# MOTHERSHIP vs DRIP and SHIP

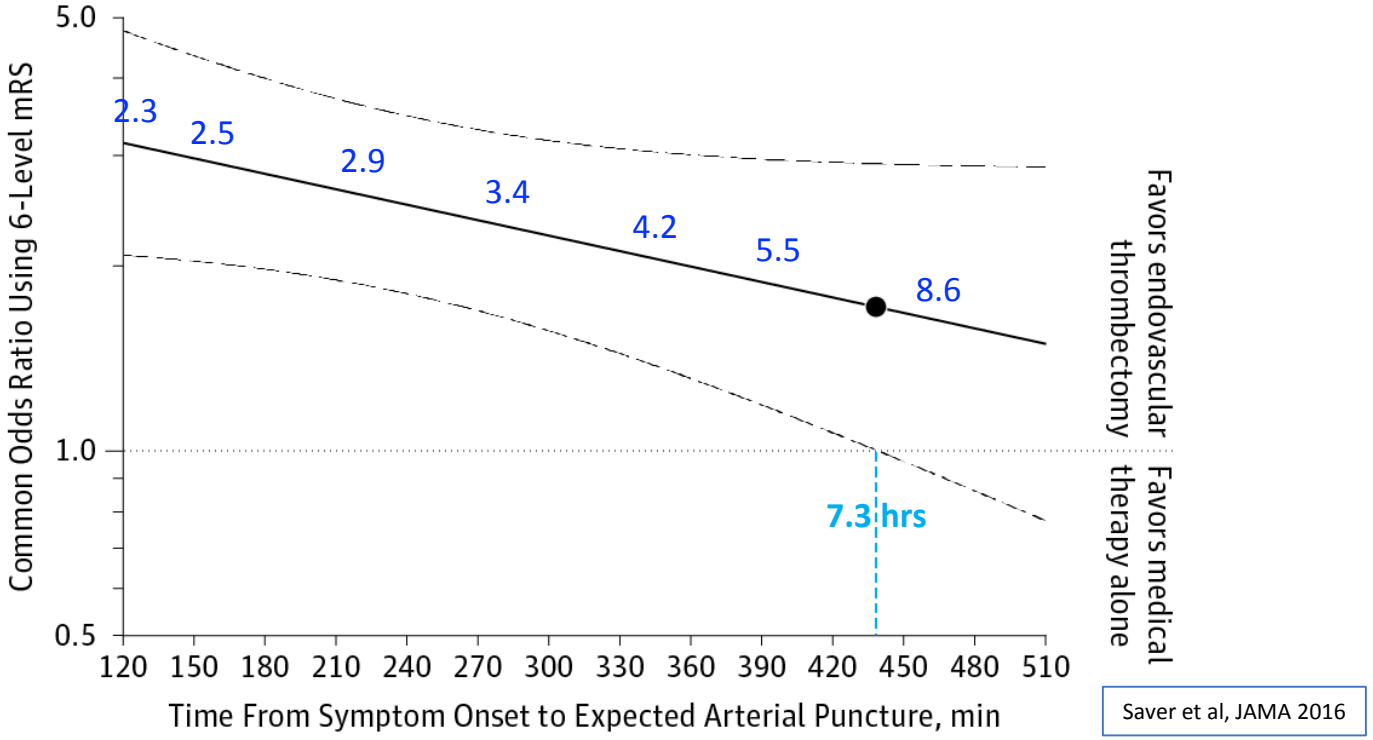
ECMINT 17DEC 2019

OXFORD

# Centralization:Bypass PSC

- High volume centers are associated with improved patients outcomes
  - Studies have consistently suggested that morbidity and complications from endovascular or open surgical procedures are lower at high-volume centers and that higher-volume stroke centers are associated with higher rates of good outcomes in comparison with lower-volume centers *Fargen KM, et al.J NeuroIntervent Surg 2015;7:229–230*
- Bypass the PSC and transport LVO patients directly to the CSC (in most situations)  OR ensure rapid DIDO of <40 minutes at the PSC. (Southerland et al. Stroke 2016)

# Observed clinical benefit of MT is time dependent




Saver et al, JAMA 2016

NNT to have a favourable clinical result ( mRS0-2)

From: **Time to Treatment With Endovascular Thrombectomy and Outcomes From Ischemic Stroke: A Meta-analysis**

JAMA. 2016;316(12):1279-1289. doi:10.1001/jama.2016.13647

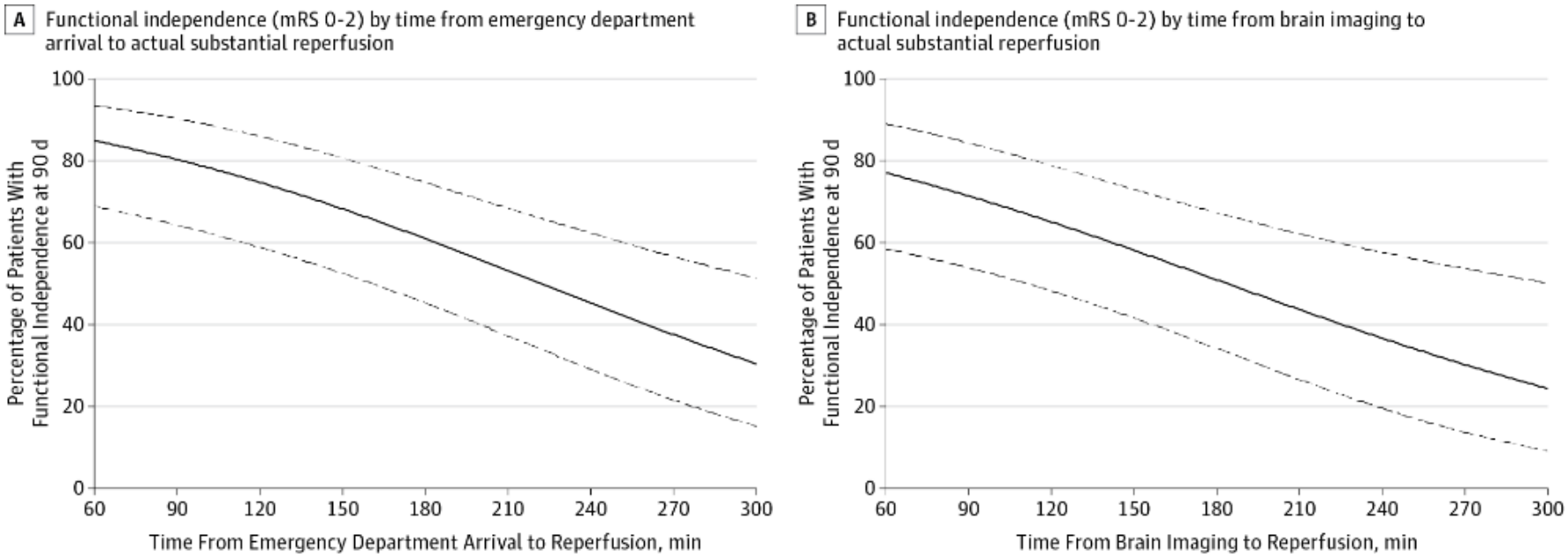
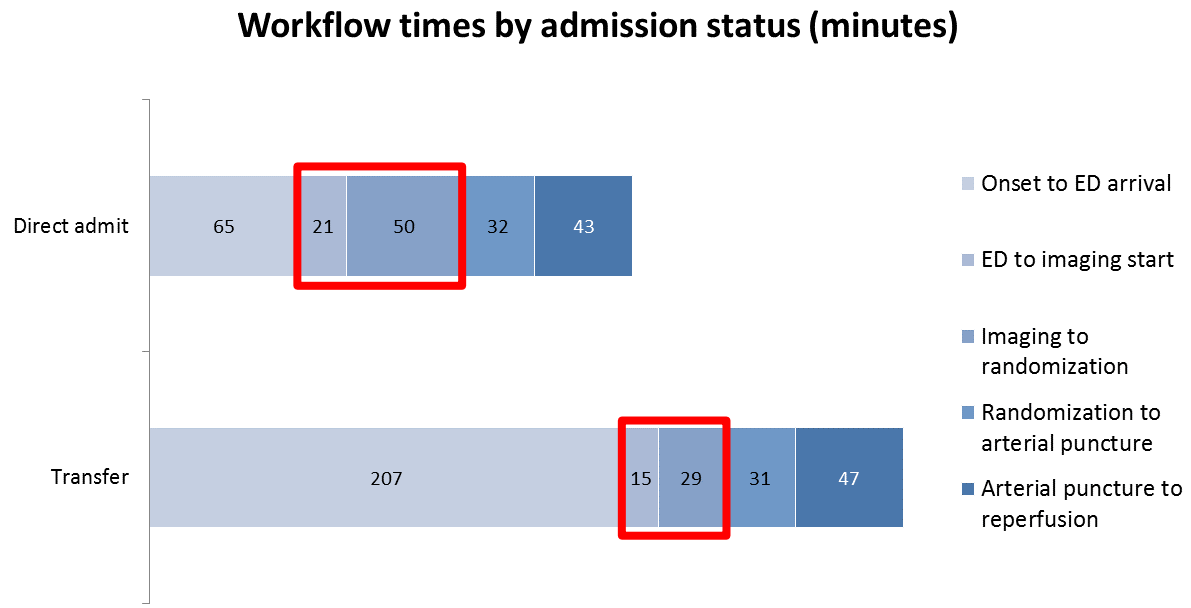



Figure Legend:

Relation Between In-Hospital Treatment Speeds and Functional Independence (mRS 0-2) at 3 Months Among Direct Arrival Patients in the Endovascular Thrombectomy Group Achieving Substantial Reperfusion (mTICI score, 2b or 3.

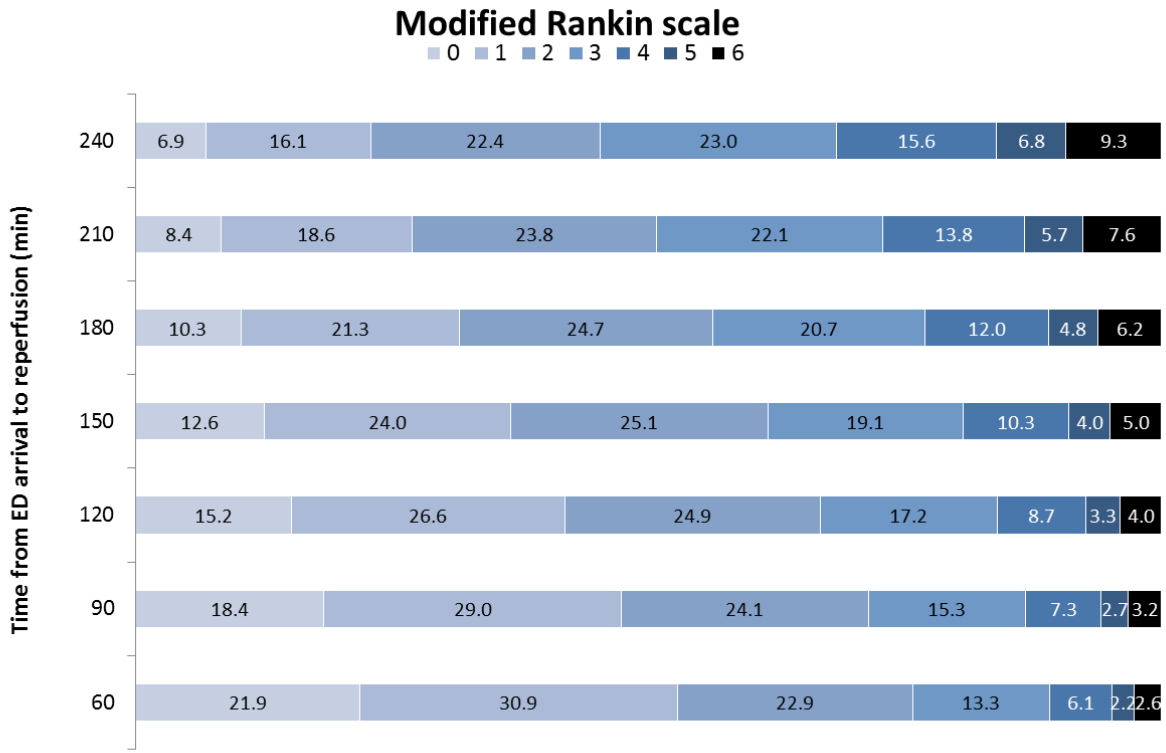
# Workflow time intervals in Direct-Arriving and Inter-Hospital-Transfer Patients.




* Median time values

Saver et al, JAMA 2016

# Association of time from ED arrival to endovascular reperfusion with predicted 90-day disability outcomes




Saver et al, JAMA 2016

The associations of time delay with poorer outcomes were magnified in the time segment from emergency department arrival through reperfusion

eTable 12. Number Needed to Treat, Benefit Per Thousand, and Minutes Needed to Treat for Faster Reperfusion Times

| | Onset to Reperfusion | | ED Arrival to Reperfusion | |
|---|---|---|---|---|
| | Less Disability | Functional Independence | Less Disability | Functional Independence |
| Benefit per thousand per 15 min faster* | 16 | 9 | 39 | 25 |
| NNTB per 15 min faster | 62 | 112 | 26 | 40 |
| Minutes Faster Needed to Treat (MNT) | 9 | 17 | 4 | 6 |

MNT: Minutes faster needed to treat – the number of minutes faster reperfusion needs to be achieved for 1 more reperfusion patient out of 100 to have a better outcome (lower 3 month disability by 1 or more grades on the 7 level mRS).

Saver et al, JAMA 2016

# Major emphasis on speed of treatment

- MR CLEAN showed a 7% decreased probability of good outcome for each hour delay in revascularization. For patients revascularized within 2 hours of stroke onset, the absolute difference in good outcomes between the endovascular and control groups was 33%, decreasing to 6.5% at 6 hours.

Time to reperfusion and treatment effect for acute ischemic stroke: a randomized clinical trial. Fransen et al. JAMA Neurol 2016;73:190–6.

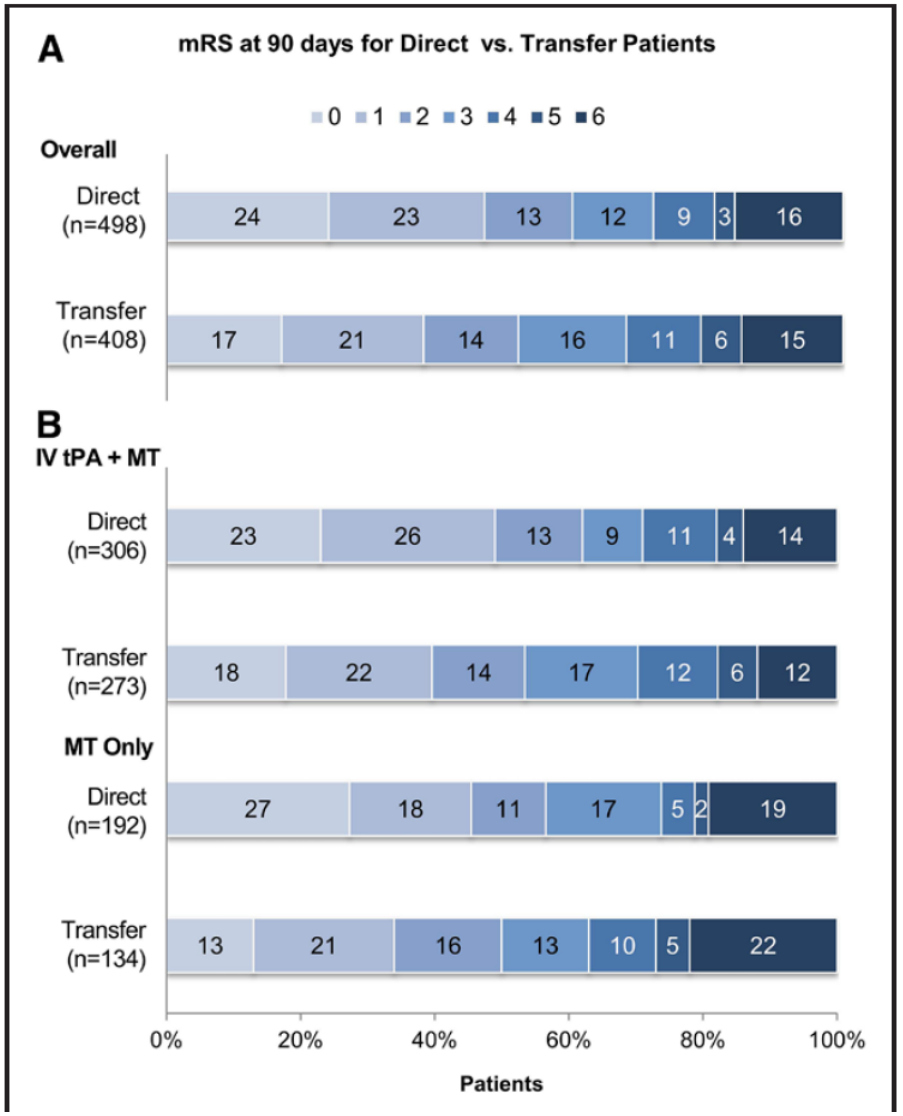



**Table 2. Effect on Good Functional Outcome Attributable to Delay in Time to Treatment**

| Predictor | Effect on Functional Independence: Odds Ratio (95% CI) | *P* Value |
|---|---|---|
| Age (per 10 y) | 0.78 (0.71–0.87) | <0.001 |
| Qualifying NIHSS (per 5 points) | 0.66 (0.58–0.76) | <0.001 |
| Location of intracranial target occlusion | | |
| Internal carotid artery | 0.57 (0.41–0.81) | 0.002 |
| Middle cerebral artery–second segment (M2) | 0.86 (0.58–1.27) | 0.455 |
| Middle cerebral artery–first segment (M1) (reference) | 1.00 (NA) | NA |
| IV-tPA delivered (vs. mechanical thrombectomy alone) | 1.04 (0.77–1.41) | 0.809 |
| Direct admit (vs. transfer) | 1.05 (0.76–1.45) | 0.767 |
| Time: onset to puncture (per 30 min) | 0.93 (0.89–0.98) | 0.008 |

CI indicates confidence interval; IV-tPA, intravenous tissue plasminogen activator (alteplase); NA, not applicable; and NIHSS, National Institutes of Health Stroke Scale.

Delays to endovascular treatment account for the difference in outcomes between direct and transfer patients.

**Interhospital Transfer Prior to Thrombectomy is Associated with Delayed Treatment and Worse Outcome in the STRATIS Registry.Froehler et al Circulation 2017**

# Centralization:Bypass PSC

- Clinical outcomes were better in the direct group with 60.0% (299/498) achieving functional independence, compared to 52.2% (213/408) in the transfer group (odds ratio 1.38, 95%CI 1.06-1.79; p=0.02).
- Likewise, excellent outcome (modified Rankin Score 0-1) was achieved in 47.4% (236/498) of direct patients vs. 38.0% (155/408) of transfer patients (odds ratio 1.47, 95%CI 1.13-1.92; p=0.005).
- Mortality did not differ between the two groups (15.1% for direct, 13.7% for transfer; p=0.55). IV-tPA did not impact outcomes.

**Interhospital Transfer Prior to Thrombectomy is Associated with Delayed Treatment and Worse Outcome in the STRATIS Registry.Froehler et al Circulation 2017**

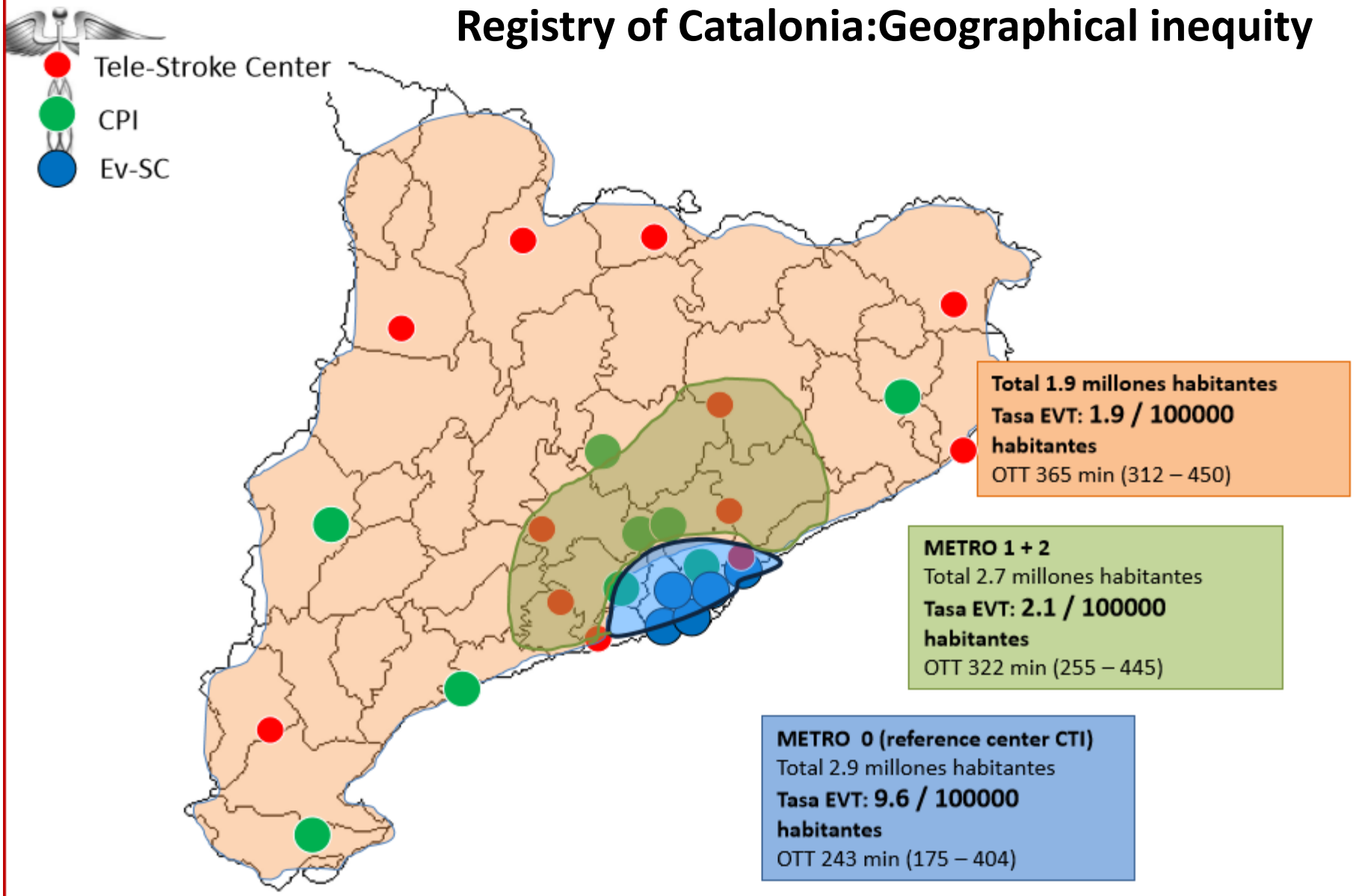
Association of Time From Stroke Onset to Groin Puncture With Quality of Reperfusion After Mechanical Thrombectomy *JAMA Neurol 2019*

**Table 2. Association of Delays in Workflow With TICI 2b/3 Outcome[a]**

| Outcome/Predictor | No. | OR (95% CI) | *P* Value |
|---|---|---|---|
| TICI 2b/3 by workflow predictors: all patients (adjustments: age, alteplase, and occlusion location) | | | |
| Onset to arterial puncture, per 60 min | 714 | 0.92 (0.81-1.03) | .15 |
| Imaging to arterial puncture, per 60 min | 670 | 0.74 (0.59-0.93) | .01 |
| ED arrival to arterial puncture, per 60 min | 680 | 0.78 (0.64-0.95) | .01 |
| TICI 2b/3 by workflow predictors: CT (adjustments: age, alteplase, occlusion location, and collateral grade) | | | |
| Onset to arterial puncture, per 60 min | 541 | 0.93 (0.82-1.06) | .26 |
| Imaging to arterial puncture, per 60 min | 499 | 0.83 (0.64-1.08) | .17 |
| ED arrival to arterial puncture, per 60 min | 508 | 0.81 (0.65-1.02) | .07 |
| TICI 2b/3 by workflow predictors: MR (adjustments: occlusion location only due to sample size) | | | |
| Onset to arterial puncture, per 60 min | 117 | 0.97 (0.64-1.48) | .89 |
| Imaging to arterial puncture, per 60 min | 117 | 0.54 (0.30-0.99) | .05 |
| ED arrival to arterial puncture, per 60 min | 117 | 0.60 (0.34-1.07) | .09 |

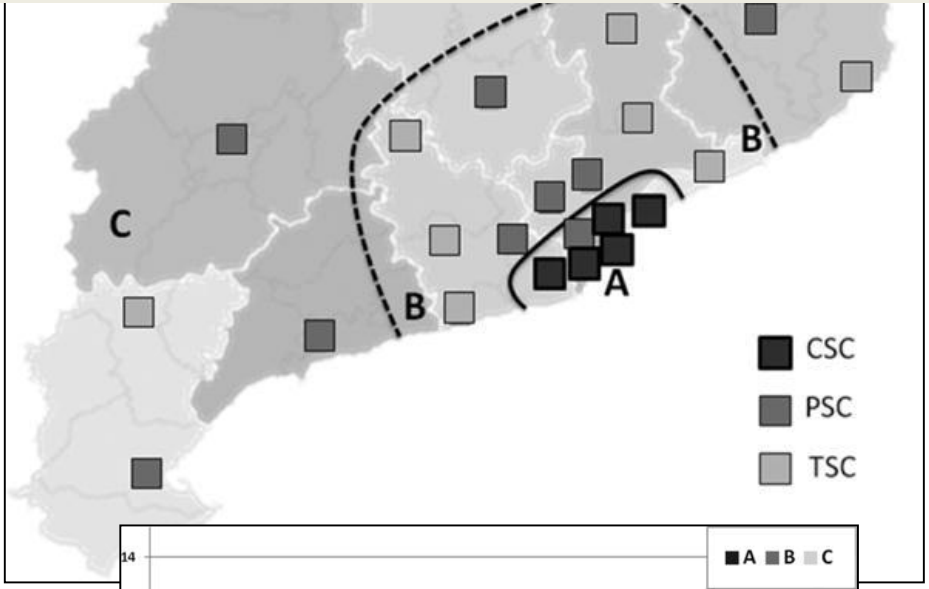
In the HERMES the intervention arm,
**every additional hour between arrival at the emergency department and groin puncture** was associated with a 22% reduction in the odds of TICI 2b/3 reperfusion.
**every additional hour between imaging and groin puncture** was associated with a 26% reduction in the odds of TICI 2b/3 reperfusion; this time interval had the strongest association with final reperfusion.

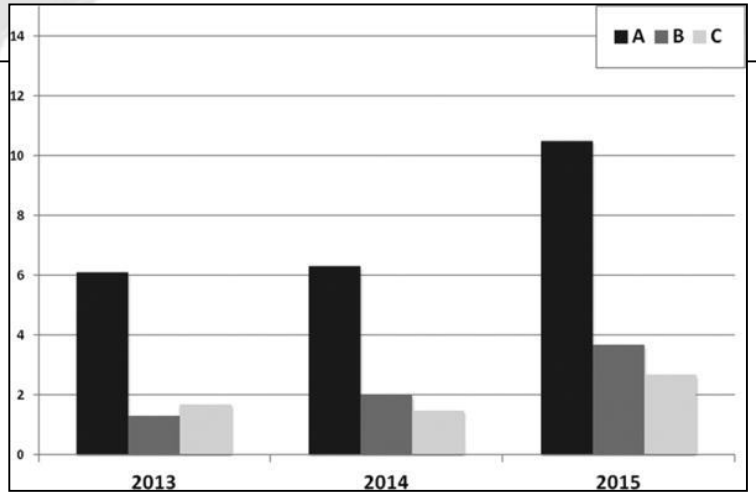
# Registry of Catalonia:Geographical inequity



Geographic differences in acute stroke care in Catalunya: impact of a regional interhospital network .Ribo et al. Cerebrovascular diseases 26:284-288, 2008

An interhospital network based on transfers to CSC does not warrant geographical equity: equal access to best therapeutic Interventions is only partially achieved at the expense of a high proportion of unecessary transfers.




| | | | | |
|---|---|---|---|---|
| Baseline NIHSS | 16 [11–20] | 16 [12–19] | 17 [12–20] | 0.47 |
| Site of occlusion, % | | | | |
| TICA | 10.2% | 6.5% | 11.9% | 0.02 |
| ICA | 5.8% | 7.5% | 4.6% | |
| Tandem | 13.0% | 10.7% | 11.0% | |
| MCA M1 | 40.8% | 53.3% | 53.2% | |
| MCA M2 | 15.9% | 10.3% | 4.6% | |
| Basilar | 9.5% | 8.4% | 12.8% | |
| Other | 4.8% | 3.3% | 1.9% | |
| EVT modality | | | | |
| Rescue (after IV r-tPA), % | 42.8% | 53.7% | 70.6% | <0.001 |
| Primary EVT, % | 57.2% | 46.3% | 29.4% | |
| Delays and clinical outcomes | | | | |
| Time from onset to groin puncture, min | 230 [160–407] | 312 [245–435] | 350 [284–408] | <0.001 |
| Time from onset to CSC arrival, min | 123 [57–401] | 233 [181–341] | 285 [240–368] | <0.001 |
| Time frome onset to IV r-tPA, min | 110 [80–156] | 109 [80–165] | 135 [116–189] | <0.001 |
| TICI 2b-3, % | 79.0% | 79.4% | 85.3% | 0.30 |
| SICH (ECASS II criteria), % | 3.1% | 1.9% | 5.5% | 0.44 |
| Good clinical outcome at 3 mo, % | 59.8% | 67.4% | 67.9% | 0.14 |
| Mortality at 3 mo, % | 16.2% | 13.1% | 13.8% | 0.47 |

AF indicates atrial fibrillation; CSC, Comprehensive Stroke Center; DL, dyslipidemia; DM, diabetes mellitus; ECASS II, European Cooperative Acute Stroke Study II; EVT, endovascular treatment; HT, hypertension; ICA, internal carotid artery; IV r-tPA, intravenous recombinant tissue-type plasminogen activator; MCA, middle cerebral artery; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; SICH, symptomatic hemorrhagic transformation; TICA, terminal internal carotid artery; and TICI, Thrombolysis in Cerebral Infarction.

**Access to Endovascular Treatment in Remote Areas: Analysis of the Reperfusion Treatment Registry of Catalonia.**

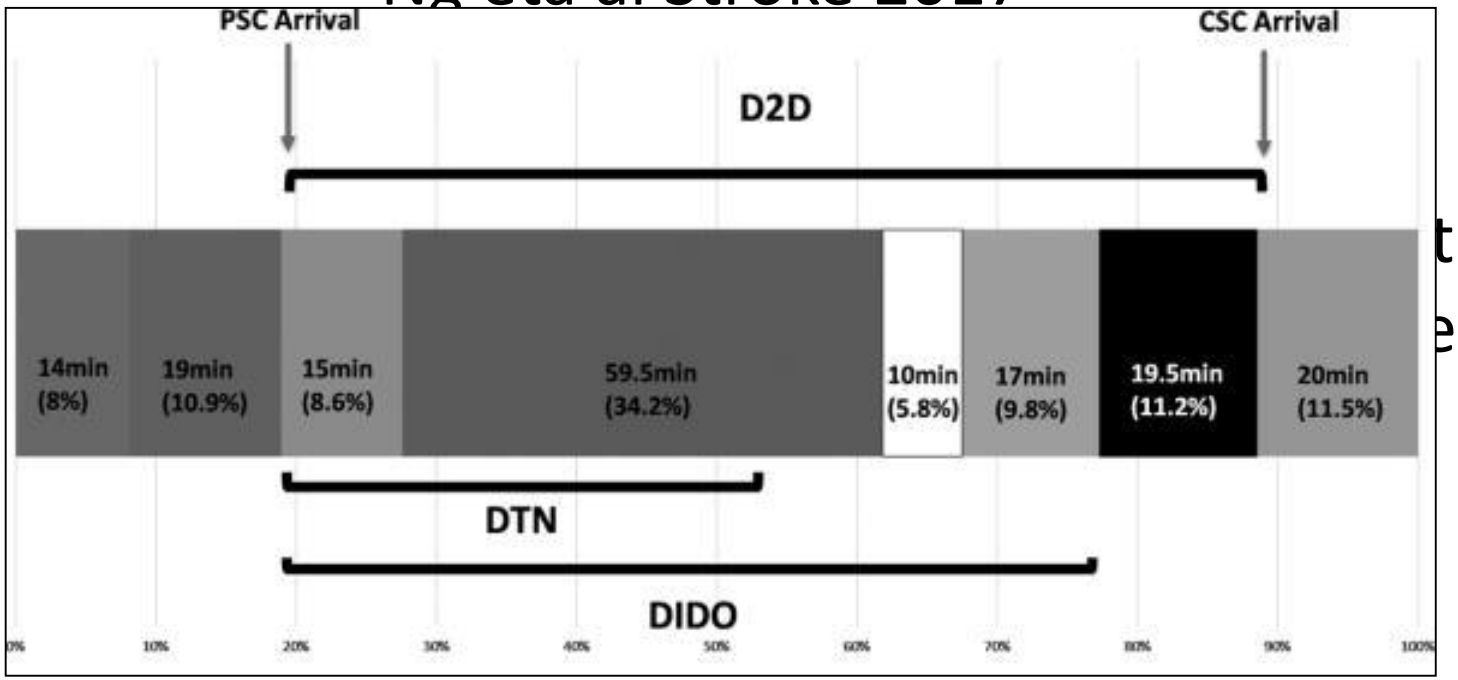
Perez de la Ossa, Natalia;

Stroke. 47(5):1381-1384, May 2016.

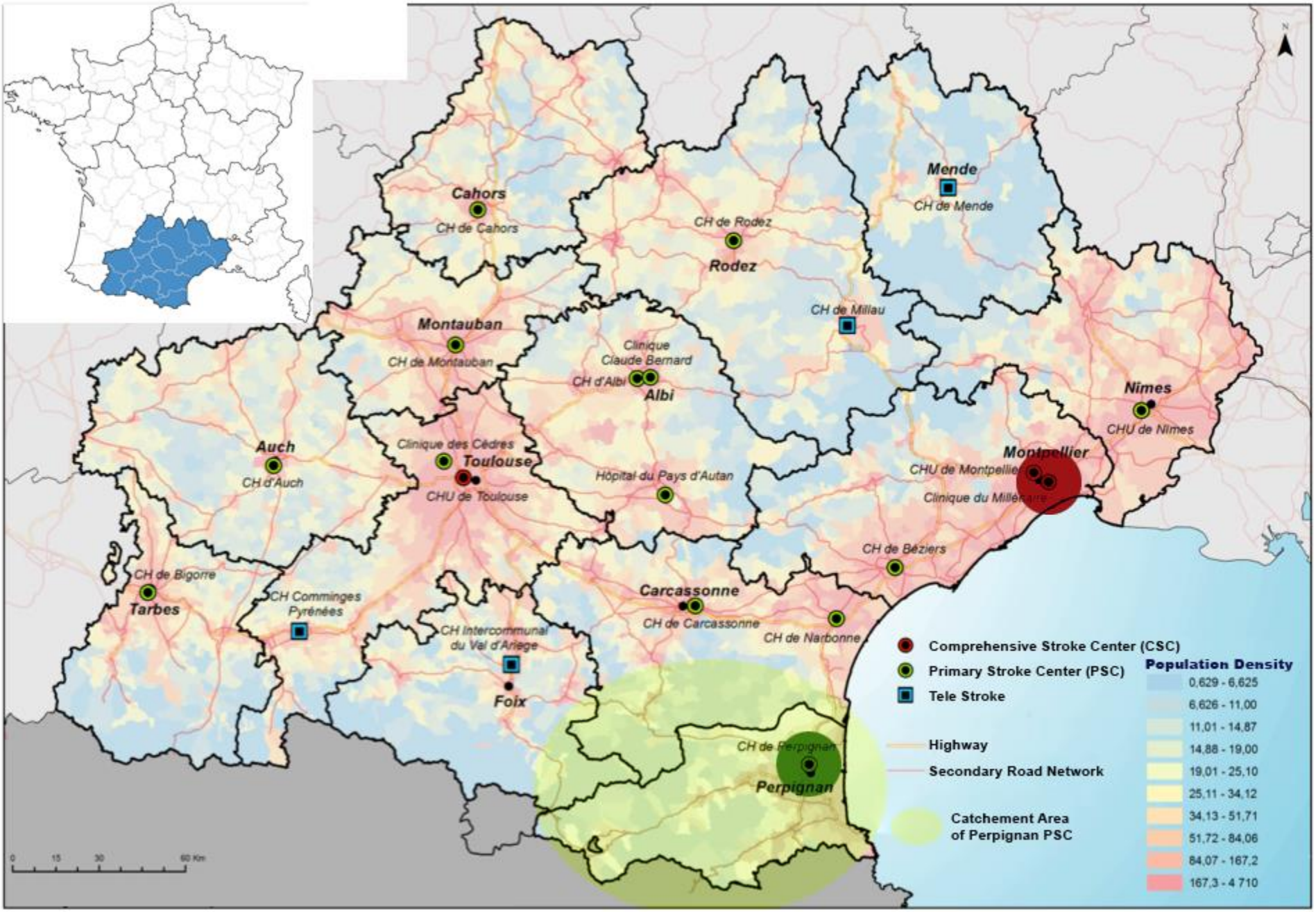
# Workflow optimization strategies for transfer AIS

- Primary stroke center
  - DIDO
    - Door to Imaging ( CT v MRI);
    - Door to Needle
  - D2D
- CSC In hospital time metrics
  - Direct to Angiosuite

# Reducing time intervals in metropolitan areas
# Deconstruction of interhospital worflow
# Ng eta al Stroke 2017




What a reasonable DIDO time target should be? In 2017, we proposed a target of 75 minutes, which was the top 15th percentile of the data available at the time. The current study would suggest **45 minutes** (top 10th percentile**) should be the new target** median; arguably the target median should be even lower as <=40 minutes was achieved on several occasions.


Cahors
CH de Cahors
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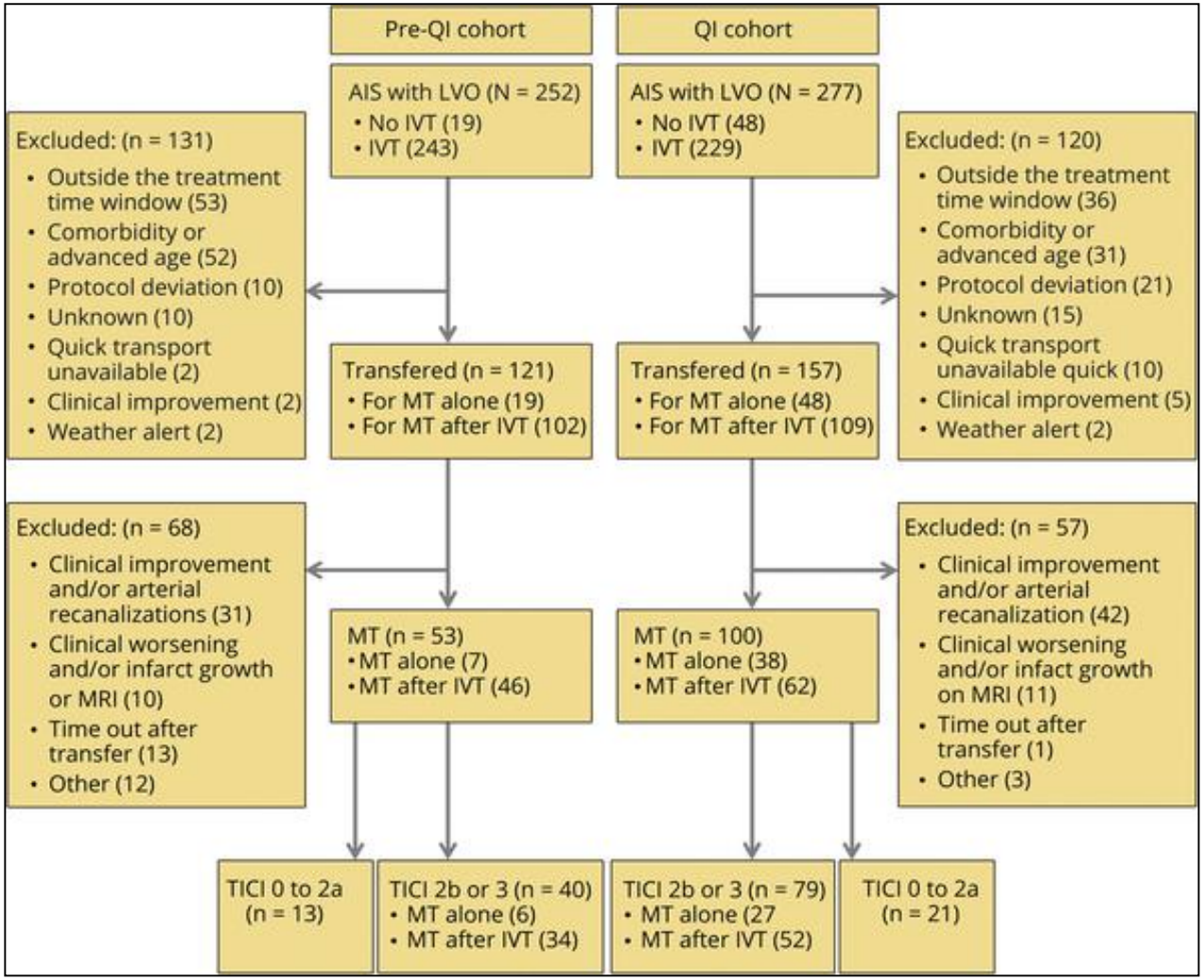
Rodez
CH de Millau
Montauban
CH de Montauban
Clinique
Claude Bernard
CH d'Albi
Albi
Nimes
CHU de Nimes
Auch
CH d'Auch
Clinique des Cèdres
Toulouse
CHU de Toulouse
Hôpital du Pays d'Autan
Montpellier
CHU de Montpellier
Clinique du Millénaire
CH de Béziers
CH de Bigorre
Tarbes
CH Comminges
Pyrénées
Carcassonne
CH de Carcassonne
CH de Narbonne
CH Intercommunal
du Val d'Ariège
Foix
CH de Perpignan
Perpignan
Comprehensive Stroke Center (CSC)
Primary Stroke Center (PSC)
Tele Stroke
Highway
Secondary Road Network
Catchement Area
of Perpignan PSC
Population Density
0,629 - 6,625
6,626 - 11,00
11,01 - 14,87
14,88 - 19,00
19,01 - 25,10
25,11 - 34,12
34,13 - 51,71
51,72 - 84,06
84,07 - 167,2
167,3 - 4 710
0
15
30
60 Km

**Shortening time to reperfusion after transfer from a primary to a comprehensive stroke center.**

**Neurology Clinical Practice. 9(5):417-423, October 2019**.



**Shortening time to reperfusion after transfer from a primary to a comprehensive stroke center.**

**Neurology Clinical Practice. 9(5):417-423, October 2019.**

**Table 3** Main median times

| Median time in minutes (IQR) | All patients | Pre-QI cohort (2012–2014) | QI cohort (2015–2017) | *p* Value |
|---|---|---|---|---|
| **Symptom onset to PSC door** | 80 (56–115) | 76 (56–115) | 77 (57–108) | 0.83 |
| **Door to imaging** | 42 (20–73) | 54 (18–80) | 18 (13–28) | 0.03 |
| **Symptom onset to IVT start** | 145 (115–180) | 165 (135–195) | 125 (104–161) | 0.0001 |
| **DTN** | 61 (45–87) | 82 (61–103) | 49 (40–64) | 0.0001 |
| **DIDO (patients with DIDO time ≤75 min, %)** | 90 (76–110) [22.5] | 118 (85–138) [10] | 78 (59–104) [34.8] | 0.01 [0.0001] |
| **Transfer** | 90 (67–107) | 87 (60–102) | 92 (89–115) | 0.5 |
| **Symptom onset to CSC door** | 275 (239–319) | 294 (248–347) | 264 (225–292) | 0.005 |
| **D2D** | 180 (143–217) | 205 (145–240) | 170 (148–219) | 0.002 |
| **Imaging to reperfusion** | 262 (239–316) | 288 (264–333) | 252 (231–323) | 0.12 |
| **CSC door to MT puncture** | 64 (33–82) | 69 (37–87) | 60 (30–85) | 0.32 |
| **MT puncture to reperfusion** | 58 (39–88) | 67 (45–88) | 50 (38–87) | 0.13 |
| **Symptom onset to reperfusion** | 393 (332–454) | 417 (378–492) | 367 (322–406) | 0.04 |

Abbreviations: CSC = comprehensive stroke center; DTN = door-to-needle; DIDO = door-in-door-out; D2D = door-to-door (PSC-door-in-CSC-door-in); IQR = interquartile ratio; IVT = IV thrombolysis; MT = mechanical thrombectomy; PSC = primary stroke center; QI = quality improvement.
Data are reported as median (interquartile ratio: 25–75).

**Shortening time to reperfusion after transfer from a primary to a comprehensive stroke center.**

**Neurology Clinical Practice. 9(5):417-423, October 2019.**

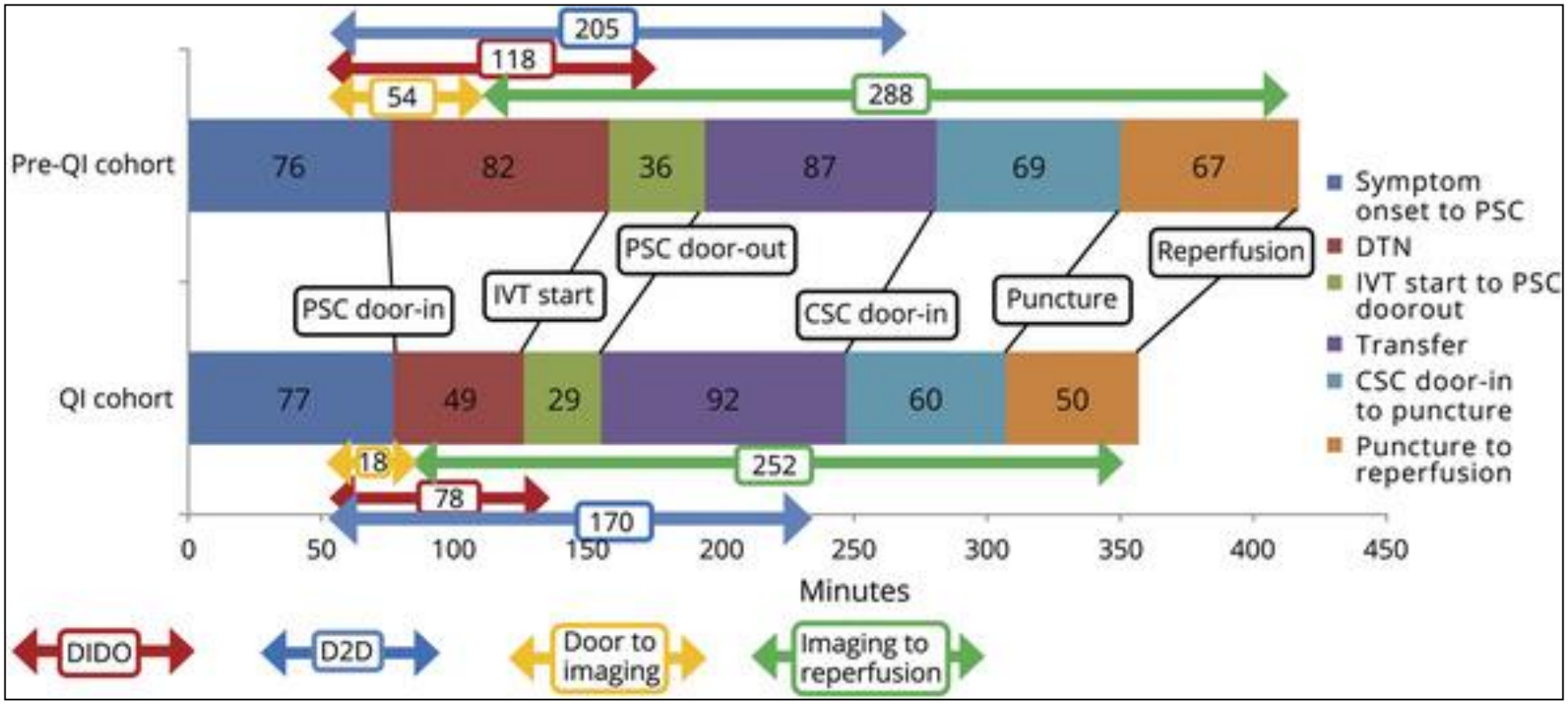
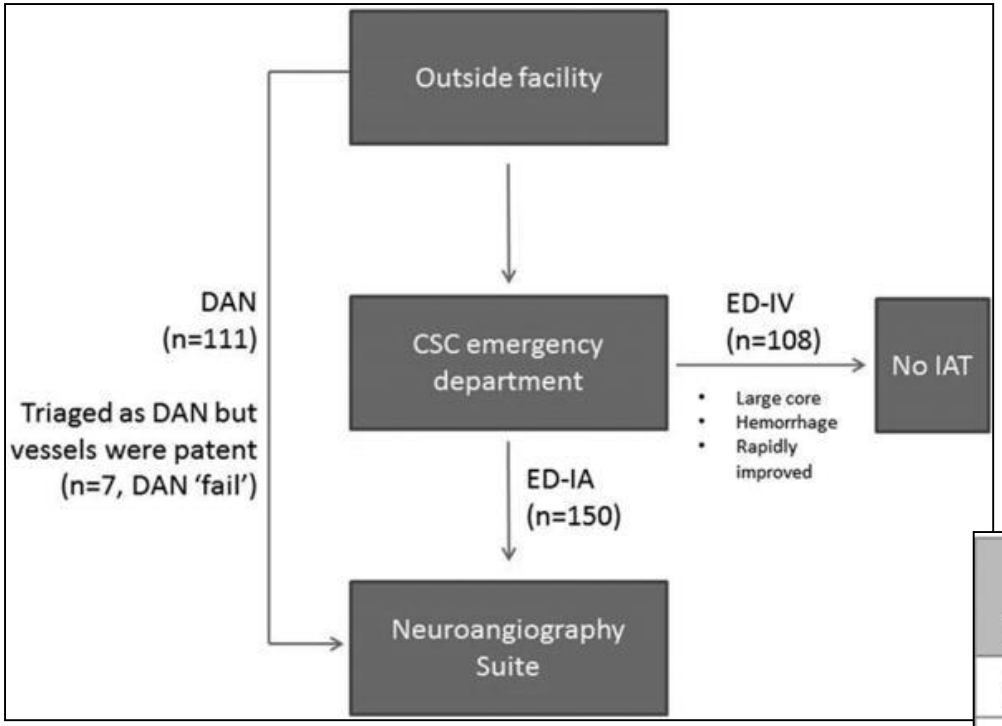


**Table 2** Demographic and clinical characteristics

| Characteristics | All patients (n = 278) | Pre-QI cohort (n = 121) | QI cohort (n = 157) | *p* Value |
|---|---|---|---|---|
| Age, mean (SD) | 69 (13) | 67 (13) | 71 (13) | 0.0038 |
| Sex, % women | 41.7 | 36.4 | 45.9 | 0.11 |
| NIHSS at admission | | | | 0.51 |
| ≤10 | 26.5 | 20.7 | 30 | |
| 11–17 | 25.3 | 30.1 | 24.2 | |
| ≥18 | 48.2 | 49.2 | 45.8 | |
| Topography, % | | | | |
| Anterior/posterior circulation | 88.1 | 84.3 | 91.1 | 0.11 |
| Occlusion location, n (%) | | | | |
| IC, ICA, and carotid terminus | 28.4 | 33.9 | 24.2 | 0.08 |
| M1 segment of MCA | 53.6 | 47.1 | 58.6 | 0.07 |
| M2 segment of MCA | 3.6 | 0.8 | 5.7 | 0.03 |
| BA | 11.9 | 15.7 | 8.9 | 0.09 |
| Other or multiple LVO | 2.5 | 2.5 | 2.6 | 0.95 |
| DWI-ASPECT score, % | | | | 0.80 |
| 9–10 | 11.5 | 6.6 | 15 | |
| 6–8 | 68.8 | 68.1 | 69 | |
| 0–5 | 19.7 | 25.3 | 16 | |
| Transfer mode (% air transport) | 78 | 82 | 74 | 0.08 |
| New imaging at CSC, % | 59.7 | 69.4 | 52.2 | 0.005 |
| Reperfusion TICI 2b-3, % | 77.6 | 75.4 | 78.8 | 0.67 |
| Symptomatic hemorrhagic transformation,[a] % | 3.9 | 4.1 | 3.8 | 0.9 |
| mRs 0–2 at 3 mo, % | 40.8 | 35.6 | 45.7 | 0.2 |
| Death at 3 mo, % | 15.9 | 14.4 | 17.3 | 0.5 |




**Interfacility Transfer Directly to the Neuroangiography Suite in Acute Ischemic Stroke Patients Undergoing Thrombectomy.**
Jadhav,et al.
Stroke. 48(7):1884-1889, July 2017.

Based on findings from virtually all randomized endovascular stroke trials, conventional angiography in the ≈15% of patients with patent vessels is highly unlikely to result in harm.

| Variable | Transfer Location | | *P* Value |
|---|---|---|---|
| | ED-IA | DAN | |
| No. of patients (% of IAT) | 150 (57.5) | 111 (42.5) | |
| Age (median) | 69.5 | 74 | 0.507 |
| CT ASPECTS (median) | 9 | 9 | 0.181 |
| NIHSS score just before IAT (median) | 17 | 18.5 | 0.038 |
| LSW to hospital arrival (mean, min) | 304 | 303 | 0.745 |
| Intravenous tPA (% of IAT) | 65 | 34 | 0.001* |
| Intubation/general anesthesia, % | 11.4 | 8.1 | 0.479 |
| Anterior circulation (% of IAT) | 95 | 96 | 1 |

ASPECTS indicates Alberta Stroke Program Early CT Score; CT, computed tomography; DAN, direct admission to neuroangiography suite; ED-IA, emergency department before intra-arterial therapy; IAT, intra-arterial thrombectomy; LSW, last seen well; NIHSS, National Institutes of Health Stroke Scale; and tPA, tissue-type plasminogen activator.
*Statistical significance at $P<0.05$.

| Variable | Transfer Location | | *P* Value |
|---|---|---|---|
| | ED (n=150) | DAN (n=111) | |
| Door to angiosuite | 67 (34–72) | 10 (3–6) | 0.001* |
| Door to puncture | 81 (46–91) | 22 (12–25) | 0.001* |
| Door to recanalization | 125 (81–146) | 66 (39–84) | 0.001* |
| Angiosuite to access | 13 (8–17) | 12 (8–14) | 0.177 |
| Access to recanalization | 44 (27–53) | 43 (20–61) | 0.883 |
| Angiosuite to recanalization | 57 (37–74) | 56 (29–73) | 0.548 |
| LSW to recanalization | 429 (258–468) | 348 (221–394) | 0.052 |

Mean (interquartile range). DAN indicates directly admitted to the neuroangiography suite; ED, emergency department; and LSW, last seen well.
*Statistical significance at $P<0.05$.

**Interfacility Transfer Directly to the Neuroangiography Suite in Acute Ischemic Stroke Patients Undergoing Thrombectomy.**

Jadhav, Ashutosh; MD, PhD; Kenmuir, Cynthia; MD, PhD; Aghaebrahim, Amin; Limaye, Kaustubh; Wechsler, Lawrence; Hammer, Maxim; Starr, Matthew; Molyneaux, Bradley; MD, PhD; Rocha, Marcelo; MD, PhD; Guyette, Francis; Martin-Gill, Christian; Ducruet, Andrew; Gross, Bradley; Jankowitz, Brian; Jovin, Tudor

Stroke. 48(7):1884-1889, July 2017.
DOI : 10.1161/STROKEAHA.117.016946

Table 2 . Outcome Times Stratified by Treatment

Table 3 . Subgroup Multivariate Analysis Comparing IAT Treatment Groups With Transferred Patients Treated With Intravenous Thrombolysis but Not IAT

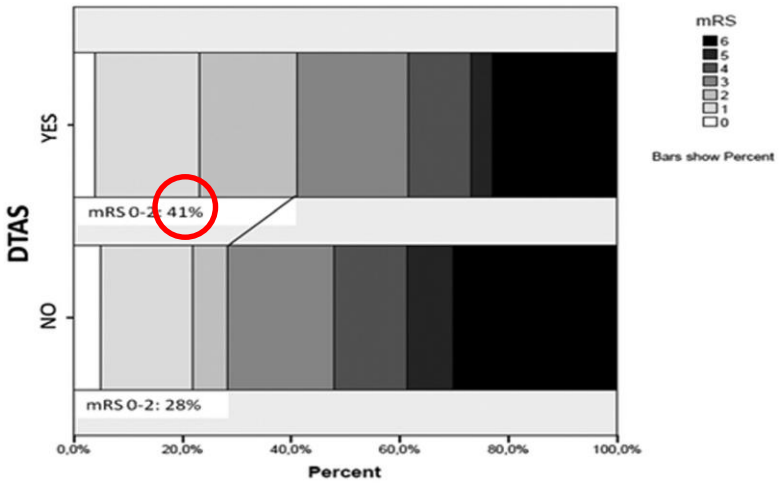
| Variable | Treatment Group | | | *P* Value |
|---|---|---|---|---|
| | ED-IA | DAN | ED-IV | |
| No. of patients (% of total) | 150 (41) | 111 (30) | 108 (29) | |
| Age (median) | 69.5 | 74 | 78.5 | 0.041 |
| Anterior circulation (% of subgroup) | 95 | 96 | 98 | 1 |
| NIHSS score before IAT/intravenous tPA (median) | 17 | 18.5 | 19 | 0.011 |
| NIHSS score at 24 h (median) | 11 | 11.5 | 16 | 0.032 |
| NIHSS score change (median) | −5 | −6 | −3.5 | 0.015 |
| mRS score 0–2 at 90 d (% of subgroup) | 44 | 43 | 22* | 0.001 |
| Mortality at 90 d (% of subgroup) | 23 | 33 | 55 | 0.001 |

*P*=0.05 Tukey post hoc analysis. DAN indicates directly admitted to the neuroangiography suite; ED-IA, emergency department before intra-arterial therapy; ED-IV, transferred to the emergency department but did not receive intra-arterial therapy; IAT, intra-arterial thrombectomy; mRS, magnetic resonance spectroscopy; NIHSS, National Institutes of Health Stroke Scale; and tPA, tissue-type plasminogen activator.
*Statistical significance vs ED-IA and DAN.

**Direct Transfer to Angio-Suite to Reduce WorkflowTimes and Increase Favorable Clinical Outcome (Stroke. 2018;49:2723-2727**

A cone beam CT is performed to exclude ICH for patients directly admitted from the field.
for patients transferred from another institution, where previous neuroimaging
has been acquired (noncontrast CT±CT angiography), cone-beam CT was not performed unless
an evident clinical deterioration was observed during transfer.
LVO was confirmed by an initial diagnostic cerebral angiogram.

During an 18 months period a total of 97 patients were directly transferred to the angio-suite after admission:11 (11.6%) showed an intracerebral hemorrhage on cone beam computed tomography, 7 (7.2%) did not have a LVO on initial angiogram, and 79 (76.3%) had a LVO and received EVT.


DTAS protocol was independently associated with 3 months favorable outcome (OR, 2.5; 95% CI, 1.2–5.3; *P*=0.01)

# Effect of Workflow Improvements in Endovascular Stroke Treatment
# A Systematic Review and Meta-Analysis

| Anesthetic Management |
| --- |
| A=Nongeneral anesthesia vs general anesthesia |
| **Prehospital Management*** |
| B1=Prenotification ED team, CT technologist, and stroke team by EMS |
| B2=Mobile stroke treatment unit with CT scanner, point of care laboratory testing, vascular neurologist available via telemedicine |
| B3=Ship and drip for transfer patients vs drip and ship |
| B4=CTA at PSC vs at CSC |
| B5=Cloud based image sharing between PSC and CSC |
| B6=Use of telemedicine assessment by a stroke neurologist at PSC |
| B7=Air transfer vs ground transfer |
| **In-hospital Patient Transfer** |
| C1=Transporting patients directly to CT scanner by EMS |
| C2=Transporting (transfer) patients directly to angiosuite by EMS |
| C3=No turn around approach (not returning to ED after imaging for decision-making) |
| C4=Single room used for CT, angiography, and EVT |
| C5=Single room for patient evaluation, CT, angiography, and EVT |

| Teamwork |
| --- |
| D1=Early communication between ED team and stroke team about plan of care |
| D2=Early activation neurointerventional team |
| D3=Parallel processing from ED/hospital ward to CT: clinical assessment, laboratory tests, imaging, patient/family education by the teams in a parallel workflow |
| D4=Parallel processing from CT to angiosuite: neurointerventional team meets patient at CT, teams evaluate CT/CTA and make treatment decision while angiosuite is set up, patient/family education |
| **Feedback** |
| E1=Education and feedback all teams |
| E2=Smartphone application/digital system for real-time window from stroke onset to puncture for all teams, visualizing performance metrics |
| **Other** |
| F1=Limiting nonessential interventions (eg, ECG, chest X-ray, additional venous access, bladder catheter placement) |
| F2=Standard angiography set for all of the devices needed for EVT |
| F3=No groin shaving |
| F4=Standard operating procedure for intubation at the intensive care unit before EVT |
| F5=Standard operating procedure for EVT |
| F6=Not waiting for effect IV tissue-type plasminogen activator vs waiting for 1 h |

## Effect of Workflow Improvements in Endovascular Stroke Treatment A Systematic Review and Meta-Analysis (Stroke. 2019;50:665-674)

**Table 3. Random-Effects Meta-Analysis of Difference in Mean Time to Treatment for Categories of Workflow Interventions in Endovascular Stroke Treatment**

| | No. of Studies | No. of Patients (Intervention/ Control Group) | Weighted Mean Difference, min (95% CI) |
|---|---|---|---|
| All interventions | 47 | 3480/4002 | 26 (19–32); *P*<0.001 |
| Anesthetic management | 23 | 2283/2445 | 12 (6–17); *P*<0.001 |
| Prehospital management | 10 | 442/463 | 37 (22–52); *P*<0.001 |
| In-hospital patient transfer management | 13 | 730/1150 | 41 (27–54); *P*<0.001 |
| Teamwork | 7 | 502/708 | 47 (228–67); *P*<0.001 |
| Feedback | 4 | 161/417 | 64 (24–104); *P*=0.002 |
| Multiple interventions simultaneously | 8 | 531/735 | 50 (31–69); *P*<0.001 |

**Effect of Workflow Improvements in Endovascular Stroke Treatment**
**A Systematic Review and Meta-Analysis (Stroke. 2019;50:665-674)**

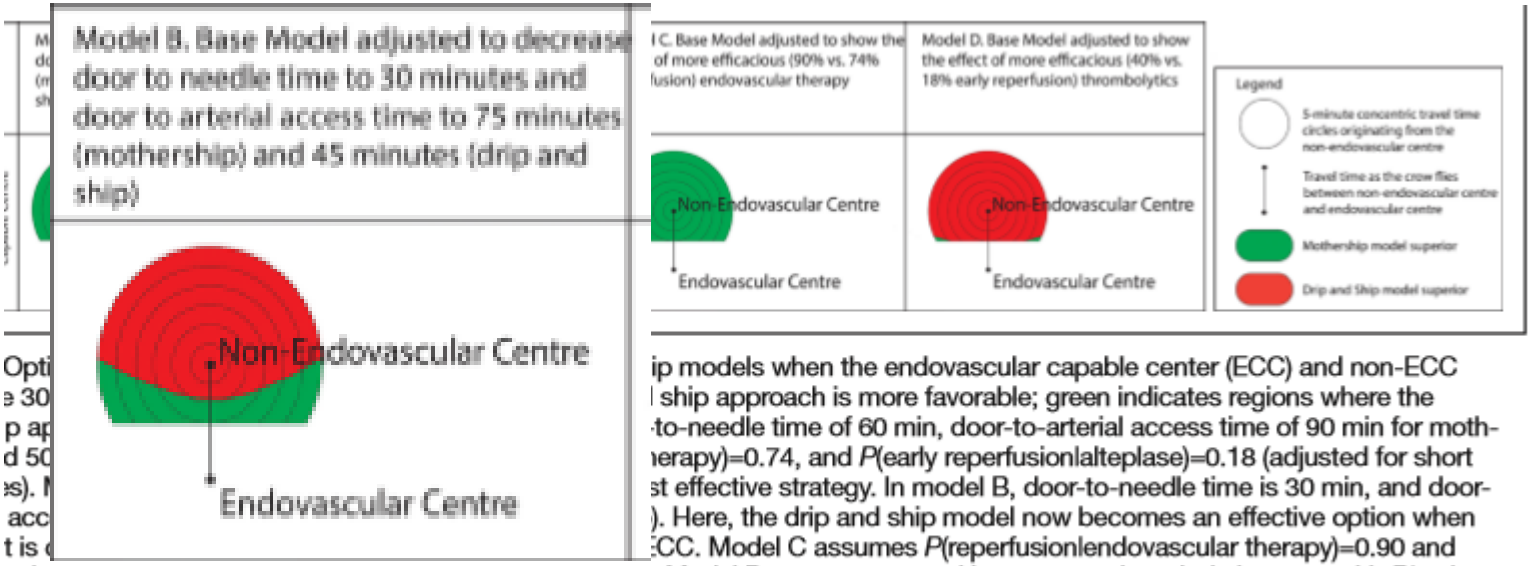
Our meta-analysis showed **a difference in time to treatment effect of 26 minutes**, with **a total absolute risk difference of good functional outcome of 12%,** which is higher compared with the ≈4% absolute risk difference per hour as seen in the meta-analysis of 5 endovascular stroke treatment trials.

A meta-analysis of 5 large endovascular stroke trials showed no effect of time to treatment on rates of mortality and symptomatic intracranial hemorrhage. Our study showed **no difference in rate of symptomatic intracranial hemorrhage, but significantly lower mortality** among patients in the intervention group.

# Drip and Ship Versus Direct to Comprehensive Stroke Center Conditional Probability Modeling
# Holodinsky et al Stroke .2017;48:233-238

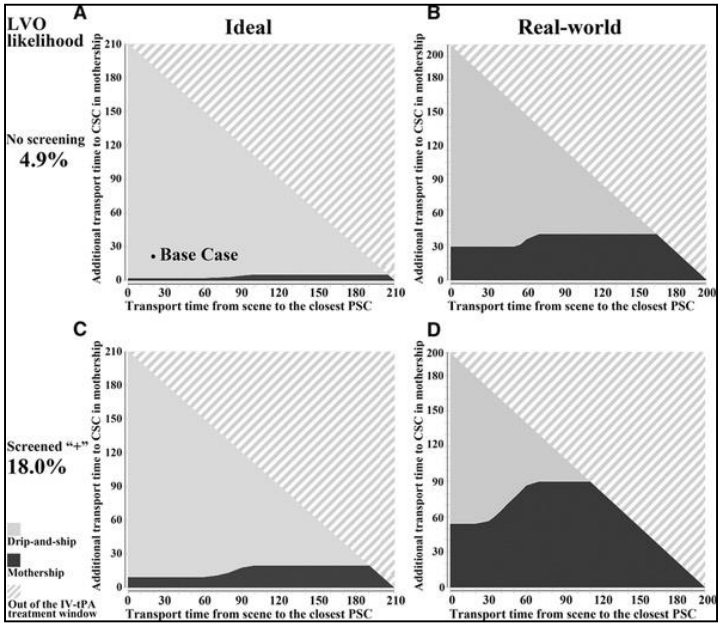
Theoretical models were built on recanalization rate of 74% for EVT and 18% for IVT

**in case of a transfer time superior to 45 minutes between the PSC and the CSC**, if the patient is close to a PSC, **DS paradigm is better than MS**




ip models when the endovascular capable center (ECC) and non-ECC
ship approach is more favorable; green indicates regions where the
-to-needle time of 60 min, door-to-arterial access time of 90 min for moth-
erapy)=0.74, and *P*(early reperfusion|alteplase)=0.18 (adjusted for short
st effective strategy. In model B, door-to-needle time is 30 min, and door-
). Here, the drip and ship model now becomes an effective option when
CC. Model C assumes *P*(reperfusion|endovascular therapy)=0.90 and
it the mothership approach is always the superior option. Model D assumes a novel intravenous thrombolytic agent with *P*(early
nlthrombolysis)=0.40 (adjusted for shorter travel times) and shows that the drip and ship approach is superior in almost all scenarios.

# Decision Analysis Model for Prehospital Triage of Patients With Acute Stroke.




| *Workflow metrics* | *Ideal(min)* | *Real world* |
|---|---|---|
| *Door to puncture* | | |
| • *Mothership* | *65* | *84* |
| • *Drip and ship* | *50* | *57* |
| *Puncture to reperfusion time* | *30* | *37* |
| *Onset reperfusion time* | | |
| • *Mothership* | *160* | *184* |
| • *Drip and ship* | *190* | *289* |

Figure 2 . Selected results of 3-way sensitivity analyses under ideal and real-world time metrics. Three-way sensitivity analysis was conducted by jointly varying transport time from scene to primary stroke center, additional transport time if taken directly to a comprehensive stroke center, and the probability of a large vessel occlusion (LVO). A and B represent ideal and real-world time metrics, respectively, in the absence of formal LVO screening; C and D represent ideal and real-world scenarios, respectively, for patients screening positive with an LVO screening scale of moderate sensitivity and specificity (post-test probability of 18%). The solid dot in A represents the base case result; dark gray shading represents favorability of the direct-to-mothership approach, light gray shading represents favorability of the drip-and-ship approach, and the angled line pattern represents patients outside of the IV-tPA (intravenous tissue-type plasminogen activator) treatment window who were not included in this model. CSC indicates comprehensive stroke center; and PSC, primary stroke center.

**Stroke.2019 50(4):970-977**

# EVT Capability Must Expand Beyond CSC Training Centers

- **Is it better for a patient to be treated in regional hospital stroke centers** covered by a VNs who does EVT than to take the extra ≥2 hours required for transfer to a CSC?
- EVT can be provided at regional stroke centers by VNs who are appropriately trained and who have created a team of nurses, anesthesiologists, technologists, radiologists,and stroke unit personnel to take care of the patient.
- although thorough and expert training in all aspect of neurovascular intervention is required, we suggest **that it might not be necessary that all VNs carrying out EVT outside of CSCs maintain skills to treat aneurysms, AVMs and other non-ET cases**
- **(*Stroke. 2017;48:2313-2317)***