Technological advances and perspectives in endovascular stroke treatment

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M1 OCCLUSION: passage of thrombus with Renegade HiFlo and SilverSpeed 16
Merci X6 Retriever
PTA of thrombus

168 patients multimodal:

ia-rTPA, ia-Urokinase, ia-IIbIIIa: OR 2.9
Snare, Merci, pTA, Stent: OR 4.8

| TABLE 2. Summary of Recanalization and Hemorrhage Rates Based on the No. of Modalities Used |
|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
|                                             | TIMI 2–3 Flow n (%) | TIMI 3 Flow n (%) | Symptomatic Hemorrhage (%) | Asymptomatic Hemorrhage (%) |
| One modality (n=40)                        | 20 (50)             | 10 (25)           | 5 (13)                      | 8 (20)                       |
| Two modalities (n=65)                      | 39 (60)             | 18 (28)           | 9 (14)                      | 14 (22)                      |
| Three or more modalities (n=63)            | 45 (71)*            | 25 (40)**         | 10 (15)                     | 14 (22)                      |

\*P<0.045 for TIMI 2–3 flow using ≥3 modalities; \*\*P<0.012 for TIMI 3 flow using ≥3 modalities.
Started in 2008, but **NOT** used in major trials
Cell size, radial force, delivery, radiopacity....

- Trevo Pro
- Solitaire FR
- Separator 3D
- PreSet
Safe and effective in severe stroke within 6h of onset - maybe even beyond if ASPECTS > 5 NIHSS > 8 ...
...from now on?

...and which one?
Influence of device on outcome: most likely none
<table>
<thead>
<tr>
<th>Serious Adverse Events</th>
<th>Intervention (N=233)</th>
<th>Control (N=267)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE total</td>
<td>110 (47.2%)</td>
<td>113 (42.3%)</td>
</tr>
<tr>
<td>Parenchymal hematoma</td>
<td>14 (6.0%)</td>
<td>14 (5.2%)</td>
</tr>
<tr>
<td><strong>Stroke in previously unaffected territory</strong></td>
<td><strong>13 (5.6% clinically)</strong></td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>pneumonia</td>
<td>25 (10.7%)</td>
<td>41 (15.4%)</td>
</tr>
<tr>
<td>craniectomy</td>
<td>14 (6.0%)</td>
<td>13 (4.9%)</td>
</tr>
<tr>
<td>death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>within 7 days</td>
<td>27 (11.6%)</td>
<td>33 (12.4%)</td>
</tr>
<tr>
<td>within 30 days</td>
<td>44 (18.9%)</td>
<td>49 (18.4%)</td>
</tr>
</tbody>
</table>

**MR-CLEAN: 8% clot migration to previously unaffected territory**
Balloon Guide Catheter Improves Revascularization and Clinical Outcomes With the Solitaire Device

Analysis of the North American Solitaire Acute Stroke Registry

Thanh N. Nguyen, MD, FRCP; Timothy Malisch, MD; Alicia C. Castonguay, PhD; Rishi Gupta, MD; Chung-Huan J. Sun, MD; Coleman O. Martin, MD; William E. Holloway, MD; Nils Mueller-Kronast, MD; Joey D. English, MD, PhD; Italo Linfante, MD; Guilherme Dabus, MD; Franklin A. Marden, MD; Hormozd Bozorgchahi, MD; Andrew Xavier, MD; Ansaat T. Rai, MD; Michael T. Froehler, MD, PhD; Aamir Badruddin, MD; Muhammad Taqi, MD; Michael G. Abraham, MD; Vallabh Janardhan, MD; Hashem Shaltoni, MD; Roberta Nova Kovacic, MD; Albert J. Yoo, MD; Alex Abou-Chebl, MD; Peng R. Chen, MD; Gavin W. Britz, MD; Ritesh Kaushal, MD; Ashish Nanda, MD; Mohammad A. Issa, MD; Hesham Masoud, MD; Raul G. Nogueira, MD; Alexander M. Norbash, MD; Osama O. Zaidat, MD, MS

Background and Purpose—Efficient and timely recanalization is an important goal in acute stroke endovascular therapy. Several studies demonstrated improved recanalization and clinical outcomes with the stent retriever devices compared with the Merci device. The goal of this study was to evaluate the role of the balloon guide catheter (BGC) and recanalization success in a substudy of the North American Solitaire Acute Stroke (NASA) registry.

Methods—The investigator-initiated NASA registry recruited 24 clinical sites within North America to submit demographic, clinical, site-adjudicated angiographic, and clinical outcome data on consecutive patients treated with the Solitaire Flow Restoration device. BGC use was at the discretion of the treating physicians.

Results—There were 354 patients included in the NASA registry. BGC data were reported in 338 of 354 patients in this subanalysis, of which 149 (44%) had placement of a BGC. Mean age was 67.3±15.2 years, and median National Institutes of Health Stroke Scale score was 18. Patients with BGC had more hypertension (82.4% versus 72.5%; P=0.05), atrial fibrillation (50.3% versus 32.8%; P<0.001), and were more commonly administered tissue plasminogen activator (51.6% versus 38.8%; P=0.02) compared with patients without BGC. Time from symptom onset to groin puncture and number of passes were similar between the 2 groups. Procedure time was shorter in patients with BGC (120±28.5 versus 161±35.6 minutes; P=0.02) and less adjunctive therapy was used in patients with BGC (20% versus 26.6%; P=0.05). Thrombolysis in cerebral infarction 3 reperfusion scores were higher in patients with BGC (53.7% versus 32.5%; P<0.001). Distal emboli and emboli in new territory were similar between the 2 groups. Discharge National Institutes of Health Stroke Scale score (mean, 12±14.5 versus 17±16; P=0.002) and good clinical outcome at 3 months were superior in patients with BGC compared with patients without (51.6% versus 35.8%; P=0.02). Multivariate analysis demonstrated that the use of BGC was an independent predictor of good clinical outcome (odds ratio, 2.56; 95% confidence interval, 1.2–4.9).

Conclusions—Use of a BGC with the Solitaire Flow Restoration device resulted in superior revascularization results, faster procedure times, decreased need for adjunctive therapy, and improved clinical outcome. (Stroke. 2014;45:141-145.)
Distal access catheter with lesional aspiration

- Stent retriever
- Microcatheter
- Intermediate catheter
Quite often:

Stentretriever with limited success...

...and clot ends up here.
The direct aspiration technique alone was successful in 28 of 37 (75%) patients although six cases had large downstream emboli that required additional aspiration. The use of the large bore aspiration catheter alone to achieve complete recanalization was successful in 22 of 38 (57%) cases. Nine cases required the additional use of a stent retriever to achieve recanalization.

One case required the addition of a Penumbra aspiration separator to achieve recanalization. One case had an underlying atherosclerotic lesion which, while initially recanalized with direct aspiration very quickly, ultimately required a stent to maintain patency.
5F catheter tracking a .014” wire to M2
Direct aspiration in long segment occlusion: Efficient reduction of clot burden
Quick!

3 minutes!
Large variety of DAC/aspiration catheters available, estimated 40-50% treated successfully by aspiration only (cost/reimbursement - TIME !)
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Kabbasch (n=30)</th>
<th>Kowoll et al. (ACE) (n=54)</th>
<th>ADAPT (n=37)</th>
<th>MR CLEAN (n=196)</th>
<th>ESCAPE (n=165)</th>
<th>NASA registry (n=354)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device mTICI ≥2b* (lesional aspiration alone %)</td>
<td>95</td>
<td>97</td>
<td>96</td>
<td>NA</td>
<td>NA</td>
<td>73</td>
</tr>
<tr>
<td>Final mTICI ≥2b (aspiration + stent-retriever %)</td>
<td>90</td>
<td>93</td>
<td>95</td>
<td>58.7</td>
<td>72.4</td>
<td>73</td>
</tr>
<tr>
<td>Time to recan. (min), all cases</td>
<td>41.5</td>
<td>41</td>
<td>28.1</td>
<td>66</td>
<td>56 (time to first reperfus.)</td>
<td>50</td>
</tr>
<tr>
<td>Aspiration only success (mTICI ≥2b) and time needed (mean)</td>
<td>67% in 20min.</td>
<td>54% in 30min.</td>
<td>75% in 26min.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Technological advances so far

- Variations of stent retriever ???
- Flow control and distal aspiration !!!
- Aspiration only !!

✅ Safety
✅ Efficacy
✅ Time

- Proc. SAEs low
- >80% TICI 2b+
- Groin to recan of 30min not irrational

*Not fully addressed:*
- Distal emboli

⇒ new developments underway (mesh technology, Lazarus)

**Difficult to challenge current technology because of overwhelming evidence**
Boat! 

Land!
TIME IS BRAIN
CONCLUSION AND RELEVANCE For every hour of reperfusion delay, the initially large benefit of IAT decreases; the absolute risk difference for a good outcome is reduced by 6% per hour of delay. Patients with acute ischemic stroke require immediate diagnostic workup and IAT in case of intracranial arterial vessel occlusion.
Since 2015, we know that it works - what to do next?

Alarm

Primary transfer

In-Hospital transfer

In Hospital diagnostics

Inter-Hospital transfer

In Hospital-2-transfer (potentially more diagnostic)

Intervention
M1-occlusion

Emergency unit arrives

STEMO etc. With CT and CTA - 20 bis iv Lyse

Regional SU, no MTE

Transport

Imaging 40

Neurovascular center, MTE

Imaging 30

FP-CT 20

Angio and MTE

Arbitrary times...

Var. 1: reg. SU, imaging, drip and ship, more imaging, thrombektomy: 245 min.

Var. 2: bypassing regional stroke unit: 145 min

Var. 3: direct to angio unit: 115 min
1. Eye deviation?
2. Patient awake?
3. Paresis of arm or leg?
4. Speech problems?

if 1+2 oder 2-4 pos. => LVO

476 Patients
In-hospital delay as “main driver”
Same rate for IVL
62 vs. 43 % mRS 0-2
OR 3.08
Time saved in thrombectomy patients: 49min.
OR for mRS 0-2 = 3.02

<table>
<thead>
<tr>
<th>Time delays</th>
<th>EVT Pre-intervention(^a) (n = 35)</th>
<th>EVT Post-intervention(^a) (n = 65)</th>
<th>Adjusted relative delay(^b)</th>
<th>IV tPA pre-intervention(^a) (n = 118)</th>
<th>IV tPA post-intervention(^a) (n = 258)</th>
<th>Adjusted relative delay(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System delay</td>
<td>234 (184–282)</td>
<td>185 (141–226)</td>
<td>0.79 (0.67–0.93)</td>
<td>119 (96–143)</td>
<td>112 (92–140)</td>
<td>0.99 (0.92–1.07)</td>
</tr>
<tr>
<td>Pre-hospital</td>
<td>64 (45–76)</td>
<td>58 (43–74)</td>
<td>0.86 (0.71–1.04)</td>
<td>53 (38–68)</td>
<td>56 (43–69)</td>
<td>1.00 (0.92–1.08)</td>
</tr>
<tr>
<td>In-hospital delay</td>
<td>173 (119–227)</td>
<td>115 (90–156)</td>
<td>0.76 (0.62–0.94)</td>
<td>59 (50–73)</td>
<td>51 (42–71)</td>
<td>0.97 (0.87–1.08)</td>
</tr>
</tbody>
</table>

**Modified Rankin Scale Score**

- 0: No symptoms
- 1: Slight disability
- 2: Moderate disability
- 3: Severe disability
- 4: Bedridden, unable to leave bed
- 5: Comatose, eyes open
- 6: Comatose, eyes closed

![Modified Rankin Scale Score Graph](image-url)
...assuming that fewer (severe stroke-) patients receive IV-tPA prior to thrombectomy when bypassing primary stroke units ....
IVL in MRCLEAN, ESCAPE, REVASCAT without effect

✓ Most patients (84%) treated with IV
✓ No effect of recanalization success
✓ No effect on outcome
How much and what type of imaging is needed?
Perfusion imaging in MRCLEAN (CTP; core = MTT >1.45, CBV <2ml/100mg)

Small core = better outcome (!)

but

Effect independent of core size
And: MISMATCH not predictive of outcome
Maybe, all we need can be done in one room...
C-Arm Conebeam CT Perfusion Imaging in the Angiographic Suite: A Comparison with Multidetector CT Perfusion Imaging

Evaluation of an Acute Stroke Patient with Flat Detector CT Prior to Mechanical Thrombectomy

Nadine Amelung¹*, Daniel Behme², Michael Knauth² and Marios Nikos Psychogios²

IV-contrast and FP-CT CTP and CTA: MCA occlusion with successful IV-thrombolysis => no DSA
University of Wisconsin
Quantum Workflow: at least 2h saved
How good is your team?
Present
Future ?
summary

• Procedure and technology
  • Stentretriever will remain, maybe we will see slight modifications
  • Direct aspiration already widespread, with potential in certain situations

• Logistics and new concepts
  • Networking!
  • Bypassing centers that do not offer thrombectomy
  • IV should not cause a delay
  • Do not overrate imaging
  • Quantum workflow ...