POST-TRAUMATIC HYDROCEPHALUS

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10/25/10

• Associated with Delayed Functional Recovery
• Associated with Post-traumatic Seizures
• Responsive to Shunt Placement
• Early identification and treatment can improve the functional outcome of a patient and possibly their quality of life

Why is PTH important?

• Most associated with severe TBI (GCS<8)
• Tends to occur within the first year after head injury
• Reported incidence varies from 0.7% to 90%
• 0.7% to 27% incidence

How common is it?
• Traumatic SAH
• Meningitis
• Cerebellar Contusion
• Intracerebral hematoma with contralateral ventricular enlargement
• Fibrosis after craniotomy

**Contributing Factors**

VENTRICULOMEGALY ≠ HYDROCEPHALUS

• Cerebral tissue necrosis
• Anoxia, DAI
• Slow process ≥6 mos
• Ventricular enlargement is passive
• Asymptomatic aside from deficits resulting from the head injury

**Cerebral Atrophy**
• Active process
• Within 3 mos
• Ventricles progressively enlarge
• Symptomatic
• Clinical Deterioration
• Change in CSF dynamics:
  - ♦ Brain Compliance
  - ♦ Resistance to CSF outflow
  - ♦ Intracranial Pressure

Post-traumatic Hydrocephalus

• Gudeman CT Criteria for PTH
  - Enlarged anterior horns of lateral ventricles
  - Enlarged temporal horns
  - Enlarged 3rd ventricle
  - Normal/absent sulci
  - Periventricular hypoattenuation

Radiologic Definition
CT criteria are not adequate to differentiate PTH from atrophy. Proposed a diagnostic approach using lumbar infusion testing to determine the CSF dynamics.

**Atrophy vs. PTH**

Slow, constant infusion of NS @1.5 ml/min injected into the intrathecal space tests the global compliance of the craniospinal axis:
- Initial ICP, pulse wave amplitude
- Resistance to CSF outflow ($R_{out}$)
- Brain compliance using the pressure-volume index (PVI)

**Lumbar Infusion Test**
CTH @ 1, 3, 6 mos. frontal horn index > 0.3

Lumbar Infusion Test
- LP pressure ≥15 mmHg
- LP pressure <15 mmHg
- High Pressure Hydrocephalus
- Low Pressure Hydrocephalus
- Shunt
- Aplasia
- NO Shunt

Diagnostic Approach

Posttraumatic Hydrocephalus: A Clinical, Neuroradiologic, and Neuropsychologic Assessment of Long-Term Outcome

Goals:
- to find clinical and radiological correlations with PTH
- to define it’s prognostic value
- to assess the effects of shunt surgery

Results

> Functional status
  - Decreased level of consciousness
  - Change in behavior
  - Worsening memory
  - Alterations in gait

> SPECT scanning
  - Decreased perfusion in the temporal lobes and to a lesser degree frontal lobes

> Shunting indicated
  - Clinical deterioration
  - Complications: infection, shunt dysfunction

10/25/10 Mazzini 2003
Improvement after shunt placement
- 52.1% had improvement in GOS scores
- 27% had improvement in neuropsychological testing and performance of ADL’s
- Improvement was independent of age

41.7% complication rate
- 35% seizures w/in 9wks; 10% w/in 1 wk.
- 19% shunt failure
- 6% hemorrhage
- 2% failure of wound closure

Prognostic Indicators of Shunt Candidates
- GOS ≥ 3 had more significant improvements
- Clinical deterioration and progression of ventriculomegaly on CT is helpful, but not sensitive enough
- CSF scintigraphy was not sensitive enough
- NEED to identify better diagnostic imaging for the diagnosis of PTH; possibly new MRI techniques
Fractional anisotropy (FA) patterns in the caudate nucleus of hydrocephalus patients was increased when compared to known atrophy patients. FA values returned to normal after shunt placement. MR DT imaging may be a non-invasive diagnostic tool for PTH.

**MR Diffusion Tensor Imaging**

- PTH does occur in ~30% of severe TBI pts
- Identifying them early is crucial to their recovery
- Differentiating posttraumatic atrophy from posttraumatic hydrocephalus is challenging, need better diagnostic tools
- Shunting does improve outcomes

**Summarize**

- CSF dynamics
  - normal ICP
  - decreased $R_{out}$
  - increased PVI
- Predictive factors:
  - presence of interhemispheric hygroma
  - large craniectomy with <25mm width at the sagittal sinus

**Decompressive Hemicraniectomy**
• Decompressive Hemicraniectomy
  - Shunt, wait 3-6 mos., then cranioplasty?
  - Cranioplasty, wait a few mos., then shunt?

When to shunt?

• Syndrome of Trephine
  - CSF over drainage due to the effects from atmospheric pressure on the intracranial cavity
  - sunken scalp flap
  - midline shifting and sinking of the brain
  - Symptoms: contralateral upper extremity weakness, headaches, dizziness, seizures, mood swings

Shunt before cranioplasty

• Place programmable shunt to allow for CSF drainage to treat PTH, then before cranioplasty, change the shunt setting to decrease the amount of CSF drainage which elevates the skin flap and facilitates the cranioplasty

• Another group suggested applying an aneurysm clip to the shunt tubing to allow for expansion of the skin flap and facilitate the cranioplasty

Shunt before cranioplasty
**Shunting after cranioplasty** resulted in improved outcomes with fewer post-operative complications.

**Shunt before or after cranioplasty?**

**Management of hydrocephalus with programmable valves after traumatic brain injury and subarachnoid hemorrhage**

- Pt. factors: baseline ICP, brain compliance, brain atrophy, ventricular size, height, degree of obesity
- Goal: to reduce the transmantle pressure gradient just enough to relieve the symptoms of hydrocephalus without creating any complications related to overdrainage

**What type of shunt is best?**
In patients with severe TBI, any decline in consciousness or functional status OR a failure to improve within the first 3-6 months, should be evaluated for PTH.

Severe TBI patients that develop new onset seizures should be evaluated for PTH.

**Take Home Points**

Ventriculomegaly ≠ Hydrocephalus

Diagnosis of true post-traumatic hydrocephalus should involve multiple tools including:

- reports from therapists and family members of functional decline or failure to improve
- worsening cognitive function as seen on neuropsychological testing
- progressively enlarging ventricles on serial CT’s
- even all of these things taken together are not enough to identify patients that will improve after shunting

SPECT, MR DT Imaging may offer be helpful.

**Take Home Points**
Decompressive Hemicraniectomy
- associated with increased incidence of PTH when there is a large (>6cm) skull defect
- Interhemispheric Hygroma could be prognostic
- placing a shunt after the cranioplasty has been performed results in fewer post operative complications and improved patient outcomes

Take Home Points

Shunt Selection
- Programmable shunts offer the best flexibility when treating PTH because it allows the clinician to adjust the shunt to optimize the right ICP for the patient

Take Home Points

References


