**CSF shunting procedures**

**SHUNT TIE-OFF**

- use thick silk.
- place sleeve of rubber (e.g. opened rubber shod) on catheter - if later will need to untie, will cut on rubber and not on catheter.

**VENTRICULOOPERITONEAL (VP) SHUNT**

**RESOURCES**

R. Jandial “Core Techniques in Operative Neurosurgery” (2011)

**PENDING READ**: Connolly ch. 118-121, 123

Karl Storz NeuroEndoscopes and Instruments >>

**INDICATIONS**

1. Hydrocephalus, communicating or obstructive:
   a) not amenable to endoscopic third ventriculostomy
   b) not amenable to treatment of primary etiology (e.g. removal of 4th ventricle neoplasm).
2. Failure of previously placed shunt system

**CONTRAINDICATIONS**

1. Fevers
2. Any evidence of active intracranial infection
3. Abnormal CSF rheology (pleocytosis, intraventricular hemorrhage or SAH with still bloody CSF)
   N.B. high protein (e.g. > 100) does not affect shunt performance!
4. Body weight < 2 kg (relative)
5. Peritoneal cavity with reduced absorptive capacity (e.g. multiple operations, recent abdominal sepsis, known malabsorptive peritoneal cavity).

**PREOPERATIVE**

1. Check CSF (protein content, pleocytosis, infection)
2. Clamp EVD at midnight to expand ventricles (for pediatric / critical patient may raise EVD instead of clamping)
3. Recent CT / MRI

**EQUIPMENT FOR OR**

Valve and programming device
Catheter
Manometer
X-ray (for air ventriculogram) / ventricular endoscope / O-arm – all for verification
C-arm – for finding old catheters (in revision cases)
Laparoscopic tower

**PROCEDURE**

- supine with head turned to left.
CSF SHUNTING

JRC - bump under shoulders (Holloway – only for kids – large head) to allow for straight trajectory from right occiput, across clavicle, to abdomen.

Tye, Collins place large bump under shoulders to get good neck extension; Collins covers entire prep zone perimeter with self-adhesive clear plastic drape “3M 1010” (keeps patient dry and warm – allows to keep lower temperature in OR and keep sheets dry)

PREP

Ritter uses alcohol → Betadine → Chloraprep.

Ritter may not use local anesthetic to prevent introducing skin flora.

Tye uses Betadine for kids < 2 months.

Remove EVD (unless doing soft pass or on opposite side – may leave EVD until end of case – remove all stitches, pull EVD a little bit until you see sterile part and tie long silk string on it; drop silk down so that anesthesia can pull it in the middle of case; prep and drape so that catheter is hidden).

Tye does not use staples to keep drape! Collins uses lots of staples. Ritter uses few staples.

CRANIAL PORTION

curvilinear (horseshoe or C*) scalp incision over planned bur hole; very little horseshoe radius for infants; Ritter creates opposite direction horseshoe flap in pericranium.

with knife/needle electrocautery; may incorporate EVD incision (unless infected).

*base towards shunt direction

N.B. use shallow C (complete C is suboptimal for blood supply)

Entry and trajectory

Frontal – see p. Op6 >

Occipital – see p. Op6 >

Dr. Day:

1) use stylet always, never soft pass (catheter easily gets deflected).

2) use bur-hole ultrasound to guide the catheter!

Bur hole:

a) with 14 mm perforator (Young saves bone dust and replaces back to bur hole at the end)

b) with M8 bit – better small hole, esp. for little kids to prevent CSF leak (Ritter)

for newborns, insert shunt via lateral corner of open anterior fontanel:

Tye – coagulate soft tissue membrane with bipolar layer by layer until entering CSF space

Collins – incise scalp skin over mosquito (advanced under galea), then open dural membrane by gentle incision with #15 blade.

for premature kids use tip of # 15 blade to scrape hole in cranium.

Valve

create subcutaneous pocket with blunt dissection (spreading tonsillar clamp or large Kelly clamp) to accommodate reservoir and valve.

pump valve in saline bucket so no air inside remains (vs. Tye connects temporary short piece of catheter on proximal valve to protect from blood entry into valve and flushes with saline via blunt needle in catheter tip).

inline valve is secured (with silk tie*) to proximal end of distal catheter.

— Tye, JRC, Holloway like fixed medium-low pressure Codman valve (without Rickham)

— Graham uses exclusively Medtronic (Codman has spiral antisiphon device that clogs very often)

— for NPH patients use programmable valves

* knot on undersurface of valve to prevent skin erosion

small hole in dura, same diameter as ventricular catheter, is made by electrocautery applied to blunt needle.
• antibiotic-impregnated Bactiseal ventricular catheter is cut* to appropriate length and passed over stylet into right lateral ventricle
  - JRC, Holloway leave catheter intact but move blue angle bender to 6 cm mark
  - "perpendicular to skull" catheter trajectory usually results in prompt entry into ventricle, and if catheter is advanced while removing stylet, tip of catheter heads toward frontal horn.
  - intraoperative US/CT/MRI, intraacatheter endoscopy (Neuropen®; need to make slits in catheter tip beforehand); frameless stereotaxy can be useful adjuncts for ventricles that are difficult to cannulate.
  - ventricular cannulation failure:
    a) admit to ICU with hope of progressive ventricular dilatation → respiration
    b) if patient's life is in jeopardy, place shunt in CT scanner suite (or use O-arm).  
* always send CSF for cultural and other studies (e.g. cytology).

• young measures opening pressure with saline-filled manometer.
• may flush and aspirate valve chamber with 25G needle
• young injects 4.5 ml of air inside ventricles (for air ventriculogram in PACU or in OR).
• ventricular catheter is cut and secured* to valve; and valve is placed in previously created subcutaneous scalp pocket.

*never secure ventricular catheter to valve unless CSF is clear (H: gentle irritation through catheter can resolve issues with blood or debris in ventricular catheter).

TUNNELING

• subcutaneous tunneler* (with plastic stylet within) is passed from cranial to abdinal incision (or opposite - JRC, Tye)
  - alternatively, create path and pocket with tonsillar forceps / uterine sound → tie catheter tip with thick silk to incision (or)
  - may need additional incision in neck (most attendings prefer transverse [less chance of "kinking" of distal tubing at level of attachment to skull] catheter trajectory usually results in prompt entry into ventricle)
  - Dr. Tye tries to tunnel as posterior from auricle as possible for small kids.
  - Dr. Collins uses nondisposable long metal tunneler (very stiff - allows long tunnels and tip steering) with plastic sheath over it.

• antibiotic-impregnated Bactiseal distal catheter is passed through tunneler (may continuously spray saline into tunneler lumen to facilitate passage), and tunneler is removed.

if SHUNT ASSISTANT is needed, it is placed at postauricular incision level (tie the silk on catheter to mark location, then pull catheter to scalp incision, place SHUNT ASSISTANT and pull catheter back into position → SHUNT ASSISTANT must be vertical in position).

after confirmation of steady* CSF egress from distal catheter, catheter is fed into peritoneal cavity under direct vision.
  - do not implant peritoneal catheter unless continuous CSF egress is observed.
Correctable issues:
  1) "air blocks" in tubing (H: aspirate with blunt tip needle from distal end)
  2) "kinking" of distal tubing at level of attachment to valve in insufficiently capacious subcutaneous scalp pocket.

ABDOMINAL PORTION

• Tye, Young - horizontal incision close to midline in right mid- abdomen → cricket retractor → cut anterior rectus sheath vertically and split muscle fibers bluntly longitudinally → see peritoneum
• Ritter - vertical incision in right mid-abdomen with needle electrocautery.
• JRC, Broadus - 4-5 cm midline* incision 2 finger breadths below xiphoid; large Weitlaner → linea alba (where fascial fibers cross) incised sharply → two perpendicular (to each other and to the floor) small Weitlaners → see peritoneum
  *muscle fiber division is minimized!

• peritoneum is gently elevated with mosquito clamps and incised with No. 11 blade; avoid bowel injury (insert tip of scissors under peritoneum fold before cutting to make sure bowel is
CSF and flush with ventricle increase; may also think of installing Rickham reservoir at bur hole (will allow to aspirate work as a safety valve and can be pulled on POD1 of EVD drainage very sensitive to EVD clamping.

N.B. if placing shunt because of unable to wean EVD, pull EVD now but ventriculogram, endoscope, o

N.B. for

To minimize infection rate

— Surgical sponges should be avoided.
— Implants should not be opened from sterile packaging.
— Advance catheter through trocar with DeBakey forceps.
— Verify inside peritoneum.
— Insert catheter (make sure trocar is rotated so C openin

— Use special trocar (Codman disposable split trocar – has C shape in cross-section; make sure plastic stylet is locked in place at the end) – advance through subcutis, Scarpa, until feel gritty – it is abdominal muscle-aponeurosis, direct trocar cranially and pressing on it down direct it caudally (this way aponeurosis is made taught – it is attached to rib cage) – pop through aponeurosis; continue pressure down (anesthesia gives Salvalga) and pop two more times – get inside peritoneum.
— Verify inside peritoneum – saline syrinx inject easily in and nothing comes back; plus, catheter is inserted easily without resistance
— Insert catheter (make sure trocar is rotated so C opening faces cranially.
— Advance catheter through trocar with DeBakey forceps.

N.B. if there is any concern regarding placement of peritoneal tubing (i.e., morbidly obese patient, history of laparotomy and excessive scarring), obtain KUB before patient leaves OR.

To minimize infection rate:
— Surgical sponges should be avoided.
— Implants should not be opened from sterile packaging until immediately before use.
— Implants should be handled with surgical instruments using "no touch" technique.
— Externous room traffic should be minimized.
— Expedite surgical time from incision to closure.
— Keep catheters wrapped in the gauze with bacitracin solution.

N.B. for difficult anatomy / revisions for malpositions – consider intraop verification (air ventriculogram, endoscope, or O-arm).

CLOSURE

• Abdominal incision – close peritoneum, fascia, subcutaneous layer, skin.
• Scalp – close galea, skin.

N.B. nonabsorbable monofilament simple running suture to skin minimizes wound breakdown and CSF-cutaneous fistula/occasionally in active child.

— For kids at VCU: use running 0 Monocryl for scalp incision with ± Dermabond.
— For adults at VCU: use staples for scalp incision.
— "No touch" technique; make sure trocar is rotated so C openin

— Use special trocar (Codman disposable split trocar)
— Verify inside peritoneum.
— Insert catheter (make sure trocar is rotated so C opening faces cranially.
— Advance catheter through trocar with DeBakey forceps.

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— Surgical sponges should be avoided.
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— Verify inside peritoneum.
— Insert catheter (make sure trocar is rotated so C opening faces cranially.
— Advance catheter through trocar with DeBakey forceps.

N.B. if placing shunt because of unable to wean EVD, pull EVD now but think twice – if patient was very sensitive to EVD clamping during wean trial (or if ventricles dilate significantly even at low level of EVD drainage), may leave EVD catheter in and clamp and watch patient postop – EVD will work as a safety valve and can be pulled on POD1-2 after postop CT shows good position and no ventricle increase; may also think of installing Rickham reservoir at bur hole (will allow to aspirate CSF and flush with alteplase if system clots off).

* Ritter never places Dermabond on scalp!!!!!!!

N.B. if placing shunt because of unable to wean EVD, pull EVD now but think twice – if patient was very sensitive to EVD clamping during wean trial (or if ventricles dilate significantly even at low level of EVD drainage), may leave EVD catheter in and clamp and watch patient postop – EVD will work as a safety valve and can be pulled on POD1-2 after postop CT shows good position and no ventricle increase; may also think of installing Rickham reservoir at bur hole (will allow to aspirate CSF and flush with alteplase if system clots off).

REVISION CASES

See below >”

POSTOPERATIVE

— Next day:
1) Head CT (Ritter*, JRC do not use it) or head US
• “It takes 3-4 months for ventricles to equilibrate to new true baseline size
2) Plain radiographs of entire hardware system. Shunt series (TV: does not use it) – “If you have concerns, do intraop fluoroscopy”; Ritter may not use as well) - confirm good position + baseline for future.

— Wounds should remain dry for at least 3 days postoperatively, until epithelialization has occurred.
— Monitor every 6-12 months:
• Head growth in infants (occipitofrontal head circumference
• Detailed funduscopy
• Distal tubing length (with plain radiographs) when child grows.
4) Neuropsychological testing and developmental assessment (in younger children)
— Although some children cease to need shunt as they become older, determination of this is difficult, thus shunts are rarely removed.
CATHETERS

ANTIBIOTIC IMPREGNATED

Codman Bactiseal

- Impregnated with two antibiotics: rifampicin and clindamycin

VALVES

CHOICE OF VALVE

Best valve:
NPH: Aesculap ProGAV + Pro ShuntAssist — does not regulate flow, only prevents siphoning.
Small babies: Codman Certas with SiphonGuard — regulates flow independent of position.

Bloody CSF (e.g. after SAH) — need the simplest design (most patients don’t need shunt after several months): fixed medium pressure valve.

Shunt Design Trial

Standard differential pressure valve versus Delta valve (PS Medical-Medtronic) versus Sigma valve (NMT Cordis).
- 344 pediatric patients (age ≤ 18 yrs), 12 centers in North America and Europe.
- Overall shunt failure at 1 year was 19% with all three valves.
- No significant differences in causes of shunt failure between the three valves.
- No significant advantage with any of the three valves.

FIXED PRESSURE

PS Medical Delta (Medtronic)

Cannot be implanted below ventricle level!

Holter valve:
- Dual slit valve mechanism
  - Usually used in combination with Rickham or Salamon–Rickham reservoir
Hakim valve

**PROGRAMMABLE, NON-MRI-RESISTANT (1ST GENERATION)**

**PS MEDICAL (MEDTRONIC)**

- small and regular sizes:

  - Optional Delta Chamber – closed mechanism which opens in response to positive ventricular pressure, but stays closed in response to negative distal pressure – allows pressure in the brain to be maintained within a certain range, regardless of body position – i.e. antisiphon feature.

  - MRI up to 3.0 T may be used any time after implantation and will not damage the Strata II valve mechanism, but can change the performance level setting.

  - provide the full range of Performance Levels: 0.5, 1.0, 1.5, 2.0, and 2.5:
Strata Adjustment Kit:

StrataVarius adjustment system:

**Medtronic Strata NSC (non-siphon-control)**

**Codman Hakim Programmable Valve**

Hakim Programmable Valve >>
PROGRAMMABLE, MRI-RESISTANT (2ND GENERATION)

AESCULAP

MITEK PROVA
- MRI compatible - do not need valve resetting.
- come preset at 5 cmH2O.
- two metal instruments (“sticks”) to adjust valve; approach valve with button depressed – magnet will help to localize valve (may be hidden under scalp edema); valve setting can also be verified on XR.

ShuntAssist

- antisiphon device choice according to patient height:
  - ≥ 6 feet – 30 cmH2O
  - 5-6 feet – 20 cmH2O
  - ≤ 5 feet – 10 cmH2O.

ProSA – programmable antisiphon device.
- needs to be implanted in strictly vertical position – closes system when in vertical position and, thus, prevents siphoning.

CODMAN

CERTAS Plus MRI Resistant Valve >>

1. A range of 8 settings including a ‘Virtual Off’ (Virtual Off ensures operating pressure setting 8 is consistently greater than 400 mm H2O); can be adjusted and verified at bedside!
2. MRI Resistant up to 3 Tesla
3. Has flow regulating unit – spiral tiny canal – opens when pressure differential suddenly increases; N.B. it is more than just antisiphon device (prevents CSF overdrainage when distal pressure drops in vertical position), as it also prevents CSF overdrainage when proximal pressure suddenly increases (e.g. when child cries – CSF dump would cause slit ventricles); thus, “SiphonGuard” is a misnomer – it is more than just a guard against siphoning, it is a true flow regulator!
4. Position INDEPENDENT - can be placed anywhere (occipital, frontal, retro auricular, sub clavicular)
5. Has model with UNITIZED BACTISEAL Distal Catheter

CERTAS Plus Inline Valve with SiphonGuard Anti-Siphon Device:

CERTAS Plus without the SiphonGuard Device:
SOPHYNA POLARIS MRI resistant up to 3T

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Codman CERTAS® Plus Programmable Valve

Codman® HAKIM® Programmable Valve
The Polaris® valve can be associated with SiphonX®, an anti-siphon device, which adds 200 mmH2O in vertical position:

- tantalum weight ball presses on a ruby ball, which occludes the aperture for the passage of the CSF - when SiphonX® is in the vertical position, the ruby ball is subjected to the full weight of the tantalum ball, occludes the anti-siphon aperture and the device adds 200 mmH2O to the operating pressure of the valve; when SiphonX® is in the horizontal position, the device is open and does not add any additional resistance to the operating pressure of the valve; for all intermediate positions, SiphonX® adds a resistance which depends on the angle of inclination.
- by design SiphonX®is not affected by the implantation height relatively to cerebral ventricles.
1 - Operating pressure range visible on Locator MUST match valve range.

2 - Valve location should determine optimum patient position for adjustment. Having valve horizontal is recommended.
3 - Position Locator parallel to valve, with valve seated in center cut-out, and green arrow pointing in direction of CSF flow path, aligning Locator with valve axis.

4 - Place Compass within Locator.

5 - Adjust Locator orientation, in same horizontal plane as valve, so that Compass needle centers within white target circle, and aligns with current operating pressure setting. Note the valve’s current operating pressure setting.

6 - Without moving Locator, remove Compass, then insert Magnet, with center line of Magnet aligned with current operating pressure setting.

7 - Without moving Locator, quickly slide Magnet, with back and forth motion, along the current operating pressure setting axis. With Magnet again centered inside Locator, turn magnet slowly, just beyond the highest or lowest operating pressure setting, whichever is furthest from the initial operating pressure setting. Without moving Locator, remove Magnet vertically, and place Magnet 0.5 meters away from valve, then insert Compass into Locator. If Locator orientation is accurate, Compass needle aligns exactly with the highest or lowest operating pressure setting, providing a reference point for calibration of the Locator along the valve’s axis. If the Compass needle does not align exactly with the highest or lowest operating pressure setting.
setting, re-calibrate Locator, by turning it slightly, in same plane as valve, until the Compass needle does align exactly with the highest or lowest operating pressure setting.

8 - Without moving Locator, remove Compass, then re-insert Magnet, with center line of Magnet aligned with current (highest or lowest) operating pressure setting. Without moving Locator, quickly slide Magnet, with back and forth motion, along the current operating pressure setting axis, and, with Magnet once again centered inside Locator, turn Magnet slowly to new operating pressure setting.

9 - Without moving Locator, remove Magnet vertically (place Magnet 0.5 meters away from valve).

10 - Without moving Locator, re-insert Compass, confirming that needle aligns with new operating pressure setting.

**ANTI-SIPHON FEATURE**

- prevents overdrainage in vertical position (i.e. keeps intraventricular pressure within physiological range when patient is upright) – especially for tall slender elderly people (brain atrophy predisposes to SDH from overdrainage). Caution in obese people – may impede CSF flow.

**Codman Certas with SiphonGuard** - spiral canal opens when pressure differential suddenly increases - regulates flow independent of position (i.e. not just anti-siphon as also prevents overdrainage due to sudden ICP increase); Position INDEPENDENT implantation

**Sophysa SiphonX** – true anti-siphon device, which adds 200 mmH2O in vertical position

**Aesculap ShuntAssist** – must be implanted in strictly vertical position

**Aesculap PresA** - programmable

Medtronic valves with Delta Chamber (e.g. Strata valves) – closed mechanism which opens in response to positive ventricular pressure, but stays closed in response to negative distal pressure – allows pressure in the brain to be maintained within a certain range, regardless of body position – i.e. anti-siphon feature.

**VALVES WITH NO ANTI-SIPHON FEATURE**
Ventriculo-Pleural Shunt (VAS)

- Early postoperative chest radiograph - large effusions can occur in short periods (→ respiratory problems), esp. in children ≤ 10 yo.

Ventriculo-Atrial Shunt (VAS)

- into Internal Jugular using Seldinger technique – IR (interventional radiologist) places guide wire as of placing central line (→ pass peel-away sheath over it) → tunnel catheter into neck and exit at guidewire skin entry site → flush entire shunt system with heparinized saline → insert distal catheter into atrium-SVC junction (use XR to verify).
- Fluoroscopic guidance - to prevent catheter thrombosis (short distal catheter)/cardiac arrhythmias (long distal catheter).
- Additional tubing cannot be inserted to allow for growth – anticipate electively scheduled VAS lengthening procedures (educate patient parents about it).

- Complications: serious - renal failure (shunt nephritis), great vein thrombosis & pulmonary embolism, sepsis, cardiac arrhythmia, pulmonary hypertension, and even atrial perforation and cardiac tamponade have been reported.

- Historically, VAS was 1st choice over VPS until polyethylene distal catheters were replaced by silicone distal catheters – choice shifted back to the peritoneum as the preferred terminus for CSF reabsorption in 1970s.

VPS vs. VAS

- Retrospective analysis
- 544 pediatric shunt patients (459 VPS and 85 VAS) followed for at least 90 d (VPS: 5.9 yr; VAS: 5.3 yr).
- VPS has significantly greater survival in patients < 7 yo (P = .001), but showed no difference in older children (P > 1), more frequent shunt infection (4.0% vs 0.01% VAS, P < .05).
- VAS had a significantly lower rate of infections (P < .05) and proportion of proximal failure as a reason for shunt failure (29% vs 53% with VPS, P < .001).
- No statistical difference in rate of distal catheter failure (P = .08) or valve malfunction (P = .9).
- Complications related to placement occurred at a rate of 5.5% VPS vs 3% VAS.
- No mortality attributed to shunt insertion.

- 54% of VPS and 60% of VAS required at least 1 revision. VPS demonstrated superior survival overall; however, if electively scheduled VAS lengthening procedures are not considered true “failures,” no statistical difference is noted in overall survival (P = .08).

Conclusions

- VPS is preferable due to ease of insertion and more favorable complication profile.
- VPS exhibits a trend towards more revisions being necessary. VAS was prone to more serious complications. VPS is preferable due to ease of insertion and lower morbidity.
- VPS is preferable to VAS due to greater morbidity from VAS.
- VPS is preferable due to ease of insertion and lower morbidity.
- Young children are the most likely to require revision. Pedicle shunts are less durable than Hakim models. VPS may not be superior in all facets due to patient variables.

Ventriculo-Gallbladder Shunt

- check HIDA scan to make sure bladder empties.
**Ventriculo-subgaleal shunt**
- temporary measure until newborn reaches 2 kg for a permanent VPS.
- repeated trans-fontanel taps – too high risk of infection

**SHUNT REVISION**
- prep entire system – may need to open abdomen.
- open scalp incision at valve and proximal catheter junction, medial* and parallel to the valve
  - if distally no flow, extend cranial incision alongside of valve – can reach valve in situ - check distal runoff on catheter.
- replace obstructed component.
- replacing ventricular catheter – never soft pass (catheter easily gets deflected).

**Ventricular endoscopy**
Pending
Jandial, procedure 47

Dr. Collins, Dr. Ritter sometimes use Stealth navigation and pin patient into Mayfield
for infants – use Mayfield Infinity system – very shallow pins (Dr. Ritter always uses adult pins
regardless of age) – just keep head steady without skull perforation while head weight rests on
horseshoe.

- establish scalp entry point with navigation
  - a) simple slit incision
  - b) in horseshoe and pericranium in horseshoe in opposite direction (at the end will help to seal
    CSF leak)
- drill skull hole with matchstick just large enough to fit introducer sheath
  - use "Dr. Collins’ shunt passer" (hollow metal tube with attached SureTrak) to align to trajectory
    and pass Becker catheter to ventricle (note beforehand how deep catheter should go from shunt
    passer tip, then note where is stop mark on Becker catheter flush to shunt passer’s port edge).
  - remove Becker stylet and shunt passer.
- use endoscope (continuous irrigation with warm (!!!) Lactated Ringer sol);
  - about endoscopes – see p. Op140
- align endoscope to 12 o’clock, adjust focus and white balance.
- select on camera “Flexiscope”.
- monopolar cautery:
  1) soft, blunt ended (Bugbee) to coagulate – touch on twist (helps to shrink membranes).
  2) stiff and sharp ended
- hemostasis may be achieved with monopolar cautery and vigorous irrigation (to verify hemostasis,
  pinch irrigation hose to stop irrigation – watch for blood wisp in CSF).
- at the end, put dry Gelfoam (squeezed into cone) through the sheath – to plug parenchymal path
  and bur hole – to minimize CSF leak.
- postop – HOB up.

**Endoscopic Third Ventriculostomy (ETV)**
Pending video
ETV may not work if patient has extensive metastatic deposits in subarachnoid spaces (absorptive
capacity?) H. regular VP shunt.
Classical bur hole site – just in front of the right coronal suture, in midpupillary sagittal plane (allows straight trajectory via right lateral ventricle to foramen of Monro).

- use sharp monopolar probe (without cautery current) to perforate 3rd ventricular floor in several spots just anterior to mamillary bodies; then keep Fogarty catheter balloon inflated a little bit for hemostasis and tissue hole expansion (use 0.2 mL, then may add 0.75 mL balloons); a use microforceps to remove tissue debris.

N.B. do not go too anterior – will damage pituitary stalk and cause DI!

- then advance Fogarty catheter – need to perforate Liliequist arachnoid membrane below 3rd ventricle floor – should clearly see dorsum sellae and basilar artery.

Liliequist membrane – see p. A40 >=

- may use monopolar cautery (Bugbee) to coagulate choroid plexus.

- may place Ommaya reservoir with catheter in ventriculostomy orifice – keeps orifice open and also gives access to CSF in case ETV fails; alt – may leave clamped EVD in place postoperatively.

- may take biopsy during same procedure by endoscopic guidance.

- at the end, may close dura completely with running 2-0 silk.

A. Septum pellucidum
B. Column of fornix
C. Body of fornix
D. Caudate nucleus
E. Anterior caudate vein
F. Foramen of Monro
G. Thalamostriate vein
H. Thalamus
I. Choroid plexus
SEPTOSTOMY

Need more lateral bur hole than for Kocher approach (classically – lateral eye canthus); use endoscope and Fogarty balloon.

Dr. Collins:
- uses navigation for better orientation (e.g. to avoid injury to fornices) – chose entry and target points so trajectory spans frontal horn (important if ventricles are slit)
- uses SureTrak attached to “Dr. Collins shunt passer” secured in Mitaka robotic arm
- measure the distance (on Stealth) from Dr. Collins shunt passer tip to target; insert Becker catheter through shunt passer so that exact length exits, then mark Becker at proximal end flush to shunt passer hub; align shunt passer to trajectory and pass Becker; remove shunt passer; advance 10F peel-away sheath (aka introducer) on the Becker catheter; staple peel-away sheath hands to the skin; insert endoscope through sheath.
- locate septum and poke with sharp monopolar tip (use coagulation intermittently) or just mechanically with blunt Bugbee tip; hemostasis with monopolar Bugbee; then insert 2F Fogarty balloon and dilate the opening with balloon (also helps with hemostasis).

LUMBO-PERITONEAL (LP) SHUNT

(Spektler Catheter >>)
Pressure control is achieved through combination of double slit valve at peritoneal end and small inner diameter catheter.

INDICATION

Pseudotumor cerebri
- may consider preop ICP monitoring, LPs with opening pressure measurements.
**PROCEDURE**

- Left lateral position on bean bag.
- Use loupes and headlight (usually midline incision sags downward – need to look upwards and no OR light will help).
- Sit on chair.
- Incise skin in midline over L4 and L5 spinous processes.
- Dissect down to fascia.
- 14G Tuohy needle is inserted at L4-5 interspace (under optional fluoroscopic guidance – usually don’t need it).
- Spetzler lumbar catheter is advanced to lumbar subarachnoid space (if have fluor available, may inject contrast to verify myelographic effect); place 2-0 silk purse string on fascia around catheter (while needle is still in – protects catheter); suture 1-2 butterfly plastic anchors (around catheter) to fascia.
- Good distal CSF egress must be verified (if needed, attach blunt needle and aspirate air bubbles)
- Tunnel catheter from spine to abdomen using bent tunneler.
- Place into peritoneal cavity (e.g. laparoscopically).
- If using valve (often Spetzler is enough and no valve is needed).
  - Create pocket for valve in flank subcutaneous fat with big Kelly clamp
  - Tunnel distal Bactiseal catheter from spinal incision to lateral abdominal incision
  - Connect valve to Bactiseal
  - Connect short segment of Bactiseal to proximal valve inlet, then stepdown connector (as Spetzler lumbar catheter is of smaller diameter).
  - Trim Spetzler lumbar catheter short and connect to stepdown connector.
  - Pull Bactiseal catheter to abdomen while situating valve in pocket.