients had improvement in clinical outcome
- Kaplan Meier analysis: One year success 75%
- ETV failed in 8/58 (13.8%) patients with a mean of 3.4 months
- No predictive value of reduced ventricle size on MRI within 2 weeks, however, it was significant in predicting good outcome at 3 months and 6 months

Adult Outcomes

- Patent stoma on cine phase contrast MR images provided high correlation with ETV success

TABLE 3

*Patency of the stoma on cine phase-contrast MR images obtained after ETV in 29 patients with obstructive hydrocephalus**

Cine Phase-Contrast MRI	Successful ETV	Failed ETV
positive	12	4
negative	5	8

* Pearson chi-square test: $\chi^2 = 3.948$, $p = 0.047$ (asymptotic significance [two sided]).

Adult Outcome

- Complications
 - Seven major complications (12.1%)
 - Intraoperative venous bleeding
 - Intraoperative arterial bleeding
 - Occlusion of the ventriculostomy immediately postop

Long Term Outcomes

- *Kadrian et al. Long Term Reliability of ETV. Neurosurgery, 2005.*
- **Methods**
 - Retrospective analysis
 - 181 patients (203 procedures) from one institution over 22 years
 - From 1979 to 2001
 - Age range 2 days to 78 years old
 - 51% male
 - 54/118 (54%) patients less than 2 years old

Long Term Outcomes

- Results

- 22 patients had initially unsuccessful procedures
- Surgical success: probability of performing an successful ETV was 89%
- Failure to perforate floor: 9.3%
 - Excessive bleeding
 - Thickening of the ventricle floor
 - Unfavorable anatomy

Long Term Outcomes

- Reliability of ETV was stratified according to age.
 - 0-1 month: 31 % success
 - 1-6 months: 50% success
 - 6-24 months: 71% success
 - Greater than 24 months: 84%
- 16 patients had ETV revisions with a success rate of 65% at four year follow-up.

Long Term Outcomes

- Complications
 - Infections occurred in 9 patients (4.9%)
 - One case of midbrain injury
 - One case of rupture of basilar aneurysm
 - One death due to delayed failure of ETV

ETV following VPS malfunction

- *Woodworth et al, Neurol Res, 2007*
- 11 patients underwent ETV at VPS failure
- Compared to patients who underwent ETV as primary procedure (16 patients)
- Following ETV at time of shunt failure, 71% of patients experienced immediate improvement, but only 25% remained recurrence free at 2 years.
- ETV after shunt failure was 2.5 fold more likely to fail

Repeat ETV for Failures

- *Sioman et al., CNS, 2001*
- 20 patients underwent repeat ETV
- Age ranged from 8 months to 53 years
- Intraoperative finding at repeat ETV
 - 1. Occlusion by scar (10 cases)
 - 2. Virginal floor of the third ventricle (5 cases)
 - 3. Pinhole ventriculostomy (3 cases)
 - 4. Incompletely penetrated membrane (1 case)
 - 5. Blood clot occluding orifice (1 case)
- Repeat ETV successful in 65%
- Seven patients required placement of VPS after repeat ETV (35%)

Evaluating Patency of ETV

- This has been a challenging problem especially in cases where the clinical course is unclear
 - Cine-mode MRI is able to detect flow across ETV
 - Minor flow appears to be an early sign of closure
 - Doppler Ultrasonography can be used to detect flow

ETV Patency on Imaging

- *Bargallo et al., AJNR, 2005*
- Goal: To determine the utility of cine phase contrast MR imaging to determine efficacy of ETV.
- 25 patients reviewed at one year
- Results
 - Restoration of pulsate motion of CSF circulation observed post operatively.
 - The stroke volume registered at ventriculostomy was maintained with time.

Changes in Ventricular Size

- *Schwartz et al., J Neurosurg, 1999*
- Compared preoperative lateral and 3rd ventricular size with serial post-op CT in 16 patients
- At 21 days, 15 patients symptomatically improved. One patient did not improve.
- 3rd ventricular volume decreased by mean of 35%

Lumbar Puncture

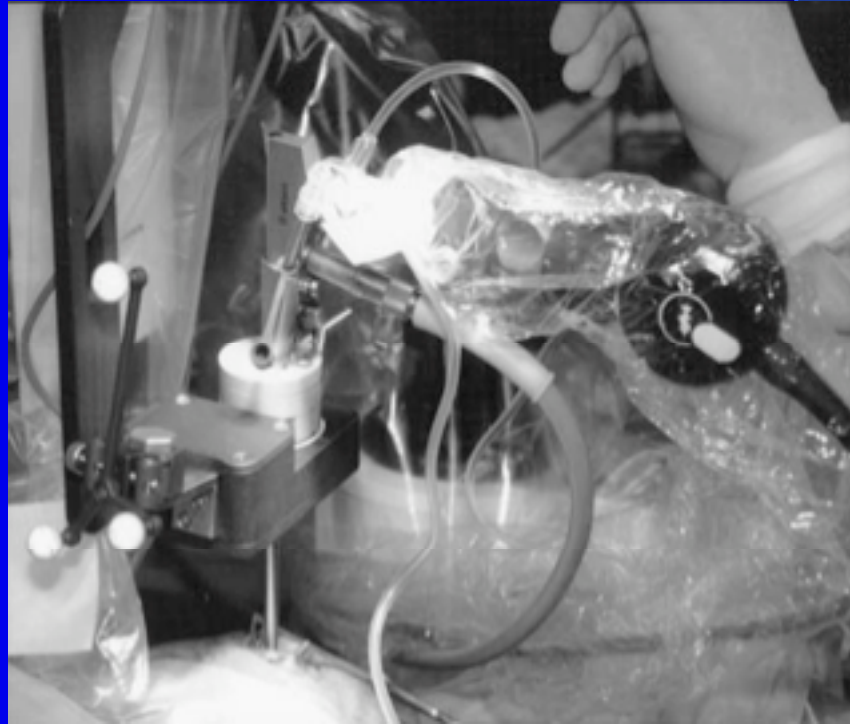
- *Cinalli et al., Neurosurgery, 2006*
- Recorded ICP in 64 patients who underwent ETV
 - In 54.5% ICP was persistently high, however decreased slowly over the course of 2-9 days.
 - LP was noted to bring about fast normalization of ICP and resolution of clinical symptoms

New Concepts

- Robot assisted ETV:
 - *Zimmerman et al. Acta Neurochir, 2004.*
 - Robot “Evolution 1”
 - Used for robot-assisted navigated ETV in six patients with aqueductal stenosis
 - ETV initially successful in all patients
 - Time to setup robot decreased from 60 min with first case to 30 min

Robotic ETV





Future

- Virtual training models

- http://www.umi.cs.tu-bs.de/full/research/virtual_med/robosim/robosim.html