How to organize a quick and effective thrombectomy protocol?

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Heart and Stroke Foundation Chair in Stroke Research
Professor, Depts of Clinical Neurosciences/Radiology
Cumming School of Medicine
University of Calgary

Financial/Academic Disclosure Slide

- I have not received an honorarium from Hoffman LaRoche (licensure of tPA) but have received honorarium from Medtronic (supplier of SOLITAIRE FR stentriever) for CME events

- No stocks or direct investments with pharmaceutical or device companies involved in stroke

- Co-founder/shareholder Quikflo Health start-up (acute stroke software)

- Several clinical trial responsibilities:
  - IMS-3- Exec committee, CT core lab PI
  - ESCAPE- Neuro PI
  - REVASCAT- CT core lab co-PI
  - CLOTBUST-ER - CTA substudy PI
  - ARTIS-2 - CTA substudy core lab PI
  - ENCHANTED - International Advisory Committee
  - PRACTICE- DMC chair
  - DEFUSE 3- Safety monitor
  - ANNEXA-4 - Adjudication committee
I wore a Kiprusoff jersey for 12 years!

I was so disappointed we did not win draft lottery!

U18 and U20 Ice Hockey Champions Congrats!

Credit New Coaching Approach as Finland Hockey Seeks Triple Gold
During this day somewhere in Finland

At least two individual have suffered a major ischemic stroke that is very suitable for endovascular rescue if....
Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials

HERMES Collaborators
Highly Effective Reperfusion evaluated in Multiple Endovascular Stroke trials (HERMES)

Overall Treatment Effect
NNT = 2.6

Control population (n=545)

Intervention population (n=523)

25.5%

46%

13/06/2016 HERMES Collaboration
Patients **much improved** the next day

<table>
<thead>
<tr>
<th>Baseline NIHSS score</th>
<th>Intervention population (n=615)</th>
<th>Control population (n=630)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17 (14-20)†</td>
<td>17 (13-21)‡</td>
</tr>
<tr>
<td>NIHSS score at 24 h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>10.4 (8.7)</td>
<td>14.2 (7.8)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>8 (3-16)†</td>
<td>15 (9-19)‡</td>
</tr>
<tr>
<td>Change in NIHSS score from baseline to 24 h</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>-6.4 (8.2)</td>
<td>-2.6 (6.6)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>-7 (-12 to -1)*</td>
<td>-2 (-6 to 1)‡</td>
</tr>
</tbody>
</table>

No increase in intracranial bleeding

<table>
<thead>
<tr>
<th>Symptomatic intracranial haemorrhage</th>
<th>Intervention population, % (n/N)</th>
<th>Control population, % (n/N)</th>
<th>Risk difference</th>
<th>Risk ratio (95% CI)</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.4% (28/634)</td>
<td>4.3% (28/653)</td>
<td>0.1%</td>
<td>1.06 (0.63-1.80); p=0.82</td>
<td>1.07 (0.62-1.83); p=0.81</td>
</tr>
<tr>
<td>Parenchymal haematoma type 2</td>
<td>5.1% (32/629)</td>
<td>5.3% (34/641)</td>
<td>-0.2%</td>
<td>0.99 (0.61-1.61); p=0.97</td>
<td>0.99 (0.60-1.63); p=0.97</td>
</tr>
<tr>
<td>Mortality at 90 days</td>
<td>15.3% (97/633)</td>
<td>18.9% (122/646)</td>
<td>-3.6%</td>
<td>0.82 (0.63-1.07); p=0.15</td>
<td>0.77 (0.54-1.06); p=0.16</td>
</tr>
</tbody>
</table>

Table 4: Safety outcomes at 90 days
Mortality reduction trend

<table>
<thead>
<tr>
<th>Intervention population, % (n/N)</th>
<th>Control population, % (n/N)</th>
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<th>Risk ratio (95% CI)</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
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</tr>
</tbody>
</table>

Table 4: Safety outcomes at 90 days

Effect size by age

<table>
<thead>
<tr>
<th>Age (years) (Ptransaction=0.07)</th>
<th>n</th>
<th>cOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-49</td>
<td>158</td>
<td>1.36 (0.75-2.46)</td>
</tr>
<tr>
<td>50-59</td>
<td>218</td>
<td>2.85 (1.72-4.72)</td>
</tr>
<tr>
<td>60-69</td>
<td>333</td>
<td>2.58 (1.49-4.48)</td>
</tr>
<tr>
<td>70-79</td>
<td>371</td>
<td>2.41 (1.55-3.74)</td>
</tr>
<tr>
<td>80-79</td>
<td>1080</td>
<td>2.44 (1.70-3.50)</td>
</tr>
<tr>
<td>&gt;80</td>
<td>198</td>
<td>3.68 (1.95-6.92)</td>
</tr>
<tr>
<td>Total</td>
<td>1278</td>
<td>2.49 (1.76-3.53)</td>
</tr>
</tbody>
</table>

13/06/2016 HERMES Collaboration
Effect size by bNIHSS

<table>
<thead>
<tr>
<th>NIHSS score (p_interaction &lt; 0.45)</th>
<th>n</th>
<th>cOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤10</td>
<td>177</td>
<td>1.67 (0.80–3.50)</td>
</tr>
<tr>
<td>11–15</td>
<td>307</td>
<td>2.68 (1.39–5.19)</td>
</tr>
<tr>
<td>16–20</td>
<td>473</td>
<td>2.81 (1.80–4.38)</td>
</tr>
<tr>
<td>≥21</td>
<td>321</td>
<td>2.52 (1.40–4.54)</td>
</tr>
<tr>
<td>Total</td>
<td>1278</td>
<td>2.49 (1.76–3.33)</td>
</tr>
</tbody>
</table>

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CTA Mandatory
Carotid or M1 MCA occlusion are candidates for MT

ICA    proximal M1    distal M1
Effect size by intracranial occlusion site

<table>
<thead>
<tr>
<th>Stroke location (p_{interaction}=0.17)</th>
<th>n</th>
<th>cOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA</td>
<td>274</td>
<td>3.96 (1.65-9.48)</td>
</tr>
<tr>
<td>M1</td>
<td>887</td>
<td>2.29 (1.73-3.04)</td>
</tr>
<tr>
<td>M2</td>
<td>94</td>
<td>1.28 (0.51-3.21)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1278</td>
<td>2.49 (1.76-3.53)</td>
</tr>
</tbody>
</table>

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### Table 3. Study Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Alteplase-Only Group (N=35)</th>
<th>Endovascular-Therapy Group (N=35)</th>
<th>Effect Size (95% CI)</th>
</tr>
</thead>
</table>
| Median home time (IQR) — days          | 15 (0 to 69)                 | 73 (47 to 86)                    | 64 (28 to 90)        | 0.001

### Results: time in rehabilitation

- **Median**
  - tPA only: 27 days
  - tPA + endovascular: 0 days
- **Mean**
  - tPA only: 33 days
  - tPA + endovascular: 14 days

P value: 0.03
Endovascular Treatment of Acute Stroke

How Do We Build A System of Care To Treat Maximum Number of Stroke Patients As Fast As Possible?
What is the potential for EVT?

~1 in 4 or 5 strokes = EVT accessible occlusion
100-150 endo eligible/1 million/yr

Finland
5 Stroke Scenarios of EVT eligible patients

- Metro area patients- EMS activation
- Small urban area patients- EMS activation
- Rural patients- EMS activation
- Walk-in/private vehicle- no EMS activation
- In hospital stroke
~40 PCI Facilities in Canada for Acute Myocardial Infarction

All Metros serving >500,000 population need facilities

Neuro-angio labs in Canada: 16: 24h/365d; 4: sporadic; 5+ needed soon
Major metros have many competing hospitals

Centralize care: Redirect ambulance to stroke centres only

EMS transport to any hospital should be unacceptable!
Metro: CSC near  Small Urban: PSC near  Rural

Finland
Metro: CSC near
REVIEW

Developing a statewide protocol to ensure patients with suspected emergent large vessel occlusion are directly triaged in the field to a comprehensive stroke center: how we did it

Mahesh V Jayaraman, 1-3, 4 Arshad Iqbal, 5 Brian Silver, 6 Matthew S Sikret, 5 Caren Amedee, 7 Ryan A McTaggart, 3 Gino Paeduccio, 7 Jason Rhodes, 6 John Potvin, 7 Megan Tucker, 7 Nicole Alexander-Scott 5

SUMMARY

We have achieved a statewide protocol for rapid identification and transport of potential ELVO patients directly to a CSC. This included several key components:

1. Collaboration among physicians from different hospitals and healthcare systems.
2. Establishing a field severity screen for ‘high risk’ ELVO patients.
3. Having EMS transport ‘high risk’ patients directly to a CSC if within 30 min transport time.
4. Ensuring that patients who are ‘high risk’ and arrive at a PSC receive vessel imaging rapidly on arrival.
5. Facilitating the transport of patients with intravenous tissue plasminogen activator infusion to a CSC for intervention. Similar mechanisms already exist for trauma systems of care.

Centralize care: Redirect ambulance to stroke centres only

PSC

CSC

PSC
Severe stroke: Redirect ambulance to endo ready stroke centre

Facial Smile
- Normal (0)
- Right-Droop (1)
- Left-Droop (1)

Hand Grips
- Normal (0)
- Right-Weak grip (1)
- Left-Weak grip (1)
- Right-No grip (2)
- Left-No grip (2)

Arm Strength
- Normal (0)
- Right-Drifts down (1)
- Left-Drifts down (1)
- Right-Falls rapidly (2)
- Left-Falls rapidly (2)

LAMS Score (0 - 5): Calculated by adding the corresponding number from each of the three categories above

TOTAL =
### Golden 2 Hours of Stroke

P=0.001

<table>
<thead>
<tr>
<th>Time from onset to reperfusion [min]</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>16.1</td>
<td>26.5</td>
<td>24.3</td>
<td>26.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

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### Baseline Characteristics Differed by Time Window of Randomization

<table>
<thead>
<tr>
<th></th>
<th>30-120 mins</th>
<th>121-240 mins</th>
<th>241-360 mins</th>
<th>&gt;360 mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>194</td>
<td>657</td>
<td>352</td>
<td>79</td>
</tr>
<tr>
<td>Age</td>
<td>68.7</td>
<td>66.5</td>
<td>65.8</td>
<td>64.5</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>53.1%</td>
<td>46.0%</td>
<td>44.7%</td>
<td>53.2%</td>
</tr>
<tr>
<td>NIHSS</td>
<td>17.2</td>
<td>17.0</td>
<td>16.5</td>
<td>16.1</td>
</tr>
<tr>
<td><strong>Direct (vs transfer)</strong></td>
<td><strong>97.9%</strong></td>
<td>75.5%</td>
<td>37.8%</td>
<td>66.7%</td>
</tr>
<tr>
<td>IV tPA</td>
<td>85.6%</td>
<td>89.0%</td>
<td>86.9%</td>
<td>45.6%</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICA</td>
<td>32.1%</td>
<td>21.8%</td>
<td>16.2%</td>
<td>21.8%</td>
</tr>
<tr>
<td>M1</td>
<td>62.2%</td>
<td>70.2%</td>
<td>76.2%</td>
<td>71.8%</td>
</tr>
<tr>
<td>ASPECTS</td>
<td>9.0</td>
<td>8.4</td>
<td>7.8</td>
<td>8.0</td>
</tr>
</tbody>
</table>

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Workflow Times in Direct and Transfer Patients
(minutes, medians)

- Direct admit
  - Onset to ED: 65
  - ED to imaging start: 21
  - Imaging to randomization: 50
  - Randomization to puncture: 32
  - Puncture to reperfusion: 42

- Transfer
  - Onset to ED: 207
  - ED to imaging start: 15
  - Imaging to randomization: 29
  - Randomization to puncture: 31
  - Puncture to reperfusion: 47

Comments and Opinions

Ischemic Stroke Tissue-Window in the New Era of Endovascular Treatment

Michael D. Hill, MD, MSc; Mayank Goyal, MD; Andrew M. Demchuk, MD; Marc Fisher, MD, PhD

Epoch 1: Onset–to–imaging
Comprehensive stroke centre
30-60-90 DTN DTGP DTR rule

tPA bolus to groin puncture
<30 min

groin puncture to first reperfusion
<30 min

Finland is best at!
Finland is best at!

Reducing in-hospital delay to 20 minutes in stroke thrombolysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS involvement</td>
<td>Education of dispatchers and EMS personnel, stroke high-priority dispatch</td>
<td>1998</td>
</tr>
<tr>
<td>Hospital prenotification</td>
<td>EMS contacts stroke physician directly via mobile phone</td>
<td>2001</td>
</tr>
<tr>
<td>Alarm and preorder of tests</td>
<td>Laboratory and CT computer-ordered and alarmed at prenotification</td>
<td>2001</td>
</tr>
<tr>
<td>No-delay CT interpretation</td>
<td>Stroke physician interprets the CT scan, not waiting for formal radiology report</td>
<td>2001</td>
</tr>
<tr>
<td>Premixing of tPA</td>
<td>With highly suspect thrombolysis candidates, tPA prepared prior to patient arrival</td>
<td>2002</td>
</tr>
<tr>
<td>Delivery of tPA on CT table</td>
<td>Bolus administered on CT table</td>
<td>2002</td>
</tr>
<tr>
<td>CT relocated to ER</td>
<td>Patient transfers of several hundred meters, including elevators, were no longer needed</td>
<td>2003</td>
</tr>
<tr>
<td>CT priority and CT transfer</td>
<td>CT emptied prior to patient arrival, and patient transferred straight onto CT table, not ER bed</td>
<td>2004</td>
</tr>
<tr>
<td>Rapid neurologic evaluation</td>
<td>Patient is examined upon arrival, on CT table</td>
<td>2004</td>
</tr>
<tr>
<td>Preacquisition of history</td>
<td>Statewide electronic patient records and eyewitness interview before/after transportation</td>
<td>2005</td>
</tr>
<tr>
<td>Point-of-care INR</td>
<td>Laboratory personnel draw blood while patient on CT table, and perform instant POC INR</td>
<td>2005</td>
</tr>
<tr>
<td>Reduced imaging</td>
<td>While all patients have a CT, advanced imaging reserved for unclear cases only</td>
<td>2005</td>
</tr>
</tbody>
</table>
3. Single call/paging activation system for entire stroke team

Strategies associated with lower DTN:

- EMS prenotification.
- Written protocols with standard work; Toyota LEAN methodology.
- Single call activation system.
- Treating before labs return; INR point of care for warfarin patients.
- Straight to CT from ambulance bay or triage.
- Immediate interpretation of CT.
- Rapid access to tPA, begin mixing ASAP, treating on CT table.
- Prompt data feedback.
STAT! Stroke

Before June 2013

Acute Stroke
<12 hours
Page 00379

Subacute Stroke
>12 hours
Page 00379

After June 2013

Stat! Stroke
<4.5 hours + Red Findings
Page 12991

Acute Stroke
<12 hours, no Red Findings
Page 00379

Subacute Stroke
>12 hours
Page 00379

STAT! STROKE Specific tasks for each team member

Triage nurse
ED physician

Patient care attendant
ED bedside nurse

Stroke team physician
CT tech
**STAT! STROKE**  
*Specific tasks for each team member*

5-10 minutes for unloading and triage

5 minutes to transport/transfer onto CT table

---

**Target: Stroke**  
**Best Practice Strategies**

1. *EMS Pre-Notification*
2. Stroke Toolkit
3. Rapid Triage and Stroke Team Notification
4. *Single Call Activation System*
5. **Transfer Directly to CT**
6. Rapid Brain Imaging
7. *POC Laboratory Testing*
8. *Premix TPA*
9. *Rapid TPA Access - store TPA in ED/radiology, start in imaging suite*
10. Team approach
11. *Prompt data feedback*
STAT! Stroke – what we changed

On Scene
- LSN ≤ 4.5 hrs
  - 1 red finding
    - STAT! Stroke
- EMS patch while on scene
- Patient Name & DOB

Prep for ptt Arrival
- STAT! Stroke activated by Triage
  by paging 12991
- Registered as Unknown patient
- Stroke Team arrives at ED

SWARM! Safe for CT
- SWARM at triage
- Standard Work defined for each profession
- Work occurs in parallel
  - ED RNs
  - ED doc
  - Stroke Team
  - PCA
  - RT
  - Social Work

Imaging & Decision making
- Decision to treat based on non-contrast CT
  (before CTA)
  - call U112 nurse to come down to CT to treat if Nancy not there
  - PCA and ED RN at CT

Treatment
- treat with IV tPA on CT table after CTA with bolus/infusion

Comprehensive stroke centre
30-60-90 DTN DTGP DTR rule

Door to tPA bolus <30 min

TPA bolus to groin puncture <30 min

groin puncture to first reperfusion <30 min
Comprehensive stroke centre
30-60-90 DTN DTGP DTR rule

Door to tPA bolus <30 min

tPA bolus to groin puncture <30 min

groin puncture to first reperfusion <30 min
**BRISK** Brisk Recanalization Ischemic Stroke Kit
Pre-prepared stroke tray and kit

- Everything already there, Expensive stuff in packets
- Now used all across Canada
- Not a single case of infection reported
- Time saving estimates:
  - 15 min (daytime)-30 min (after hours)
  - Can do case without angio tech- middle of night!

---

**Comprehensive stroke centre**

30-60-90 DTN DTGP DTR rule

- Door to tPA bolus <30 min
- tPA bolus to groin puncture <30 min
- Groin puncture to first reperfusion <30 min
Stroke neurologist provides medical care
To patient in angio suite

30-90 minutes for procedure

Stroke neurologist/anesthesia
- Manage patient, vital signs, etc.
- General anesthesia avoided unless absolutely necessary

Angio procedure
- List CTA to plan procedure
- Go straight to target
- Take short cuts wherever one can
- Never devices

Talk to family
- Manage complications and post care

Fast DTNs translate to fast DTGP times
5 Stroke Scenarios of EVT eligible patients

- Metro area patients - EMS activation
- Small urban area patients - EMS activation
- Rural patients - EMS activation
- Walk-in/private vehicle - no EMS activation
- In hospital stroke
Map 5.2. Predicted Stroke Centre drive time (minutes) service areas; 2005, 2007, and 2010 infrastructure.

Metro: CSC near    Small Urban: PSC near    Rural
IV TPA Time is Brain

Emerson J et al. ISC 2014

Pooled Analysis NINDS tPA; ATLANTIS; ECASS-1,2,3; EPITHET, IST-3

~2-3% absolute decrease in excellent outcome per hour

~1-2% absolute increase in mortality per hour

Interaction p=0.016

Cost ratio (50% CI)

0 1 1.4 1.8 2.2 2.6 3

60 90 120 150 180 210 240 270 300 330 360

OTT (min)

-14%

-1%

8%

0%

+1%

5%

+2%

+3%

-5h
Time is Clot:
IV tPA reduces clot best if tx early

- Primary Stroke Centres
  - Geographically challenged areas
  - Telestroke capability to hub CSC
  - CT/CTA 24/7
"Neurons over nephrons" in major stroke

"CIN" called into question

### Propensity Score-adjusted Outcomes

<table>
<thead>
<tr>
<th>Data Set and Outcome</th>
<th>Contrast Group</th>
<th>Noncontrast Group</th>
<th>ORs and HRs*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire matched data set</td>
<td>10673</td>
<td>10673</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>AKI</td>
<td>515 (4.8)</td>
<td>544 (5.1)</td>
<td>0.94 (0.83, 1.07)^1</td>
<td>.38</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>25 (0.2)</td>
<td>27 (0.3)</td>
<td>0.96 (0.54, 1.60)^1</td>
<td>.89</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>850 (8.0)</td>
<td>875 (8.2)</td>
<td>0.97 (0.87, 1.06)^1</td>
<td>.45</td>
</tr>
<tr>
<td>AKI risk groups^3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-risk group</td>
<td>7273</td>
<td>7273</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>7 (0.1)</td>
<td>8 (0.1)</td>
<td>0.88 (0.32, 2.41)^1</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>417 (5.7)</td>
<td>426 (5.9)</td>
<td>0.95 (0.83, 1.09)^1</td>
<td>.44</td>
</tr>
<tr>
<td>Medium-risk group</td>
<td>2442</td>
<td>2442</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>7 (0.3)</td>
<td>7 (0.3)</td>
<td>1.00 (0.35, 2.86)^1</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>303 (12.4)</td>
<td>314 (12.9)</td>
<td>0.97 (0.83, 1.14)^1</td>
<td>.64</td>
</tr>
<tr>
<td>High-risk group</td>
<td>958</td>
<td>958</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>11 (1.1)</td>
<td>12 (1.3)</td>
<td>0.92 (0.40, 2.09)^1</td>
<td>.84</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>130 (13.6)</td>
<td>135 (14.1)</td>
<td>0.93 (0.73, 1.18)^1</td>
<td>.56</td>
</tr>
</tbody>
</table>
COMMENTARY

Good is not Good Enough: The Benchmark Stroke Door-to-Needle Time Should be 30 Minutes


doi:10.1017/cjn.2014.41
Can J Neurol Sci. 2014; 41: 694-696

Short Door In- Door Out in STEMI

1st Door at STEMI Referral Hospital DIDO ≤ 30 minutes

Transfer Time ≤ 60 Minutes

2nd Door to Device Time ≤ 30 minutes

*Excludes transfer patients treated initially with thrombolytics, no PCI performed, any non-system reason for delay and/or missing information
Table 3. Description of Work-Flow Metrics Between Local ED Admissions and Outside Hospital Transfers

<table>
<thead>
<tr>
<th>Interval processes, median (IQR), min</th>
<th>Local ED Admissions (n=61)</th>
<th>Outside Hospital Transfers (n=132)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVN to first hospital arrival</td>
<td>62 (38–121)</td>
<td>65 (49–104)</td>
<td>0.90</td>
</tr>
<tr>
<td>Hospital arrival to initial CT</td>
<td>16 (6–25)</td>
<td>15 (7–21)</td>
<td>0.59</td>
</tr>
<tr>
<td>Outside hospital—specific processes*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial CT to CSC notification</td>
<td>66 (38–109)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSC notification to EMS arrival at outside hospital</td>
<td>35 (25–46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMS arrival to CSC CT</td>
<td>58 (45–77)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DTN <30 min/ DIDO <45 min
Door to CT scanner <10 min
Keep on EMS stretcher and bring EMS team to scan!
NCCT prep/scanning time <5 min
Keep on the CT table for immediate CTA!

NCCT to tPA decision via telestroke <10 min

Door to CT scanner <10 min
Keep on EMS stretcher and bring EMS team to scan!

NCCT to tPA decision via telestroke <10 min
mix/prep for bolus <5 min
**DTN <30 min/ DIDO <45 min**

- Door to CT scanner <10 min
- NCCT prep/scanning time <5 min
- Keep on EMS stretcher and bring EMS team to scan!
- CTA reformatting time <5 min
- All images to decision <10 min
- Same EMS team and stretcher out door!
- NCCT to tPA decision via telestroke <10 min
- mix/prep for bolus <5 min
- Door to needle <30 minutes
- Prep for CSC <10 min
- Door in door out <45 minutes

**Centralize care: Redirect ambulance to efficient stroke centres only**
Centralize care: Redirect ambulance to efficient stroke centres only

Harmonize NCCT/mCTA Stroke Protocol

- Quality NCCT
- CTA neck/head
- Thin section NCCT
- CTA 23 mm
- Thick MIPs
- mCTA
Thick and thin section NCCT Protocol

Figure 4: The multi-phase CTA (each phase represented by an arrow). The first phase (long solid arrow) is a conventional arch to vertex CT-angiography. The next two phases (short solid arrows) are sequential skull base to vertex acquisitions acquired in the mid venous and late venous phase. The dashed arrows indicate movement of the scanner in between image acquisitions.
Alberta Acute Stroke Treatment 2016

- Comprehensive Stroke Centre
- Primary Stroke Centre
### Multiphase CTA

<table>
<thead>
<tr>
<th>Occlusion site</th>
<th>1st peak arterial</th>
<th>2nd peak venous</th>
<th>3rd late venous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor collaterals</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Minimal collaterals</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>No collaterals</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
</tr>
</tbody>
</table>

---

![Graph showing lesion volume over time from symptoms onset](image10.png)

Liebeskind D et al. ISC 2015
Multiphase CTA

<table>
<thead>
<tr>
<th>Occlusion site</th>
<th>1st peak arterial</th>
<th>2nd peak venous</th>
<th>3rd late venous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excellent collaterals</strong></td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>Good collaterals</strong></td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>Fair collaterals</strong></td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

mCTA compensates for slow transit

**CHF/afib**

<table>
<thead>
<tr>
<th>1st Peak Arterial</th>
<th>Minimal contrast – very early arterial phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Peak Venous</td>
<td>![Image]</td>
</tr>
<tr>
<td>3rd Late Venous</td>
<td>![Image]</td>
</tr>
</tbody>
</table>
5 Stroke Scenarios of EVT eligible patients

- Metro area patients- EMS activation
- Small urban area patients- EMS activation
- Rural patients- EMS activation
- Walk-in/private vehicle- no EMS activation
- In hospital stroke
Creating a Highly Time Efficient Major Stroke Transport Protocol

Metro: CSC near  Small Urban: PSC near  Rural
Creating a Highly Time Efficient Major Stroke Transport Protocol

Metro: CSC near Small Urban: PSC near Rural

Complete Physical Examination Findings below, then continue with screening process.

<table>
<thead>
<tr>
<th>Physical Examination Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level of Consciousness</strong></td>
</tr>
<tr>
<td>□ Alert</td>
</tr>
<tr>
<td>□ Responds to Verbal</td>
</tr>
<tr>
<td>□ Responds to Pain</td>
</tr>
<tr>
<td>□ Unresponsive</td>
</tr>
<tr>
<td><strong>Speech</strong></td>
</tr>
<tr>
<td>□ Normal (0)</td>
</tr>
<tr>
<td>□ Slurred</td>
</tr>
<tr>
<td>□ Incomprehensible or mute</td>
</tr>
<tr>
<td><strong>Leg Strength</strong></td>
</tr>
<tr>
<td>□ Normal</td>
</tr>
<tr>
<td>□ Right-Drifts down</td>
</tr>
<tr>
<td>□ Left-Drifts down</td>
</tr>
<tr>
<td>□ Right-Falls rapidly</td>
</tr>
<tr>
<td>□ Left-Falls rapidly</td>
</tr>
<tr>
<td><strong>Facial Smile</strong></td>
</tr>
<tr>
<td>□ Normal (0)</td>
</tr>
<tr>
<td>□ Right-Droop (1)</td>
</tr>
<tr>
<td>□ Left-Droop (1)</td>
</tr>
<tr>
<td><strong>Hand Grips</strong></td>
</tr>
<tr>
<td>□ Normal (0)</td>
</tr>
<tr>
<td>□ Right-Weak grip (1)</td>
</tr>
<tr>
<td>□ Left-Weak grip (1)</td>
</tr>
<tr>
<td>□ Right-No grip (2)</td>
</tr>
<tr>
<td>□ Left-No grip (2)</td>
</tr>
<tr>
<td><strong>Arm Strength</strong></td>
</tr>
<tr>
<td>□ Normal (0)</td>
</tr>
<tr>
<td>□ Right-Drifts down (1)</td>
</tr>
<tr>
<td>□ Left-Drifts down (1)</td>
</tr>
<tr>
<td>□ Right-Falls rapidly (2)</td>
</tr>
<tr>
<td>□ Left-Falls rapidly (2)</td>
</tr>
</tbody>
</table>

LAMS Score (0 - 5): Calculated by adding the corresponding number from each of the three categories above. TOTAL =
Rural 3 Way Field Call

- Hemiplegic - no mvt arm or leg?
- Helicopter available?
- Last seen normal?
- Clinically worsening?
- ICH?
- Should ambulance rendezvous with helicopter?
- Transport times to PSC vs CSC?
- Weather?
- Premorbid status?
- tPA ineligible?
- PSC operational?
- Gaze deviation?

DECISION! GO!

EMS
CSC stroke team
Medical control physician

Finland
RACECAT STUDY

RACECAT
Prospective, multicenter
Cluster randomized controlled (pre-established temporal sequence)
Acute stroke patients with suspected acute large vessel occlusion identified by EMS Two strategies will be compared:

A
Local Stroke Center (+/- iv tPA)

B
EVT Stroke Center (+/- iv tPA)

5 Stroke Scenarios of EVT eligible patients

- Metro area patients- EMS activation
- Small urban area patients- EMS activation
- Rural patients- EMS activation
- Walk-in/private vehicle- no EMS activation
- In hospital stroke

QuICR

ERA
~90 non-stroke hospitals

Mild Stroke Early Progression

NIHSS ≤3: 8.3%

Onset to ED: 1.9 hrs
Onset to MRI: 7.3 hrs
Minor cerebrovascular syndrome triaging

"TIA event"

Clinician determines risk/TIA Hotline called

Low/intermediate risk

Referred to SPC

Seen within days

High risk/persisting minor deficit

Sent to ED

ED assessment

CT/CTA based testing

More ultrasound based testing

---

Refinement of Imaging Predictors of Recurrent Events following Transient Ischemic Attack and Minor Stroke

Myles Horten1,2,3, Jennifer Melbourne-Thomas4,5, Andrew M. Drenckhahn4,5, Mayank Patel6,7, Michael D. West8,9,10, Shadijah K. Kassam11,12,13,14

Dorset Clinical Research Unit, University of Exeter, Exeter, UK; Royal Devon and Exeter NHS Foundation Trust, Exeter, UK; University of Exeter Medical School, Exeter, UK; Department of Neurology, University of Exeter, Exeter, UK; University of Exeter Medical School, Exeter, UK; Medical School, University of Exeter, Exeter, UK; Nuffield Department of Clinical Neuroscience, University of Oxford, Oxford, UK; University of Oxford, Oxford, UK; Division of Radiology, University of Exeter, Exeter, UK; University of Exeter Medical School, Exeter, UK; University of Exeter Medical School, Exeter, UK; Department of Clinical Neurosciences, University of Exeter, Exeter, UK; University of Exeter Medical School, Exeter, UK; Division of Radiology, University of Exeter, Exeter, UK; University of Exeter Medical School, Exeter, UK; University of Exeter Medical School, Exeter, UK; National Hospital for Neurology and Neurosurgery, London, UK; University College London Hospitals, London, UK; University of Oxford, Oxford, UK; University of Exeter Medical School, Exeter, UK; University of Exeter Medical School, Exeter, UK

NIHSS 0 to 5 (N=229)

<table>
<thead>
<tr>
<th>Progression (19 and 10 events)</th>
<th>Hazard Ratio (95% CI)</th>
<th>P-value (FDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWI lesion (one or none)</td>
<td>12.4 (4.6, 33.3)</td>
<td>0.014</td>
</tr>
<tr>
<td>Intracranial occlusion</td>
<td>11.3 (4.4, 30.8)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Imaging Findings

<table>
<thead>
<tr>
<th>Variable</th>
<th>Progression % (No./No.)</th>
<th>No-Progression % (No./No.)</th>
<th>Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute ischaemic infarct (CT)</td>
<td>21 (16/19)</td>
<td>12 (15/19)</td>
<td>1.9 (0.6-5.8)</td>
</tr>
<tr>
<td>Intracranial occlusion (CTA)</td>
<td>24 (14/19)</td>
<td>18 (10/19)</td>
<td>1.3 (0.5-3.9)</td>
</tr>
<tr>
<td>Intracranial occlusion (MRI)</td>
<td>51 (37/19)</td>
<td>9 (7/19)</td>
<td>9.9 (4.0-26.4)</td>
</tr>
<tr>
<td>Intracranial stenosis (CTA)</td>
<td>26 (19/19)</td>
<td>6 (13/19)</td>
<td>4.7 (1.7-7.1)</td>
</tr>
<tr>
<td>Extracranial carotid artery occlusion (CTA)</td>
<td>18 (13/19)</td>
<td>9 (6/19)</td>
<td>1.8 (0.5-6.5)</td>
</tr>
<tr>
<td>Original CTTA positive</td>
<td>79 (15/19)</td>
<td>33 (15/19)</td>
<td>7.3 (2.4-22.3)</td>
</tr>
<tr>
<td>DWI positive</td>
<td>79 (15/19)</td>
<td>57 (27/19)</td>
<td>2.7 (0.92-8)</td>
</tr>
</tbody>
</table>
Minor cerebrovascular syndrome triaging

- no ILT → urgent CEA/CAS
- ILT → dual antithrombotics → CEA/CAS in few days
- intracranialAS → dual antithrombotics/POINT
- eICAS

Sent to ED

ED assessment

- CTA positive
  - admit
  - Distal Intracranial occlusion
    - tPA/TEMPO-2

- CTA negative
  - home
  - Proximal Intracranial occlusion
    - tPA/TEMPO-2
    - Neurologic deterioration
    - Mechanical thrombectomy

Complete Physical Examination Findings below, then continue with screening process

**Physical Examination Findings**

<table>
<thead>
<tr>
<th>Level of Consciousness</th>
<th>Speech</th>
<th>Leg Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert</td>
<td></td>
<td>Normal (0)</td>
</tr>
<tr>
<td>responds to Verbal</td>
<td></td>
<td>Right-Drifts down</td>
</tr>
<tr>
<td>responds to Pain</td>
<td></td>
<td>Left-Drifts down</td>
</tr>
<tr>
<td>Unresponsive</td>
<td></td>
<td>Right-Drifts down</td>
</tr>
<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Left-Falls rapidly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facial Smile</th>
<th>Hand Grips</th>
<th>Arm Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (0)</td>
<td>Normal (0)</td>
<td>Normal (0)</td>
</tr>
<tr>
<td>Right-Droop (1)</td>
<td>Right-Weak grip (1)</td>
<td>Right-Drifts down (1)</td>
</tr>
<tr>
<td>Left-Droop (1)</td>
<td>Left-Weak grip (1)</td>
<td>Left-Drifts down (1)</td>
</tr>
<tr>
<td></td>
<td>Right-No grip (2)</td>
<td>Right-Falls rapidly (1)</td>
</tr>
<tr>
<td></td>
<td>Left-No grip (2)</td>
<td>Left-Falls rapidly (2)</td>
</tr>
</tbody>
</table>

LAMS Score (0-5): Calculated by adding the corresponding number from each of the three categories above

TOTAL = 

Educates nurses to perform LAMSS

Trigger transport call
Non-stroke centre Call

Non-stroke center ED doc
CSC stroke team
Medical control physician

Hemiplegic- no mvt arm or leg?
Helicopter available?
Transport times to PSC vs CSC?
Last seen normal?
tPA ineligible?
Should ambulance rendezvous with helicopter?
Clinically worsening?
ICH?
Premorbid status?
Weather?
PSC operational?
Gaze deviation?
DECISION!
GO!

5 Stroke Scenarios of EVT eligible patients

- Metro area patients- EMS activation
- Small urban area patients- EMS activation
- Rural patients- EMS activation
- Walk-in/private vehicle- no EMS activation
- In hospital stroke
Effect size by tPA use

<table>
<thead>
<tr>
<th>Alteplase (pinteraction = 0.43)</th>
<th>n</th>
<th>cOR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1090</td>
<td>2.45 (1.68-3.57)</td>
</tr>
<tr>
<td>No</td>
<td>188</td>
<td>2.43 (1.30-4.55)</td>
</tr>
<tr>
<td>Total</td>
<td>1278</td>
<td>2.49 (1.76-3.53)</td>
</tr>
</tbody>
</table>

Favours control    Favours intervention

Safety of EVT when tPA ineligible?

Table 2. Contraindications and other reasons for no treatment with intravenous alteplase

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 55)</th>
<th>Intervention (n = 36)</th>
<th>Control (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INR 1.7–3.0</td>
<td>18</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Platelet count less than $90 \times 10^9/L$</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Surgery or intervention within two weeks prior to event</td>
<td>15</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Recent ischemic stroke within six weeks prior to event</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Use of contraindicated anticoagulants</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Time from onset to arrival exceeds 4.5 h</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Cerebral contusion within four weeks prior to event</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other reasons</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

INR: international normalized ratio.
108 hospitals – multiple wards

- Education on what to do difficult
- Key is **one number to call** for immediate communication with CSC stroke team and streamlined fastest mode of transport
**TNK tPA 0.25 mg/kg versus antiplatelet(s) in minor stroke with CTA intracranial occlusion**

ClinicalTrials.gov Identifier: NCT02398656

Calgary led/coordinated: SB Coutts (PI) and MD Hill (co-PI)

Canada, Spain, Belgium, Austria, Australia,

Study progress: 42 enrolled

---

**Calgary Stroke Fellowship Program**

We have funding!
150 thrombectomy+150 IV tPA cases per year
75+ fellows trained so far from 15 countries
Weekly half day teaching, weekly case rounds
5 stroke clinician scientists: to find fun projects
10 stroke neurologists under one roof: to debate
Thank-you for your attention!

Email: ademchuk@ucalgary.ca