The Development of a Telemetric Intracranial Pressure Monitor

K Aquilina¹, M Wenzel ², M Frischholz ², RJ Edwards¹, IK Pople¹, HB Coakham¹.

¹ Department of Neurosurgery, Frenchay Hospital, Bristol, UK
² Campus Micro Technologies, GmbH, Bremen, Germany

Dissemination day, December 1st, 2005, Freiburg.

The development is running inside the framework of the European project “Healthy Aims” funded by the European Commission under IST-2002-1-001837 in the VI. Framework Programme.
Intracranial pressure
Traumatic brain injury

- Maintenance of cerebral blood flow
- Monitoring of contusions
- After evacuation of haematomas
Hydrocephalus
Current techniques

- External ventricular drain
- Catheter tip transducers
  - Strain gauge
  - Fibreoptic
External ventricular drain
External ventricular drain

- **Advantages**
  - The recognised gold standard
  - Recalibration in vivo
  - No drift

- **Problems**
  - High risk of infection
  - Consequence of poor placement
  - Interruption of fluid transduction

Catheter tip transducers
Colonisation rate of up to 13.2% in one study investigating 168 fibreoptic probes; 2 patients developed clinically significant ventriculitis at days 10 and 11.

The ideal ICP monitor

- No connection to the external environment
- No limitation on duration of monitoring
- Indefinite power supply
The ideal ICP monitor (2)

- Minimal drift
- Allows in vivo recalibration
- Not affected by temperature changes
- Range of pressure measurement
- Allows waveform analysis\(^1\)
- Easy to insert and to read
- Cost-effective

Telemetry of Intracranial Pressure

By

F. Heppner, G. Lanner, and H. Rodler

With 6 Figures

Summary

A new technique is described for telemetric measurement of intracranial pressure in man using an external energy source and a small pressure transducer, called a TELECEPTOR, implanted in the skull. The method presents advantages, especially for long term recordings.

Problem

The techniques used so far for measuring intracranial pressure have yielded accurate data (Lundberg 1960, Hulme and Cooper 1966, Co...
A pressure-balanced radio-telemetry system for the measurement of intracranial pressure

A preliminary design report

Nicholas T. Zervas, M.D., Eric R. Cosman, Ph.D., and Bernard J. Cosman, M.S.

Department of Neurosurgery, Harvard Medical School and Beth Israel Hospital, Boston, and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts

Earlier telemetric ICP monitors

Multiple problems

➤ Insertion along fluid-filled shunt or catheter

➤ Excessive drift, difficult recalibration

➤ Inability to measure negative pressure

➤ Low frequency of measurement, no waveform analysis possible

➤ Dependent on internal battery
The new sensor in clinical practice

1. Traumatic brain injury

- Allows longer monitoring period without increasing risk of infection
  - Secondary rise (3 to 10 days) in ICP common and dangerous

- May be inserted on the ICU

- May be removed on the ICU under local anaesthetic

- Eliminates risk of mechanical damage to sensor and lead as well as dislocation (10-25% in fibreoptic catheter tip transducers)


The new sensor in clinical practice

2. Hydrocephalus - shunts

- High failure rate of shunting systems, especially in children\(^1\)
- Several common conditions mimic symptoms of shunt dysfunction
- Sensor allows measurement of ICP at home/ at primary care level
- Long-term ICP measurement capability, independent of shunt function
- Diagnosis of overdrainage

Prospectively randomised shunt design trial
Failure commonest in first six months

Young children
- Overall one year failure rate was 40%
- Two year failure rate was 50%

One year failure rates of 30% in older age groups.

<table>
<thead>
<tr>
<th></th>
<th>Delta</th>
<th>Standard</th>
<th>Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main endpoints, all patients</strong></td>
<td>115</td>
<td>114</td>
<td>115</td>
</tr>
<tr>
<td><strong>Shunt obstruction</strong></td>
<td>38 (33.0%)</td>
<td>39 (34.2%)</td>
<td>31 (27.0%)</td>
</tr>
<tr>
<td>Overdrainage</td>
<td>9 (7.8%)</td>
<td>3 (2.6%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Loculated compartments</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>2 (1.7%)</td>
</tr>
<tr>
<td>Shunt infection</td>
<td>9 (7.8%)</td>
<td>7 (6.1%)</td>
<td>12 (10.4%)</td>
</tr>
<tr>
<td><strong>Secondary endpoints, shunt obstruction site</strong></td>
<td>38</td>
<td>39</td>
<td>31</td>
</tr>
<tr>
<td><strong>Ventricular catheter</strong></td>
<td>16 (42.1%)</td>
<td>18 (46.2%)</td>
<td>2 (6.5%)</td>
</tr>
<tr>
<td>Valve</td>
<td>2 (5.3%)</td>
<td>5 (12.8%)</td>
<td>8 (25.8%)</td>
</tr>
<tr>
<td>Peritoneal catheter</td>
<td>5 (13.2%)</td>
<td>2 (5.1%)</td>
<td>2 (6.5%)</td>
</tr>
<tr>
<td>Distal (valve or peritoneal catheter)</td>
<td>2 (5.3%)</td>
<td>1 (2.6%)</td>
<td>5 (16.1%)</td>
</tr>
<tr>
<td>Shunt migration disconnection</td>
<td>3 (7.9%)</td>
<td>7 (17.9%)</td>
<td>7 (22.6%)</td>
</tr>
<tr>
<td>Ventricular catheter plus other site</td>
<td>6 (15.8%)</td>
<td>1 (2.6%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>4 (10.5%)</td>
<td>5 (12.8%)</td>
<td>7 (22.6%)</td>
</tr>
<tr>
<td><strong>Main endpoints, patients of &gt;2 yr</strong></td>
<td>19</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Shunt obstruction</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Overdrainage</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Loculated compartments</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shunt infection</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

*a Mean age, 7.7 years; median age, 6.5 years; range, 2–17 years.*
The new sensor in clinical practice

3. Hydrocephalus – endoscopic third ventriculostomy

- Standard imaging unreliable in the evaluation of function
- ICP monitoring important in evaluation of symptoms and possible blockage
4. Idiopathic intracranial hypertension

- Incidence of 1 in 100,000 – much higher in young women above ideal body weight

- Insidious onset – progressive irreversible deterioration in vision

- Small ventricles – repeated lumbar punctures only method of measuring ICP
Summary

- There is no telemetric ICP monitor currently available for routine clinical use.
- There is a clear clinical need for a telemetric ICP monitor.
- This need extends to both short term and long term clinical applications.
Thank you