Quick-Brain MRI for VP Shunt Evaluation

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Disclosure

• Dr. Selden has no relevant disclosures
Background

- In CSF shunt dependent children, shunt failure is common
- Shunt malfunction symptoms are protean, and additional negative work-ups for failure are also common
Background

• Standard work-up for CSF shunt malfunction includes:
  – Brain CT (non-contrast)
  – Shunt series radiographs

• Sensitivity of brain CT for shunt malfunction is 54 to 83%
  – History and clinical evaluation remain critical
Background

*Significant* radiation exposure accrued over lifetime with frequent brain CTs

– *Radiation-induced cancer*
Background

**Significant** radiation exposure accrued over lifetime with frequent brain CTs

– *Radiation-induced cancer*

2 – 5 mSv dose for each brain CT

- 3 mSv background radiation each year at sea level
- 0.01 mSv for 1 chest radiograph
- 200-400 chest radiographs for 1 brain CT
Quick Brain MRI

- Introduced in 2002
- Images within seconds
- Sedation rarely needed
- No ionizing radiation
Quick Brain MRI

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- Sedation rarely needed
- No ionizing radiation
- *Is QB MRI as accurate as CT?*
Quick Brain MRI

localizer – 3 plane scout
axial, sagittal & coronal - T2 weighted fast spin echo images
QB-MRI

Pre-shunt placement

Post-shunt placement
Visible Shunt
QB-MRI

Baseline Scan  Failure Scan
Quick Brain MRI At OHSU

- Children with suspected CSF shunt malfunction
  - ≥ 200 annual ED visits

- Clinical Pathway modified in Aug 2009
  - QB-MRI **within 60 min of presentation**
  - Brain CT w/o contrast – as needed if unstable
  - Shunt series radiographs
  - Neurosurgical consultation
Study Objectives

- To compare QB-MRI and brain CT for CSF shunt malfunction evaluation
  - Accuracy
  - Time from presentation to imaging completion
  - Time from presentation to QB-MRI completion before and after shunt pathway established
- To compare sedation use for QB-MRI and brain CT imaging
Methods

• Design: Retrospective study
• Location: Two pediatric EDs in Portland
• Review of all QB-MRI and Brain CT images from hospital and ED databases
• Population: < 18 years of age
• Duration of study: July 2008 - June 2012
Results

- 1435 cases reviewed, 438 excluded
- 997 cases included 273 CT and 724 QB-MRI

<table>
<thead>
<tr>
<th></th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emanuel CT</td>
<td>134</td>
</tr>
<tr>
<td>OHSU CT</td>
<td>139</td>
</tr>
<tr>
<td>OHSU QB-MRI</td>
<td>724</td>
</tr>
</tbody>
</table>
Results

- Mean age 7.1 years (range 22d – 17.9y)
- 37% girls, 63% boys
- Rates of Shunt Failure
  - CT (27.3%) vs. QB-MRI (26%)  $P=0.74$
**Results: Accuracy**

Shunt revision in 235 of 997 patients (23.6%)

<table>
<thead>
<tr>
<th></th>
<th>CT (OHSU + Emanuel)</th>
<th>QB-MRI (OHSU only)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td>53.2% (38.1% - 67.9%)</td>
<td>58.5% (51.1% - 65.6%)</td>
<td>$P=0.51$</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>95.6% (92% - 97.9%)</td>
<td>93.3% (90.8% - 95.3%)</td>
<td>$P=0.23$</td>
</tr>
</tbody>
</table>
Results: Accuracy

Shunt revision in 235 of 997 patients (23.6%)

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<th>P=NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPV</td>
<td>71.4%</td>
<td>75.3%</td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>90.8%</td>
<td>86.5%</td>
<td></td>
</tr>
</tbody>
</table>

PPV = ‘Precision rate’
## Results: Accuracy

Shunt revision in 235 of 997 patients (23.6%)

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<tr>
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<th>P = NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive LR</td>
<td>12.02</td>
<td>8.71</td>
<td></td>
</tr>
<tr>
<td>Negative LR</td>
<td>0.49</td>
<td>0.44</td>
<td></td>
</tr>
</tbody>
</table>

LR = Likelihood Ratio
OHSU Time Intervals

<table>
<thead>
<tr>
<th>Time Intervals</th>
<th>CT</th>
<th>QB-MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation to Order</td>
<td>32</td>
<td>51</td>
</tr>
<tr>
<td>Order to Image</td>
<td>33</td>
<td>84</td>
</tr>
<tr>
<td>Presentation to Image</td>
<td>83</td>
<td>115</td>
</tr>
</tbody>
</table>

(P<.0001)
OHSU QB-MRI Time Intervals

<table>
<thead>
<tr>
<th>Time Intervals</th>
<th>Pre-pathway</th>
<th>Post-pathway</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation to Order</td>
<td>28</td>
<td>52</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Order to Image</td>
<td>81</td>
<td>84</td>
<td>.61</td>
</tr>
<tr>
<td>Presentation to Image</td>
<td>112</td>
<td>132</td>
<td>.01</td>
</tr>
</tbody>
</table>
Sedation or Anxiolysis
3.7% of CTs and 4.4% of QB-MRI ($P=0.74$)

<table>
<thead>
<tr>
<th></th>
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<th>QB-MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intranasal Midazolam</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Intranasal Fentanyl</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IV Lorazepam</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IV Midazolam</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>IV Ketamine</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>IV Propofol</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Oral Lorazepam</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oral Midazolam</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

10 of 273 patients, 32 of 724 patients
Conclusions

- CT and QB-MRI have similar accuracy
- CT is completed 32 min faster than QB-MRI
- Clinical pathway reduces total time by 20 minutes
- CT and QB-MRI require similar, rare use of sedation
- QB-MRI may be used in the evaluation of ventricular shunt malfunction to avoid radiation exposure
Adoption

Results of a North American survey of rapid-sequence MRI utilization to evaluate cerebral ventricles in children

Clinical article

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Object. Growing concern about potential adverse effects of ionizing radiation exposure during imaging studies is particularly relevant to the pediatric population. To decrease radiation exposure, many institutions use rapid-sequence (or quick-brain) MRI to evaluate cerebral ventricle size. There are obstacles, however, to widespread implementation of this imaging modality. The purpose of this study was to define and quantify these obstacles to positively affect institutional and governmental policy.

Methods. A 9-question survey was emailed to pediatric neurosurgeons who were either members or candidate members of the American Society of Pediatric Neurosurgeons at every one of 101 institutions in the US and Canada having such a neurosurgeon on staff. Responses were compiled and descriptive statistics were performed.

Results. Fifty-six institutions completed the survey. Forty-four (79%) of the 56 institutions currently have a rapid-sequence MRI protocol to evaluate ventricle size, while 36 (64%) use it routinely. Of the 44 institutions with a rapid-sequence MRI protocol, 29 (66%) have had a rapid-sequence MRI protocol for less than 5 years while 39 (89%) have had a rapid-sequence MRI protocol for no more than 10 years. Thirty-six (88%) of 41 rapid-sequence MRI users responding to this question obtain a T2-weighted rapid-sequence MRI while 13 (32%) obtain a T1-weighted rapid-sequence MRI. Twenty-eight (64%) of 44 institutions never use sedation while an additional 12 (27%) rarely use sedation to obtain a rapid-sequence MRI (less than 5% of studies). Of the institutions with an established rapid-sequence MRI protocol, obstacles to routine use include lack of emergency access to MRI facilities in 18 (41%), lack of staffing of MRI facilities in 12 (27%), and the inability to reimburse a rapid-sequence MRI protocol in 6 (14%). In the 12 institutions without rapid-sequence MRI, obstacles to implementation include lack of emergency access to MRI facilities in 8 (67%), lack of staffing of MRI facilities in 7 (58%), the inability to reimburse in 3 (25%), and lack of administrative support in 3 (25%). To evaluate pediatric head trauma, 53 (96%) of 55 institutions responding to this question use noncontrast CT, no institution uses rapid-sequence MRI, and only 2 (4%) use standard MRI.

Conclusions. Many North American institutions have a rapid-sequence MRI protocol to evaluate ventricle size, with most developing this technique within the past 5 years. Most institutions never use sedation, and most obtain T2-weighted sequences. The greatest obstacles to the routine use of rapid-sequence MRI in institutions with and in those without a rapid-sequence MRI protocol are the lack of emergency access and staffing of the MRI facility during nights and weekends.

(10.3171/2014.2.PEDS13567)

Key Words • rapid sequence MRI • radiation • hydrocephalus • ventricles • technique
Adoption

A

Number of institutions

Length of time quick brain MRI utilized

>10 years | 5-10 years | <5 years | Unsure

B

Number of institutions

Types of quick brain MRI sequences obtained

T1 | T2 | Both

C

Number of institutions

Frequency of sedation use to obtain quick brain MRI

Never | Rarely | Occasionally | Unsure
Thanks

• Pediatric Emergency Medicine, OHSU
  – Esther Yue, MD
  – David Spiro, MD, MPH
  – Garth Meckler, MD, MSSH
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