Neurocritical Care

Does it make a difference?

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John Radcliffe Hospital, Oxford

ANZCA Neuroanaesthesia SIG
July 2013
Neurocritical Care Capacity

32 neurosurgical centres in UK
13 dedicated NCCUs
19 combined ICUs
Neurocritical Care Capacity - snapshot

– Snapshot audit 9th Feb 2006
– All adult ICUs England and Wales
– 84% response rate (24 of 27 neuro ICUs)
– Total 2161 critical care beds reported
  • 1378 level 3, 783 level 2

Nov 2006: Neurocritical care capacity and demand. A report from the neurocritical care stakeholder group.
83% TBI patients were thought to be more appropriate in a neurosciences centre.

<table>
<thead>
<tr>
<th></th>
<th>DGH ITU appropriate</th>
<th>Should be in neuroscience unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBI</td>
<td>3 (3.6%)</td>
<td>15 (17.9%)</td>
<td>18 (21.5%)</td>
</tr>
<tr>
<td>SAH/ICH</td>
<td>13 (15.5%)</td>
<td>5 (6.0%)</td>
<td>18 (21.5%)</td>
</tr>
<tr>
<td>Stroke</td>
<td>13 (15.5%)</td>
<td>3 (3.6%)</td>
<td>16 (19.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>18 (21.4%)</td>
<td>14 (16.7%)</td>
<td>31 (37.1%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>47 (56%)</strong></td>
<td><strong>37 (44%)</strong></td>
<td><strong>84 (100%)</strong></td>
</tr>
</tbody>
</table>

*Presented as number of patients and % of total neuroscience patients in non-neuroscience units*
... Neurocritical Care Capacity - snapshot

Table 2: Designated neurocritical care beds

<table>
<thead>
<tr>
<th></th>
<th>Level 3</th>
<th>Level 2</th>
<th>Total beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated neurocritical care unit beds</td>
<td>85</td>
<td>53</td>
<td>138</td>
</tr>
<tr>
<td>General ICU beds ring fenced for neuroscience</td>
<td>11</td>
<td>57</td>
<td>68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>96</strong></td>
<td><strong>110</strong></td>
<td><strong>206</strong></td>
</tr>
<tr>
<td>% total critical care beds</td>
<td>7.0%</td>
<td>14.1%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>

- Neuroscience = 12.6% critical care workload
- 90% occupancy neurocritical care beds
  - need rapid access
• Retrospective review
• 1991 – 1993 pre – NCCU
• 1994 – 1997 post – NCCU
• Total 285 patients
• TBI admitted within 24h injury
• GOS at 6 months or more
Specialist neurocritical care and outcome from head injury
Addenbrooke’s NCCU: ICP/CPP management algorithm

All patients with or at risk of intracranial hypertension must have invasive arterial monitoring, CVP line, ICP monitor and Rt SjO₂ catheter at admission to NCCU.

Efforts must be made to attach TCD and multimodality monitoring computer within the first six hours of NCCU stay.

Check whether the patient is in or may be a candidate for research protocols.

Guidelines may be modified at the discretion of the consultant in charge.

Treatment grades III and IV should only be initiated after express approval of the Consultant in charge of NCCU.

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**I**

• 10-15° head up, no venous obstruction
• CPP ≥ 70 (CVP 6-10; ± PAC)
• SPO₂ ≥ 97%; PaO₂ ≥ 11 kPa, PaCO₂ ≤ 4.5 kPa
• Temp ≤ 37°C; SjO₂ > 55%; blood sugar 4-7 mmol/l
• Propofol 3-5 mg/kg/hr (midazolam ~ 0.1mg/kg/hr from day 2)
• Fentanyl 1-2 µg/kg/hr; atracurium 0.5 mg/kg/hr
• Sucralfate 1g q 6 hrly (Ranitidine 50mg q 8 hrly iv if no OGT or aspirate > 200ml/6 hrs)
• Phenytoin 15 mg/kg if indicated (fits, depressed #)

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**II**

• 20% mannitol 2ml/kg X 3 or till plasma 320 mosm/l
• PAC, volume, vasoactives to increase MAP (CPP 90-100)
• Reduce PaCO₂ to 3.5-4.0 kPa providing SjO₂ stays ≥ 55%,
• Temp ≤ 35°C, Daily lipid screen if still on propofol
• EEG/CFM: ? fits -> Phenytoin 15 mg/kg iv > 300 mg/day

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**III**

CPP < 70; ICP > 25 (Check probe, ? re-CT)

Temp 33°C (discontinue propofol)

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**IV**

CPP < 70; ICP > 25 (Check probe, ? re-CT)

Trial of bolus i.v. anaesthetic (e.g. Propofol 50-200 mg),
- maintain CPP with fluids and vasoactive agents
If favorable effect on ICP and CPP start thiopentone
- 250 mg boluses up to 3-5 g + infusion 4-8 mg/kg/hr to achieve and maintain burst suppression

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- recent CT
- low risk of surgical lesion

Surgical lesion?
CSF drainage?
Role for surgical decompression?

Yes

surgery

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Menon. Ver 4, Aug 199.
309 patients pre, 239 patients post

• Single diagnostic category 

**UHC risk adjustment model**

• ↓ risk-adjusted NICU mortality (51%)
• ↓ hospital LOS 12%
• ↑ Discharge to home/rehab
• Improved documentation of prognostic indicators

JNS 2006
Impact of a neurointensivist on outcomes in patients with head trauma treated in a neurosciences intensive care unit

Panayiotis N. Varelas, M.D., Ph.D., Dan Eastwood, M.S., Hyun J. Yun, Ph.D., Marianna V. Spanaki, M.D., Ph.D., Lotfi Hacein Bey, M.D., Christos Kessaris, M.D., and Thomas A. Gennarelli, M.D.

Departments of Neurology, Neurosurgery, Biostatistics, and Radiology, Medical College of Wisconsin, Milwaukee, Wisconsin

- More intensive monitoring
- Treatment protocols with flexibility
- Clinical director, resident medical team
- Education
- Establishment of MDT
Effect of volume on outcome following cerebral aneurysm treatment

- 1995 – 2000 New York State (257 hospitals)
- aSAH admissions (3763) + unruptured aneurysms (2200)
- Endovascular + neurosurgical intervention
- Outcome measures
  - In-hospital mortality
  - Adverse outcome (death or discharge destination)
- Highest volume hospitals had resident neurosurgeon + dedicated NICU

Stroke . 2003; 34:2200-2207
### TABLE 3. Effect of Hospital-Related Variables on Outcome and Resource Utilization

<table>
<thead>
<tr>
<th></th>
<th>Unruptured Aneurysms</th>
<th>Ruptured Aneurysms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Adverse outcome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedural experience</td>
<td>0.89</td>
<td>0.84–0.94</td>
</tr>
<tr>
<td>Percent embolization</td>
<td>0.83</td>
<td>0.71–0.98</td>
</tr>
<tr>
<td>In-hospital death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedural experience</td>
<td>0.94</td>
<td>0.90–0.98</td>
</tr>
<tr>
<td>Length of stay (reduction)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedural experience</td>
<td>0.95</td>
<td>0.94–0.96</td>
</tr>
<tr>
<td>Percent embolization</td>
<td>0.93</td>
<td>0.90–0.96</td>
</tr>
</tbody>
</table>

- ↓ Adverse outcome
- ↓ In-hospital death
- ↓ LOS
- Effect of embolisation on unruptured aneurysms
Top 10 high volume hospitals

• High volume hospitals had resident neurosurgeon + dedicated NICU

• Effect greatest with surgical interventions
  – Potential effect of post-operative NICU
Designated Stroke Centre

- $N = 30,947$
- 104 designated stroke centres vs 140 non-designated in State of NY
- Adjusted for pre-hospital selection bias
- 15,927 (49.4%) admitted to DSC

*JAMA. 2011;305(4):373-380*
### Designated Stroke Centre

#### Table 3. Mortality at Designated Stroke Centers and Nondesignated Hospitals

<table>
<thead>
<tr>
<th>No. (%)</th>
<th>Designated Stroke Center (n = 15,297)</th>
<th>Nondesignated Hospital (n = 15,650)</th>
<th>Adjusted Mortality Difference (95% CI)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 d</td>
<td>90 (0.6)</td>
<td>134 (0.9)</td>
<td>-0.3 (-0.6 to -0.0)</td>
<td>.04</td>
</tr>
<tr>
<td>7 d</td>
<td>665 (4.3)</td>
<td>842 (5.4)</td>
<td>-1.3 (-2.1 to -0.6)</td>
<td>.001</td>
</tr>
<tr>
<td>30 d</td>
<td>1543 (10.1)</td>
<td>1951 (12.5)</td>
<td>-2.5 (-3.6 to -1.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>1 y</td>
<td>3412 (22.3)</td>
<td>4067 (26.0)</td>
<td>-3.0 (-4.4 to -1.5)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

<sup>a</sup>Negative values indicate lower mortality at designated stroke center vs nondesignated hospital. Adjusted for age, sex, race, health insurance status, rural status, 13 Charlson comorbid conditions, atrial fibrillation, hospital teaching status, and total number of hospital beds by using the instrumental variable analysis.

- ↑ use thrombolytic therapy (2.2%)
RAIN: Risk Adjustment In Neurocritical Care
DA Harrison et al. Health Technology Assessment, June 2013

- Evaluation of optimum location + comparative costs of neurocritical care in TBI
- Completed at N = 2975
- TBI admissions to critical care
- 13 (100%) dedicated NCCU, 14 (74%) combined neuro/general units
- GOSE, EQ-5D-3L at 6 months
RAIN: Cost-effectiveness of dedicated NCCU

Case mix adjustment to give incremental effect
Higher mean lifetime QALYs
At ceiling ratio £20,000 incremental net monetary benefit positive (£1316)
Conservative approach

TABLE 52 Lifetime cost-effectiveness: mean (SD) costs (£), QALYs and incremental net benefit for research objective 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Combined neuro/general critical care unit</th>
<th>Dedicated neurocritical care unit</th>
<th>Incremental effect (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifetime costs</td>
<td>31,007 (22,471)</td>
<td>34,909 (26,834)</td>
<td>3167 (–464 to 6797)</td>
</tr>
<tr>
<td>Lifetime QALYs</td>
<td>9.49 (6.52)</td>
<td>9.99 (6.56)</td>
<td>0.224 (0.332 to 0.780)</td>
</tr>
<tr>
<td>Lifetime cost per QALY</td>
<td></td>
<td></td>
<td>14,128</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1316 (–9857 to 12,489)</td>
</tr>
</tbody>
</table>

SD, standard deviation.

a Incremental effects are after case mix adjustment.
b INB can be calculated by following methods guidance and multiplying the mean QALY gain (or loss) by £20,000, and subtracting from this the incremental cost.
Benefits for Training

Neurosciences intensive care medicine in initial neurosurgical training

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Abstract
The authors describe a novel 4-month clinical placement in neurosciences intensive care medicine (NICM) undertaken in the first specialty registrar (ST1) year of neurosurgical training as part of a clinical neurosciences themed training year. Neurosurgery is unique among British surgical specialties in having pioneered themed early years in run-through training to replace basic surgical training in general surgical specialties as part of Modernising Medical Careers. After describing events leading to the new neurosurgical training, the knowledge, skills and attitudes acquired in NICM are highlighted alongside discussion of logistic aspects and future directions from an inaugural experience.

Key words: Intercollegiate Surgical Curriculum Programme, Modernising Medical Careers, neurointensive care medicine,

High volume of specific conditions and procedures
Referral Region
Purpose-built state of the art

• Co-location of
  – neurologists, neurosurgeons, neuroradiologists
• Adjacent neurosurgery theatres
• Neuroradiology
  – Angiography suite
  – CT
  – MRI
  – fMRI + angiography suite
• Neurophysiology
• Neuropsychology
• Neuropathology
Funnel plots of mortality ratio - ICNARC (2011) model
Your unit compared to all other units last 3 months of available data

- Mortality ratio
- Number of admissions

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Does neurocritical care make a difference?

Evidence of benefits:

• Reduced mortality
• Reduced LOS
• Cost effectiveness
• Functional outcome measures
• Training
Does neurocritical care make a difference?

Why?

• High volume across narrow range
  – Organised, standardised care

• Protocols
  – Familiarity + flexibility

• Co-location, concentration of resources
  – The facilities
  – The multidisciplinary team

• Development of expertise
Does neurocritical care make a difference?

What is done differently?

• Focus on cerebral $O_2$ demand-supply balance
• Neuromonitoring
  – Nursing expertise
• Assessment
  – Combined Neuro MDT
• Quality
  – Emphasis on benchmarking with general ICUs