The role of time on ischemic stroke progression

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Stroke Neurologist
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Declaration of Interest

Nothing to declare
WITH A STROKE, TIME LOST IS BRAIN LOST.
Average infarct growth: 5.4 mL/h
Infarct Volume Is a Pivotal Biomarker After Intra-Arterial Stroke Therapy

Albert J. Yoo, MD*; Zeshan A. Chaudhry, MD*; Raul G. Nogueira, MD; Michael H. Lev, MD; Pamela W. Schaefer, MD; Lee H. Schwamm, MD; Joshua A. Hirsch, MD; R. Gilberto González, MD, PhD (Stroke. 2012;43:1323-1330.)

Table 2. Variables With Significant Correlation to 3-Month mRS (0—6)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rho</th>
<th>95% CI</th>
<th>Univariate P</th>
<th>Multivariate P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final infarct volume, cm³</td>
<td>0.592</td>
<td>0.453 to 0.703</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.399</td>
<td>0.226 to 0.547</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TICI score (0–3)</td>
<td>−0.512</td>
<td>−0.640 to −0.357</td>
<td>&lt;0.0001</td>
<td>0.0006</td>
</tr>
<tr>
<td>Admission NIHSSS</td>
<td>0.284</td>
<td>0.100 to 0.450</td>
<td>0.004</td>
<td>NS</td>
</tr>
<tr>
<td>HTN</td>
<td>0.200</td>
<td>0.011 to 0.376</td>
<td>0.04</td>
<td>NS</td>
</tr>
</tbody>
</table>

mRS indicates modified Rankin Scale; TICI, Thrombolysis In Cerebral Infarction; NIHSSS, National Institutes of Health Stroke Scale score; HTN, hypertension.

24h infarct volume

mRS at 3 months

<50 cm³

≥50 cm³
Age-adjusted infarct volume threshold for good outcome after endovascular treatment

Marc Ribo,¹ Alan Flores,¹ Eloy Mansilla,¹ Marta Rubiera,¹ Alejandro Tomasello,² Pilar Coscojuela,² Jorge Pagola,¹ David Rodríguez-Luna,¹ Marian Muchada,¹ José Alvarez-Sabín,¹ Carlos A Molina¹

J NeuroIntervent Surg 2014;
<6hours Code Stroke Catalunya 2016-2017

M. Requena, MD. Poster presentation. ISC 2018
Time and Diffusion Lesion Size in Major Anterior Circulation Ischemic Strokes

Reza Hakimelahi, MD; Behroze A. Vachha, MD, PhD; William A. Copen, MD; Giacomo D.E. Papini, MD; Julian He, MD; Mahmoud M. Higazi, MD; Michael H. Lev, MD; Pamela W. Schaefer, MD; Albert J. Yoo, MD; Lee H. Schwamm, MD; R. Gilberto González, MD, PhD
**Time and Diffusion Lesion Size in Major Anterior Circulation Ischemic Strokes**

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**Linear Model of Infarct Growth**

- **Poor collaterals**: Average infarct growth: 12 mL/h
- **Good collaterals**
Collateral Flow Predicts Response to Endovascular Therapy for Acute Ischemic Stroke

Oh Young Bang, MD; Jeffrey L. Saver, MD; Suk Jae Kim, MD; Gyeong-Moon Kim, MD; Chin-Sang Chung, MD; Bruce Ovbiagele, MD; Kwang Ho Lee, MD; David S. Liebeskind, MD

Predictors of Hemorrhage Following Intra-Arterial Thrombolysis for Acute Ischemic Stroke: The Role of Pial Collateral Formation

ORIGINAL RESEARCH

G.A. Christoforidis
C. Karakasis
Y. Mohammad
L.P. Caragine
M. Yang
A.P. Slivka

Collateral circulation evaluation

Correlation with admission DWI lesion volume and poor outcome

CC evaluation on mCTA

Poor CC: Score 0

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>IC up</th>
<th>IC lo</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.02</td>
<td>0.97</td>
<td>1.07</td>
<td>0.32</td>
</tr>
<tr>
<td>NIHSS b</td>
<td>1.05</td>
<td>0.93</td>
<td>1.19</td>
<td>0.86</td>
</tr>
<tr>
<td>ASPECTS</td>
<td>1.05</td>
<td>0.57</td>
<td>1.96</td>
<td>0.38</td>
</tr>
<tr>
<td>Recanalization</td>
<td>7.13</td>
<td>1.67</td>
<td>30.37</td>
<td>0.01</td>
</tr>
<tr>
<td>mCTA good CC</td>
<td>4.80</td>
<td>1.26</td>
<td>18.32</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Independent predictors of good functional outcome

Rubiera et al. Poster presentation, ISC 2015
Extending the Time Window for Endovascular Procedures According to Collateral Pial Circulation

Marc Ribo, MD, PhD; Alan Flores, MD; Marta Rubiera, MD, PhD; Jorge Pagola, MD, PhD; Joao Sargento-Freitas, MD; David Rodriguez-Luna, MD; Pilar Coscojuela, MD; Olga Maisterra, MD; Socorro Piñeiro, MD; Francisco J. Romero, MD; Jose Alvarez-Sabin, MD, PhD; Carlos A. Molina, MD, PhD

Extending the Time Window for Endovascular Procedures
Dramatic Recovery in Acute Ischemic Stroke Is Associated With Arterial Recanalization Grade and Speed

Mikael Mazighi, MD, PhD; Elena Meseguer, MD; Julien Labreuche, BST; Jean-Michel Serfaty, MD; Jean-Pierre Laissy, MD; Philippa C. Lavallée, MD; Lucie Cabrejo, MD; Céline Guidoux, MD; Bertrand Lapergue, MD; Isabelle F. Klein, MD, PhD; Jean-Marc Olivot, MD, PhD; Aymeric Rouchaud, MD; Jean-Philippe Desilles, MD; Elisabeth Schouman-Claceys, MD; Pierre Amarenco, MD

(Stroke. 2012;43:2998-3002.)

Table 2. Impact of Grade and Time to Recanalization on Dramatic Recovery Outcome Among Patients With Recanalization Monitored by Angiography

<table>
<thead>
<tr>
<th>Recanalization Results</th>
<th>No.</th>
<th>DR, No. (%)</th>
<th>P Value</th>
<th>OR (95% CI)*</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients (n=128)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMI grade flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (partial)</td>
<td>49</td>
<td>7 (14.3)</td>
<td>&lt;0.001</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>3 (complete)</td>
<td>79</td>
<td>37 (46.8)</td>
<td></td>
<td>4.97 (1.96–12.51)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time to recanalization, tertiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;296 min</td>
<td>43</td>
<td>9 (20.9)</td>
<td>0.002†</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>226–296 min</td>
<td>43</td>
<td>13 (30.2)</td>
<td></td>
<td>1.75 (0.65–4.77)</td>
<td></td>
</tr>
<tr>
<td>&lt;226 min</td>
<td>42</td>
<td>22 (52.4)</td>
<td></td>
<td>3.85 (1.47–10.09)</td>
<td>0.006†</td>
</tr>
</tbody>
</table>
Impact of Onset-to-Reperfusion Time on Stroke Mortality
A Collaborative Pooled Analysis

Mikael Mazighi, MD, PhD; Saqib A. Chaudhry, MD; Marc Ribo, MD; Pooja Khatri, MD, MSc; David Skoloudik, MD; Maxim Mokin, MD; Julien Labreuche, BST; Elena Meseguer, MD; Sharon D. Yeatts, PhD; Adnan H. Siddiqui, MD; Joseph Broderick, MD; Carlos A. Molina, MD; Adnan I. Qureshi, MD; Pierre Amarenco, MD


480 patients with endovascular treatment & known time of reperfusion

For each +30 min to reperfusion - 10% chances of favorable outcome
Time to Treatment With Endovascular Thrombectomy and Outcomes From Ischemic Stroke: A Meta-analysis

A Odds ratio for less disability at 3 mo in endovas vs medical therapy alone groups by time to tre

For each +30 min to reperfusion...
10-15% chances of favorable outcome

Association Between Time to Reperfusion and Outcome Is Primarily Driven by the Time From Imaging to Reperfusion

Marc Ribo, MD; Carlos A. Molina, MD; Erik Cobo, PhD; Neus Cerdà, PhD; Alejandro Tomásello, MD; Helena Quesada, MD; María Angeles De Miquel, MD; Mónica Millán, MD; Carlos Castaño, MD; Xabier Urra, MD; Luis Sanroman, MD, PhD; Antoni Dávalos, MD; Tudor Jovin, MD; for the REVASCAT Trial Investigators

Number of candidates

Improve outcomes of treated patients
Pre-notification
RACE > 4 or NIHSS > 10
< 6 hours
Direct transfer to angiosuit to reduce door-to-puncture time in thrombectomy for acute stroke
Direct transfer to angiosuite to reduce door-to-puncture time in thrombectomy for acute stroke
Interfacility Transfer Directly to the Neuroangiography Suite in Acute Ischemic Stroke Patients Undergoing Thrombectomy

Ashutosh P. Jadhav, MD, PhD; Cynthia L. Kenmuir, MD, PhD; Amin Aghaebrahim, MD; Kaustubh Limaye, MD; Lawrence R. Wechsler, MD; Maxim D. Hammer, MD; Matthew T. Starr, MD; Bradley J. Molyneaux, MD, PhD; Marcelo Rocha, MD, PhD; Francis X. Guyette, MD; Christian Martin-Gill, MD; Andrew F. Ducruet, MD; Bradley A. Gross, MD; Brian T. Jankowitz, MD; Tudor G. Jovin, MD

*Stroke.* 2017;48:1884-1889.

Table 2. Outcome Times Stratified by Treatment

<table>
<thead>
<tr>
<th>Variable</th>
<th>Transfer Location</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ED (n=150)</td>
<td>DAN (n=111)</td>
</tr>
<tr>
<td>Door to angiosuite</td>
<td>67 (34–72)</td>
<td>10 (3–6)</td>
</tr>
<tr>
<td>Door to puncture</td>
<td>81 (46–91)</td>
<td>22 (12–25)</td>
</tr>
<tr>
<td>Door to recanalization</td>
<td>125 (81–146)</td>
<td>66 (39–84)</td>
</tr>
<tr>
<td>Angiosuite to access</td>
<td>13 (8–17)</td>
<td>12 (8–14)</td>
</tr>
<tr>
<td>Access to recanalization</td>
<td>44 (27–53)</td>
<td>43 (20–61)</td>
</tr>
<tr>
<td>Angiosuite to recanalization</td>
<td>57 (37–74)</td>
<td>56 (29–73)</td>
</tr>
<tr>
<td>LSW to recanalization</td>
<td>429 (258–468)</td>
<td>348 (221–394)</td>
</tr>
</tbody>
</table>

Mean (interquartile range). DAN indicates directly admitted to the neuroangiography suite; ED, emergency department; and LSW, last seen well.

*Statistical significance at \( P \leq 0.05 \).
Initial DWI

30 min.

60 min.

90 min.

?
Infarct growth despite full reperfusion in endovascular therapy for acute ischemic stroke

Diogo C Haussen,1 Raul G Nogueira,1 Mohamed Samy Elhammady,2 Dileep R Yavagal,2 Mohammad Ali Aziz-Sultan,3 Jeremiah N Johnson,2 Brandon G Gaynor,2 Shyian Jen,1 Seena Dehkharghani,1 Eric C Peterson2

Overall, 35% of patients had SIG.

Table 2: Procedural variables

<table>
<thead>
<tr>
<th></th>
<th>SIG (n=21)</th>
<th>No SIG (n=39)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time last normal to groin puncture (h)</td>
<td>6.8±2.7</td>
<td>6.9±3.3</td>
<td>0.83</td>
</tr>
<tr>
<td>Duration of procedure (h)</td>
<td>1.4±0.7</td>
<td>1.25±0.6</td>
<td>0.20</td>
</tr>
<tr>
<td>Occclusion site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervical ICA only</td>
<td>4 (19%)</td>
<td>2 (5%)</td>
<td></td>
</tr>
<tr>
<td>ICA-T</td>
<td>2 (10%)</td>
<td>5 (13%)</td>
<td></td>
</tr>
<tr>
<td>MCA M1</td>
<td>11 (52%)</td>
<td>25 (64%)</td>
<td></td>
</tr>
<tr>
<td>MCA M2</td>
<td>4 (19%)</td>
<td>7 (18%)</td>
<td></td>
</tr>
<tr>
<td>Tandem</td>
<td>2 (10%)</td>
<td>5 (13%)</td>
<td></td>
</tr>
<tr>
<td>Angiogram collaterals*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>4 (22%)</td>
<td>5 (13%)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7 (39%)</td>
<td>15 (38%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6 (33%)</td>
<td>7 (18%)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 (6%)</td>
<td>2 (5%)</td>
<td></td>
</tr>
<tr>
<td>Devices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First-generation devices</td>
<td>15 (71%)</td>
<td>21 (54%)</td>
<td></td>
</tr>
<tr>
<td>Stent-retrievers</td>
<td>5 (23%)</td>
<td>19 (50%)</td>
<td></td>
</tr>
<tr>
<td>IA t-PA</td>
<td>10 (47%)</td>
<td>16 (41%)</td>
<td></td>
</tr>
</tbody>
</table>

*47 patients.
IA t-PA, intra-arterial tissue plasminogen activator; ICA, internal carotid artery; ICA-T, ICA terminus; MCA, middle cerebral artery; SIG, significant infarct growth.

Table 4: Multivariate analysis for predictors of significant infarct growth

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>0.31</td>
<td>0.11 to 0.89</td>
<td>0.03</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.58</td>
<td>0.37 to 6.72</td>
<td>0.53</td>
</tr>
<tr>
<td>IV t-PA</td>
<td>0.19</td>
<td>0.04 to 0.90</td>
<td>0.03</td>
</tr>
<tr>
<td>Stent-retriever</td>
<td>0.17</td>
<td>0.03 to 0.89</td>
<td>0.03</td>
</tr>
<tr>
<td>mRS ≤2 at 3 months</td>
<td>0.15</td>
<td>0.02 to 0.80</td>
<td>0.02</td>
</tr>
</tbody>
</table>

IV t-PA, intravenous tissue plasminogen activator; mRS, modified Rankin Scale.
Predictors of Infarct Growth after Endovascular Therapy for Acute Ischemic Stroke

Shumei Man, MD, PhD, Junya Aoki, MD, PhD, Muhammad S. Hussain, MD, Dolora Wisco, MD, Yohei Tateishi, MD, PhD, Gabor Toth, MD, Ferdinand K. Hui, MD, and Ken Uchino, MD

PREDICTORS OF INFARCT GROWTH AFTER ENDOVASCULAR THERAPY

Table 4. Logistic regression of predictors for DWI no-growth versus other three groups combined

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds ratio</th>
<th>Confidence interval</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.07/unit</td>
<td>.95-1.27</td>
<td>.317</td>
</tr>
<tr>
<td>Admission glucose</td>
<td>1.00/unit</td>
<td>.98-1.03</td>
<td>.768</td>
</tr>
<tr>
<td>On statin</td>
<td>.29</td>
<td>.01-5.50</td>
<td>.395</td>
</tr>
<tr>
<td>Initial NIHSS</td>
<td>1.17/unit</td>
<td>.94-1.58</td>
<td>.063</td>
</tr>
<tr>
<td>IV tPA</td>
<td>.38</td>
<td>.04-2.78</td>
<td>.197</td>
</tr>
<tr>
<td>ICA occlusion</td>
<td>.29</td>
<td>.05-2.31</td>
<td>.294</td>
</tr>
<tr>
<td>Good collaterals</td>
<td>4.02</td>
<td>1.14-19.08</td>
<td>.030</td>
</tr>
<tr>
<td>Initial DWI volume</td>
<td>.90/unit</td>
<td>.73-99</td>
<td>.032</td>
</tr>
<tr>
<td>Time to recanalization</td>
<td>1.00/unit</td>
<td>.99-1.00</td>
<td>.281</td>
</tr>
<tr>
<td>TICI 2b and above</td>
<td>16.91</td>
<td>1.69-477.0</td>
<td>.002</td>
</tr>
</tbody>
</table>
Complete reperfusion mitigates influence of treatment time on outcomes after acute stroke
Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct

60y, NIHSS 20, M1 occ

CBF<30% volume: 51 ml
Mismatch volume: 192 ml
Mismatch ratio: 4.8
Tmax>6.0s volume: 243 ml

Not for primary diagnosis. For research purposes only. Warning: review source data quality and bolus timing.
Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct

Last Known to Be Well 6 to 12 Hr before Randomization

Type of stroke onset
- On awakening
- Witnessed stroke
- Unwitnessed stroke

Interval between time that patient was last known to be well and randomization
- 6 to 12 hr
- >12 to 24 hr

Last Known to Be Well >12 to 24 Hr before Randomization

Type of stroke onset
- On awakening
- Witnessed stroke
- Unwitnessed stroke

Interval between time that patient was last known to be well and randomization
- 0 to 6 hr
- >6 hr