CSF Overdrafange – Too much of a good thing

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Normal CSF Physiology

- CSF Volume in adult: 150 ml
- CSF Turnover in 24 hours: 500 ml
- CSF secretion rate: ~ 20 ml/hr ~ 500 ml/day in adults
CSF Flow
Shunt complications

• Shunt obstruction ~ 50%
• Shunt infection ~ 15-20%
• Shunt overdrainage ~ 10%
Shunts

Ventriculoperitoneal Shunt Placement

- Enlarged Left Ventricle
- Entry into Cranium
- Valve (Behind Ear)
- Underneath Skin
- Extra Tubing in Peritoneal Cavity for Growth
- Distal Catheter
- Shunt Valve
- Ventricular Catheter
Monroe-Kellie doctrine

\[ V_{\text{intracranial}} = V_{\text{brain}} + V_{\text{blood}} + V_{\text{csf}} \]

Good compliance in children – brain ISF increases – slit ventricles

Poor compliance in adults (stiff brain) – blood vessels (veins) expand – subdural hematoma
CSF flow through shunts

- With simulation invitro of an upright posture (+30 cm differential) flow through conventional differential pressure shunt valves is un-physiologic - 25 to 3000 ml/hr

- Normal CSF production is ~ 20 ml/hr

- For a typical medium pressure valve – 200 ml/ hr for a 25 cm differential.
Symptoms

• Headaches
• Dizziness, ringing in the ears, hearing loss
• Paradoxical worsening gait and cognition

If severe –

• Confusion, seizures, coma – subdural hematomas or shunt obstruction
Headaches

- Positional –
  - worse when upright
  - relived by lying down in a short time
- Worse with exercise or maneuvers that induce a Valsalva
- Worse towards the end of the day
- Intermittent high pressure headaches followed by low pressure headaches
  - (eg: blowing a balloon)
Hearing and Balance problems

• Decreased hearing
• Pressure sensation in the ears – like swimming under water
• Ringing in the ears
• Dizziness
• Constant sensation of floating or walking as if drunk
NPH patients with overdrainage

- May have positional headaches but more commonly ....
- Paradoxical return of symptoms of NPH
  - worsening gait and balance
  - Worsening memory and confusion
If untreated and severe

• Signs of subdural hematoma (bleeding around the brain)

• Signs of slit ventricle syndrome

• Signs of shunt obstruction
Risk factors for overdrainage

- Height increase - gravity
- Low shunt settings
- LP shunts
- VA shunts
Findings on testing

- CT – subdural hygromas/hematomas when severe overdrainage; none if mild or moderate
- MRI – enhancement of dura; sagging of brainstem, tonsillar herniation in LP shunts (iatrogenic “Chiari”)
- Nuc. Med. Shunt patency: Rapid egress of radiotracer from shunt
- ICP Monitoring – negative pressures with upright positioning
Bilateral subdural hematomas from CSF overdrainage
CT for assessing shunt function
Slit Ventricles
Slit Ventricle syndrome
MRI appearance in intracranial hypotension due to CSF overdrainage
CSF Overdrainage in LP shunts
Shunt Patency Study

• Assess proximal catheter patency by aspirating 0.5 cc CSF
• Occlude distal catheter
• Inject radio-isotope
• Flush with appropriate CSF
• Image for 20 minutes; ambulate and image 2 hours later if no flow
VA SHUNT  
T1/2 = 7 MINS
$T\frac{1}{2}$: 2 minutes
ICP changes with position
Treatment options

• Increase shunt settings if programmable

• Add a resistive device – siphon regulatory device

• Replace with a shunt that offers higher resistance to CSF flow

• Replace with a shunt that is flow regulated as opposed to pressure regulated

• Is a shunt still needed – removal ± ETV
Programmable shunts

- Higher shunt settings – higher opening pressures for the valve – more resistance to siphoning
- Needs to be done gradually over several weeks to months
- Risk of underdrainage and return of symptoms
Siphon control devices

- Add variable resistance (low in children; more in taller thin adults)
- Some are activated by upright posture; some by negative pressures when there is too much siphoning of CSF
- Implanted distal to the shunt
- Position crucial for effective operation
Shunt replacement

• Replace with fixed shunts with higher opening pressures or preferably with programmable shunts

• Replace with a flow regulated valve in contrast to a pressure regulated valve; but higher incidence of shunt obstruction
Is the shunt still needed?

- Shunt removal ± ETV

- Stepwise – shunt ligation, monitoring of ICP and imaging
  - If ICP normal and no progressive ventriculomegaly – remove shunt
  - If ICP increases and ventriculomegaly associated with aqueductal stenosis - ETV
Ideal shunt valve

• H. Pornroy –
“…an ideal valve should be flow controlled. Such a valve would have to continuously determine the formation rate and the rate of outflow through natural channels and regulate the flow through the valve so as to remove only the excess fluid.”