To drip or ship: a UK perspective

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LVO at first sight, UK Stroke Forum, Telford

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Conflicts of Interest

- Honoraria, grants and consulting fees from: Amgen, Astra Zeneca, Bayer, Medtronic, Pfizer, Pulse Therapeutics, Stryker
- Chair of UK PISTE trial
- Chief Investigator NIHR programme grant examining optimal service organisation to deliver thrombectomy
Major COI: I work in a country that is failing to deliver thrombectomy to the vast majority of patients with LVO who would benefit.
ESO ESMINT EAN SAFE survey on stroke care in Europe
Number of IVT per year / 1 Million inhabitants

Annual number of intravenous thrombolysis per million inhabitants:
- 0.0 - 51.5
- 51.6 - 103.1
- 103.2 - 154.7
- 154.8 - 206.3
- 206.4 - 257.9
- 258.0 - 309.5
- 309.6 - 361.1
- 361.2 - 412.7
- Missing information
Large Vessel Occlusion present in one out of three stroke admissions

McMeekin et al, Eur Stroke J, 2017
Number of Stroke Patients for Thrombectomy

- 95,000 UK stroke admissions
- CTA <6h  n=10,190
- CTA + advanced imaging (MR perfusion/diffusion, CTP, CTA collateral scoring)
- Additional  n=1,390
- 12% stroke admissions

Updated from McMeekin et al, Eur Stroke J, 2017
Redirection for IV Thrombolysis

- Modelled redirection patients from 10 ASUs to 2 Neuroscience Centres using hospital and ambulance data
- Thrombolysis received by 223/1884 emergency admissions
- Redirection additional 68 patients treated after redirection 1269 stroke and 363 stroke mimics
- Median ambulance journey increased 10.5 to 12.2 miles, 17 min longer
- But door to needle shorter
- 12.6 QALYs over 5 years
- Cost/QALY £534

Price et al, Stroke 2013
Current Stroke Service Configuration

Suspected stroke Patient FAST +ve

Local acute stroke unit
Service available:
- Thrombolysis
- HASU

Telemedicine

Comprehensive acute stroke unit
Services available:
- Thrombolysis
- HASU
- Thrombectomy
Timelines for Drip and Ship

Suspected stroke Patient FAST +ve

Onset to scene: 30 min
Scene to Door: 30 min
(ambulance 1 leaves)
Door to CT/CTA: 20 min
CT to tPA needle: 10 min
Needle to CTA read: 20 min
CTA to CSU accept: 20 min
Onset to accept: 130 min

Call to arrival ambulance 2: 20 min
Door to CSU door: 50 min
Door to groin: 30 min
Groin to reperfusion: 20 min
Onset to reperfusion: 250 min
Direct to Mothership

“Each minute saved in onset-to-treatment time granted on average 4.2 days of extra healthy life” Meretoja et al, Neurology 2017

Suspected stroke Patient FAST +ve

Onset to scene 30 min
Diagnosis on scene (RACE, point of care diagnostics)
Scene to CSU Door 60 min

Door to CT/CTA 10 min
CT to tPA needle CTA read 5 min
CTA read to groin 15 min
Groin to reperfusion 15 min

Onset to reperfusion 135 min

115 min saving – 16 months of healthy life
‘Drip and Ship’ or ‘Mothership’

Trade offs Mothership vs. Drip n’Ship

- More rapid access to thrombectomy for LVO patients 12% patients
- Delay in administration of IV thrombolysis 15% patients
- Delayed admission to HASU for non LVO patients
- Increased numbers of stroke patients and mimics to CSC
What do the Experts say?

ESO-ESMINT Thrombectomy Guideline Group

“To a man with a comprehensive stroke centre everything looks like a large vessel occlusion in need of thrombectomy” with apologies to Mark Twain
Drip and ship vs Mothership

- **PICO:** For adults identified as potential candidates for MT in the prehospital field, does the mothership model, compared to the drip-and-ship model, improve functional outcome?

- *We cannot make recommendations on whether for adults identified as potential candidates for MT in the prehospital field, the mothership or the drip-and-ship model should be applied to improve functional outcome.***

  Quality of evidence: **Very Low** ⊕

- **Expert opinion on prehospital organizational models.** As there is lack of strong evidence for superiority of one organizational model, the choice of model should depend on local and regional service organization and patient characteristics. (11/11 agree). The mothership model might be favoured in metropolitan areas, with transportation time to a comprehensive stroke centre of less than 30-45 minutes and the use of the drip-and-ship model when transportation times are longer (11/11 agree). As there is limited experience with the other two models (drip-and-drive and mobile stroke unit) no expert opinion can be provided when to use these models (11/11 agree).
How many Hyperacute Stroke Units and Thrombectomy Centres do we need in England?

- NIHR Programme Grant funding to determine how thrombectomy can be effectively delivered (Phil White)
- Peninsula CLAHRC service modelling team – implementation science (Ken Stein)
- Assumptions we made about desirable outcomes
  - HASUs treating > 1000 stroke patients /yr have better outcomes and provide better value
  - Maximise proportion of population within 45 min ambulance journey to a HASU
  - Thrombectomy centres best based in Neuroscience Centres with interventional neuroradiology capability
  - Aim for annual volume of > 200 thrombectomy cases (24/7 Interventional teams of 5-6 individuals each performing minimum 30-40 procedures)
Modelling Assumptions

• Modelling is based on individuals with primary diagnosis of stroke in HES (2012-2015)
• Home location assumed, and is set at ‘Lower Super Output Area’ (population groups of ~1,500 people).
• Travel times are estimated normal car road travel times on non-congested roads.
• Individuals will normally be taken to closest appropriate unit.
  – We assume no commissioning borders for emergency care (except country borders)
• A model ‘hunts’ for solutions that perform well with respect to:
  – Travel time (average, maximum and proportion of patients within defined bands)
  – Keeping the smallest unit as large as possible
  – Keeping the largest unit as small as possible
• The model does not look for a single ‘best solution’.
  – It typically returns thousands or even tens of thousands of solutions

Allen et al, BMJ Open 2017
Access to specialist centres – travel time
% within 45 min HASU

Allen et al, BMJ Open 2017
Maximising access – how many centres?

Individuals within 45 mins and attending a hospital with more than 1,000 admissions/year (%)
Would it be feasible to build on neuroscience centres to have only comprehensive stroke centres?

- ‘Mothership’ model of hyper-acute stroke care.
- All selected centres provide thrombolysis and thrombectomy.
- No other hyper-acute stroke centres.
- Minimum of 1,500* acute stroke admissions per year needed to sustain thrombectomy expertise and service.
  - (*New locations may need at least 200 thrombectomy procedures per year to develop/maintain expertise).
24 Neuroscience Centres as only Comprehensive Stroke and HASUs

<table>
<thead>
<tr>
<th>Travel time (min)</th>
<th>Admissions/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15</td>
<td>11,952</td>
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<tr>
<td>15 - 30</td>
<td>26,001</td>
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<tr>
<td>30 - 45</td>
<td>21,874</td>
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<td>45 - 60</td>
<td>12,091</td>
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<td>60 - 90</td>
<td>7,042</td>
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<td>90 +</td>
<td>1,851</td>
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**HASU admissions/year**

- Addenbrooke’s Hospital: 5,337
- Charing Cross Hospital: 2,071
- Derriford Hospital: 3,093
- Hull Royal Infirmary: 2,151
- James Cook University Hospital: 2,001
- John Radcliffe Hospital: 2,501
- King’s College Hospital HASU: 1,509
- Leeds General Infirmary: 4,120
- North Bristol Hospital NHS Trust: 3,563
- Nottingham City Hospital: 2,006
- Princess Royal Hospital (Haywards Heath): 9,549
- Queen Elizabeth Hospital Edgbaston: 5,397
- Queen’s Hospital: 5,662
- Royal Hallamshire Hospital: 2,400
- Royal Preston Hospital: 2,814
- Royal Stoke University Hospital: 2,302
- Royal Victoria Infirmary: 3,425
- Salford Royal Hospital: 4,459
- Southampton General Hospital: 4,590
- St George’s Hospital: 3,342
- The Royal London Hospital: 1,735
- University College London Hospital: 3,077
- University Hospital Aintree: 3,376
- University Hospital Coventry: 2,045

**Average travel time (min):** 35

**Maximum travel time (min):** 150

**Maximum admissions/year:** 5,662

**Minimum admissions/year:** 1,569

**Patients within 45 minutes of HASU:** 75%

**Patients within 45 mins & >1,000 admissions/year:** 75%
# Annual Stroke Admissions to CSCs if all patients admitted to Neuroscience Centre

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<td>Princess Royal Hospital (Haywards Heath)</td>
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A mothership model does not look feasible

- The maximum number of units that can be selected while maintaining at least 1,500 admissions per year is 38.
  - An infinite supply of money and neuro-interventionists won’t help.
- The largest centres will be receiving 3,000 – 3,500 strokes per year (largest now is 2,000). This does not include stroke mimics.
- About 60% of the population would live within 30 minutes of hyper acute stroke care (which may provide thrombolysis), compared with 90% now.

*Allen et al, Eur Stroke J 2018*
Trade-off when using local HASUs for drip and ship

- Providing local thrombolysis in HASUs reduces the average time to thrombolysis
- But it increases average time to thrombectomy

Allen et al, Eur Stroke J 2018
24 Thrombectomy centres (the 24 Neuroscience centres)

Thrombectomy centres with <200 thrombectomy admissions

<table>
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Travel (mins) | Thrombectomy admissions |
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<td>320</td>
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28 Thrombectomy centres (chosen by model, all centres >200 admissions)

Thrombectomy centres with <200 thrombectomy admissions

NONE
Trading off time to thrombolysis improves time to thrombectomy

- Could we have CSCs and HASUs but choose to go directly to CSC so long as it did not add too much delay to thrombolysis (IVT)?
- Preserve local IVT while providing more rapid access to thrombectomy to more people?
- Allowing up to 15 min delay for IVT increases average time to IVT by just 2 min while reducing average time to ET by 20 min.
- This allowable delay affects 25% of all patients, who have an average delay in IVT of 8 min, and an average improvement in time to ET of 80 min.

Allen et al, Eur Stroke J 2018
Impact of allowable transfer delay on stroke unit admissions

Allen et al, Eur Stroke J 2018
Implications of combined CSC and HASU structure

• Imaging at spoke hospitals – rapid delivery tPA, routine CT angiography and interpretation.

• Ambulance transfer protocols, rapid turn around at HASU sites - CT+CTA and IV thrombolysis commenced within 20 min arrival and onward transfer to CSC.

• Repatriation protocols for mimics, rapid recovering LVO stroke.
Timelines for Drip and Ship

Suspected stroke Patient FAST +ve

Onset to scene 30 min
Scene to Door 30 min
(ambulance 1 leaves)
Door to CT/CTA 20 min
CT to tPA needle 10 min
Needle to CTA read 20 min
CTA to CSU accept 20 min
Onset to accept 130 min

Call to arrival ambulance 2 20 min
Door to CSU door 50 min
Door to groin 30 min
Groin to reperfusion 20 min

Onset to reperfusion 250 min
Quicker Drip and Ship

**Suspected stroke Patient FAST +ve**

- Onset to scene: 30 min
- Scene to Door: 25 min  (ambulance 1 stays)
- Door to CT/CTA: 10 min
- CT to tPA needle and CTA read (stroke phys): 5 min
- CTA read to CSU transfer (ambulance 1 leaves for CSU): 5 min

**Comprehensive acute stroke unit**

- Door to CSU door: 50 min
- Door to groin: 20 min
- Groin to reperfusion: 15 min

- **Onset to reperfusion**: 160 min
- **90 min saving – One year of healthy life**
Conclusions

• At present drip and ship model should be optimised feeding FAST +ve suspected stroke patients into existing 24 Neuroscience/CSC mothership thrombectomy centres with establishment of additional thrombectomy centres in Devon, Kent and Norfolk.

• Enhancement of door to CT/CTA times, CTA reading/reporting and ambulance referral/repatriation protocols.

• Further consolidation/merger of 120+ HASUs in England needs to be undertaken.

• In future, with better recognition of LVO in pre-hospital setting (clinical scales and point of care diagnostics), with Telemedicine links of paramedics into CSC stroke specialists, can directly triage (< 1 hour transfer) suspected LVO patients to Mothership by passing local HASUs which continue to provide rapid initiation of IVT for non LVO stroke.

• For individuals > 1 hour from CSC. Admission to nearest HASU then ‘drip and ship’ or ‘drip and fly’ if LVO confirmed.