**Comprehensive Stroke Centers: Key Personnel and Infrastructure**

Mark J. Alberts, MD  
Professor of Neurology  
Vice-Chair, Clinical Affairs  
Department of Neurology and Neurotherapeutics  
UTSW Medical Center  
Dallas, TX

**Levels and Types of Stroke Centers**

1. Comprehensive Stroke Center
2. Primary Stroke Center
3. Acute Stroke Ready Hospital

**Characteristics of Different Stroke Centers**

- **Comprehensive Stroke Center**  
  - Academic Medical Center  
  - Tertiary Care facility  
  - Wide range of hospitals; standard stroke care; stroke unit; use TPA

- **Primary Stroke Center**

- **Acute Stroke Ready Hospital**  
  - Rural hospitals; basic care; drip and ship; use tele-technologies

**Numbers of Various Types of Stroke Centers**

- **Comprehensive Stroke Center**
  - 75 to 200 total

- **Primary Stroke Center**
  - Final count 1000-1200

- **Acute Stroke Ready Hospital**
  - Perhaps 1200-1800

> 5000 total acute care hospitals in the U.S.

**Patient Types at a Comprehensive Stroke Center**

- **Large complex ischemic strokes**  
  - Endovascular therapy  
  - Hemispherectomy  
  - Systemic disease with multi-organ involvement  
  - High ICP  
  - Cryptogenic etiology

- **Intracerebral hemorrhage**  
  - ICU level care  
  - Neurosurgical interventions

- **Subarachnoid hemorrhage**  
  - ICU level care  
  - Endovascular and neurosurgical therapies  
  - Vasospasm treatments

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**UNLABELED/UNAPPROVED USES DISCLOSURE:**  
None
Key Elements of a Comprehensive Stroke Center

- All components of a Primary Stroke Center, **plus**
  - Availability of advanced imaging techniques
    - MRI/MRA, CTA, DSA, TCD
  - Availability of personnel trained in vascular neurology, neurosurgery, endovascular techniques
  - 24/7 availability of personnel, OR, and endovascular facilities
  - ICU/Neuroscience ICU
  - Stroke registry
  - Experience and expertise treating patients with large strokes, ICH, SAH

DSA = digital subtraction angiography; TCD = transcranial Doppler.

Imaging Modalities at a CSC

- MRI and MRA (head and neck)
  - Very sensitive to image acute strokes and cerebral vasculature
  - Can also be used for perfusion studies and to identify areas of mismatch
- CT Angiography (head and neck)
  - Useful to cerebral vasculature for detection of stenosis, aneurysms, dissection
  - Needed in patients who cannot undergo MRI and MRA
- CT or MR perfusion
  - Being used widely to help identify ischemic penumbra
- Cerebral Angiogram (DSA)
  - Often considered the ‘Gold Standard’
- MRI, along with MRA or CTA are now recommended for PSCs
CT Perfusion in Stroke

Key Personnel at a CSC
- CSC Director—most likely an MD with advanced training in vascular neurology or neurosurgery, others
- Neurosurgeon(s) with training in vascular neurosurgery
- Endovascular expertise for lytic/mechanical therapy, coiling, stenting, etc.
- Intensivist/Neuro-intensivist for ICU staffing
- Nursing personnel for stroke unit, ICU/NICU, endovascular, OR, etc.
- Advanced practice nurses for stroke registry, education, referrals, possible NICU coverage
- Therapists and pharmacists—patient care and research studies

Telemedicine at a CSC
- Most CSCs will have some type of telemedicine arrangement
  - Telephone consults
  - Full video conferencing with radiology feeds
  - Remote robotic interactions
- Link CSC to PSCs and ASRHs in their network
- Pre-arranged consultations and transfers
  - Specify vendors, logistical issues, platforms, reimbursement, legal issues
  - Decide who to transfer and how to transfer
- The CSC should act as a resource for various referring hospitals
  - Consultations, education, support, etc.

Administering TPA via Telephone at a CSC
53 patients Rx via phone; 73 in-house

Telemedicine for Stroke

<table>
<thead>
<tr>
<th></th>
<th>RVE</th>
<th>TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>77</td>
<td>74</td>
</tr>
<tr>
<td>Time for consul. (min)</td>
<td>49.8</td>
<td>27.2</td>
</tr>
<tr>
<td>Length of stay, days</td>
<td>11.4</td>
<td>12.3</td>
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<td>Admission to stroke ward, % of pts.</td>
<td>59.7</td>
<td>45.9</td>
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<td>Transfer to stroke center, % of pts.</td>
<td>9.1</td>
<td>14.9</td>
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<tr>
<td>Diagnosis corrected, % of pts.</td>
<td>7.1</td>
<td>17.6</td>
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<tr>
<td>Outcome 10 days after stroke, %</td>
<td>1.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Mortality</td>
<td>1.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Institutional care</td>
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Stoke Centers in Europe
- Survey of hospitals in Germany and Austria
  - 42% response rate
- 178 total hospitals
  - > 54,000 patients admitted per year
  - Average of 376 stroke patients/hospital
- 7.3% met criteria for a CSC
- 8.4% met criteria for PSC
- 48% had basic care offered
- 36% lacked basic services
Importance of a Neurocritical Care Team

- Physician expertise in NCC
- Care protocols
- Coordinated rounds
- 2381 patients
- Significant decline in mortality
- Almost 2 day decrease in LOS

Suarez et al, CCM, 2004

Impact of a Neurointensivist on Mortality

Problem: Not enough neurointensivists for 24/7 coverage

Varelas et al, CCM, 2004

Neurocritical Care Team

<table>
<thead>
<tr>
<th>Features</th>
<th>No Team, n = 796</th>
<th>Team Available, n = 703</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurosurgical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, yrs (mean ± SD)</td>
<td>67.2 ± 13.5</td>
<td>79.2 ± 13.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length stay, days</td>
<td>76 (65-90)</td>
<td>75 (64-84)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hospital length of stay, days</td>
<td>12.0 ± 8.4</td>
<td>11.8 ± 7.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Neurologic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, yrs (mean ± SD)</td>
<td>61.2 ± 13.9</td>
<td>61.7 ± 15.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length stay, days</td>
<td>80 (55-108)</td>
<td>81 (61-106)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hospital length of stay, days</td>
<td>12.0 ± 8.4</td>
<td>11.8 ± 7.4</td>
<td>&lt;0.01</td>
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Suarez et al, CCM 2004

Care at a CSC vs General Hospital Finnish Experience

<table>
<thead>
<tr>
<th>Features</th>
<th>CSC (n=405)</th>
<th>PSC (n=1748)</th>
<th>GH (n=2981)</th>
<th>Total (n=6149)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay</td>
<td>7 (6-10)</td>
<td>7 (6-10)</td>
<td>7 (6-10)</td>
<td>7 (6-10)</td>
</tr>
<tr>
<td>Door to needle</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Onset to TPA</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Protocol Dev.</td>
<td>10.2%</td>
<td>10.2%</td>
<td>10.2%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Sx ICH</td>
<td>4.7%</td>
<td>4.7%</td>
<td>4.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Neuro improve</td>
<td>59%</td>
<td>59%</td>
<td>59%</td>
<td>59%</td>
</tr>
</tbody>
</table>

Meretoja et al, Stroke 2010

Outcomes at a CSC: Finland Study

<table>
<thead>
<tr>
<th>Table 4. Outcome of Finnish Patients With Ischemic Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted outcome, no. (%)</td>
</tr>
<tr>
<td>Case-fatality by 1 year</td>
</tr>
<tr>
<td>Institutional care by 1 year</td>
</tr>
<tr>
<td>Home at 1 year</td>
</tr>
<tr>
<td>Outcome adjusted for patient demographics, OR (95% CI)</td>
</tr>
<tr>
<td>Case-fatality by 1 year</td>
</tr>
<tr>
<td>Institutional care by 1 year</td>
</tr>
<tr>
<td>Home at 1 year</td>
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Meretoja et al, Stroke 2010

Outcomes at a CSC vs Community Hospital

<table>
<thead>
<tr>
<th></th>
<th>CSC</th>
<th>Community</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuro exam</td>
<td>69.5%</td>
<td>105%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Door to Needle</td>
<td>60</td>
<td>54</td>
<td>p = 0.1</td>
</tr>
<tr>
<td>Onset to TPA</td>
<td>135</td>
<td>165</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Protocol Dev.</td>
<td>10.2%</td>
<td>6.7%</td>
<td>NS</td>
</tr>
<tr>
<td>Sx ICH</td>
<td>4.7%</td>
<td>14%</td>
<td>p = 0.04</td>
</tr>
<tr>
<td>Neuro Improve</td>
<td>59%</td>
<td>37%</td>
<td>p = 0.014</td>
</tr>
</tbody>
</table>

Perez de la Ossa, J Neurol 2009
**Outcomes and Admission to a CSC**

**Table 4** Predictors of good outcome at 90 days: logistic regression analysis

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR (95% CI)</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>NIHSS at baseline</td>
<td>0.86 [0.80-0.92], p &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Prehospital Glasgow</td>
<td>0.99 [0.98-1.00], p = 0.04</td>
<td></td>
</tr>
<tr>
<td>Clinical history of atrial fibrillation</td>
<td>1.60 [0.69-3.66], p = 0.26</td>
<td></td>
</tr>
<tr>
<td>Direct admission to the CSC (vs. initial attention at an unspecialized hospital)</td>
<td>2.48 [1.04-5.88], p = 0.03</td>
<td></td>
</tr>
</tbody>
</table>

**Medical Director**
- Vascular neurology, critical care, vascular neurosurgery
- Must be available 24/7
- Reachable by phone within 20 min; in house within 45 minutes

**Neuro-interventionalists available 24/7**
- One person cannot cover multiple hospitals (if far apart)
- Expertise in critical care and neurology staff in the ICU

**Neurosurgeon available 24/7**
- Must be in house within 30 minutes

**Diagnostic radiologist available 24/7**

**Certified radiology technologist available 24/7**
- Includes technologists to assist with MRI and cerebral angiography

**CSC Requirements for Personnel**

- RNs with expertise in stroke nursing care
  - Assessment using scales (NIHSS)
  - Critical care skills for NICU nurses
    - Post-TPA; treatments for elevated ICP; post-surgery, etc.
    - Nursing care related to IR and NSGY are key!!

- APNs with advanced nursing skills for NICU care

- Nurse case managers and social workers with expertise related to:
  - Acute stroke care
  - Care coordination
  - Post-stroke care (including rehabilitation)
  - Community resources

**APNs with advanced nursing skills for NICU care**

**Nurse case managers and social workers with expertise related to:**
- Acute stroke care
- Care coordination
- Post-stroke care (including rehabilitation)
- Community resources

**Proposed CSC Requirements for Procedures**

- Comprehensive Neuro-imaging
  - MRI, MRA, CTA, catheter angiography, Doppler, TCD, TTE, TEE
- Most elements must be available 24/7
- CSC must be able to perform the following procedures:
  - CEA
  - Carotid stenting
  - Endovascular coiling of aneurysms

**Procedure Volumes**

- Volumes for SAH, aneurysm coiling and clipping are likely to go up:
  - At least 10 aneurysms Rx with clipping
  - At least 20 aneurysms Rx with coiling/endovascular
  - At least 35 aneurysmal SAH patients cared for each year
- At least 10 endovascular procedures for acute ischemic stroke/yr* (controversial at present)

* These numbers have not been approved by TJC at present
Possible CSC Performance Metrics

- Rates of procedural complications (stroke, death)
  - CEA, CAS 30 day stroke/death rates
- Performance of stroke severity scales
  - NIHSS, Hunt and Hess, ICH score
- Time for beginning anticoagulation reversal in ICH
  - FFP, PCC, other agents
- 30 day modified Rankin
  - will not be severity adjusted
- Rates of cerebral bleeding after TPA, endovascular Rx
  - 36 hour time window, blood on head CT
- Nimodipine for SAH
  - Rx initiated within 24 hours
- Door to groin times for endovascular therapies

Monitoring for Peri-Procedure Complications

- 30 day stroke and death rates for
  - CEA (symptomatic and asymptomatic patients)
  - Carotid artery stenting (symptomatic and asymptomatic patients)
- Strokes rates for diagnostic cerebral angiogram
- Infection rates for EVDs

Other Functions of a CSC

- Act as the "Hub" hospital to coordinate:
  - Emergent communications (telemedicine, telestroke, teleradiology, robots)
  - Emergent transfers (helicopter, ambulances)
- Consultations, assistance, advice
- Risk factors, calling 911, etc.
- Act as a resource hospital or leader for various activities:
  - Research programs and studies
  - Educational programs for professional staff and lay public
- Act as a partner and advocate for:
  - Local and regional resources (money, ambulances, etc.)
  - Regional and state regulatory and legislative initiatives

Certification of CSCs

- Four organizations (JC, HFAP, DNV, others) plus some states are now involved in CSC certification
- Currently about 60-70 hospitals have been visited by the JC, of which about 40 are certified
- The JC site visit is very challenging and comprehensive
  - 2 site visitors
  - 2 day visit
  - Very in-depth
- Self-certification is not optimal
  - Inaccurate assessments
  - Lack the rigor of an independent review

Research at a CSC

- A CSC must be involved in at least one research project
- This is based on numerous studies showing that participation in clinical research improves overall outcomes
  - Research project must be patient oriented
  - Project must require IRB approval
  - Routine databases will not count as ‘research’
  - This is a new requirement

Potential Challenges Becoming a CSC

1. The major care elements must all be available on a 24/7 basis
   - Some hospitals that think of themselves as a CSC do not do this
   - Unclear if some hospitals can meet this requirement
2. EMS diversion or triage to CSCs may be a challenge
   - Cannot easily determine in ambulance type of stroke
   - May be able to assess stroke severity
3. Financial issues
   - Some procedures done at a CSC may not be well reimbursed in the future; bundling of fees
   - Unclear what the costs of CSC certification will be
   - These issues may be overcome by increased marketing, patient volume, and procedures
Conclusions

- A Comprehensive Stroke Center will form the ‘HUB’ of any Stroke System of Care
- The CSC will provide comprehensive services for the most complicated stroke patients
- There are many important personnel and programmatic elements for a CSC
- A CSC must meet several unique performance metrics
- It is hoped that the growth and success of CSCs will mirror that of PSCs
- CSC certification began in 2012 and continues
- May have a total of 150-200 CSCs