Recent advances in Neuroradiology and their impact on Anesthesia providers

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University of Michigan
Learning Objectives

1. Review the evolution, advances and likely changes in neuro-interventional and anesthetic management of patients with cerebrovascular disease; aneurysm, arteriovenous malformation and acute stroke

2. Discuss the anesthetic management of the patient with acute ischemic stroke
Acknowledgements

Dr. Neeraj Chaudhary
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Michigan Medicine

Dr. Joseph Gemmette
Professor of Neuro-interventional Radiology
Michigan Medicine

Dr. Aditya Pandey
Associate Professor, Neurological Surgery
Associate Professor, Otolaryngology – Head and Neck Surgery
Michigan Medicine
University of Michigan Comprehensive Stroke Center Neurointerventional Team
Presentation structure

Aneurysm

Arterio venous malformation

Acute Ischemic Stroke
Aneurysms
NIR History

Guido Guglielmi 1948-

Neurosurgeon / Engineer
University of Rome 1979

Fernando Vinuela U W.O. then
UCLA 1983 - 1989 Research
project

Target Therapeutics

March 6th 1990 – Human
application

Jan 1991 – First Human
aneurysm application GDC

Sep 8th 1995 FDA approval
Fig. 7. Historic photograph showing the first label on the package of a detachable coil. It was prepared in 1989, when the detachable coils were still called GEMs. The name was then changed to GDCs.

Fig. 8. Historic photograph of the first (handmade) current generator used to detach the coils in 1989.

Fig. 6. Historic diagrammatic representations drawn in 1989 show the first two (upper) and remaining two (lower) steps of the detachable coil technique.
International Subarachnoid Aneurysm Trial (ISAT)

Lancet 2002

2143 SAH patients (WFNS I and II) randomly assigned to coiling vs. open clipping
7.4% risk reduction (death and dependency) in coiling group
Survival benefit extended to at least 7 years
High risk of re-rupture in coiled aneurysms

Anesthesia for aneurysm coiling

GA ETT usually with muscle relaxation

Neuromonitoring common – SSEP

TIVA considered

Access to patient remains major obstacle – local variation

Arterial invasive monitoring essential; may not be able to share femoral access
Coil Embolization Techniques

Coil Procedure for Cerebral Aneurysm

A. ‘Jailing’
B. ‘Coil-Through’
C. ‘Coil-Stent’
D. ‘Balloon-Stent’
E. Coils and stent
Balloon Assisted Coiling (or “remodeling balloon technique”, BAC)
Pipeline™ stents – flow diverter

Pipeline embolization device (Covidien/ev3 Neurovascular, Irvine, California, USA)
Pipeline for Uncoilable or Failed Aneurysms: Results from a Multicenter Clinical Trial

Figure 2: (a–d) Pretreatment images from a 40-year-old woman with left occulsive pain and a giant carotid aneurysm in the (a) frontal and (b) lateral projections. (c) Three-dimensional reconstruction shows near circumferential involvement of the internal carotid artery at the aneurysm neck. (d) Axial T2-weighted MRI image demonstrates aneurysm adjacent to the medial aspect of the temporal lobe (arrow). (e–g) Follow-up images 166 days after treatment with PED: (f) concentrated trial the aneurysm no longer filled on angiography, (g) evolution of the aneurysm is confirmed on MRI. The patient's symptoms resolved.

radiology.rsna.org • Radiology: Volume 267: Number 3—June 2013
What is different about Pipeline™?

Do not “cure” the aneurysm
Promote stasis and thrombosis in the sac
Patient placed onto systemic dual anti-platelet agents to prevent IN STENT thrombosis
At least one antiplatelet lifelong
Usually aspirin & clopidogrel minimum 3 months
Platelet function assays necessary and may need to re-dose intra-op – check pre-op & put in an NG
Evolution of Neuro-interventional Arterio-venous malformation therapies
Cerebral arterio-venous malformation

Healthy cerebral arteriovenous structure

Artery

Capillary

Vein

Cerebral arteriovenous malformation

Artery

Capillary

Abnormal vascular structure = arteriovenous malformation

Vein
Onyx™

First described by Takei 1990
FDA 2010
Elastic copolymer (ethylene vinyl alcohol copolymer (EVOH)), dissolved in dimethyl-sulfoxide (DMSO)
“Slow superglue” – up to 90 minutes procedure
Makes the patient smell of fish / old cornflakes!

Anesthesia for Onyx™

GA ETT

May require neuromonitoring for SSEP or similar: consider TIVA to improve signals

Usually with muscle relaxation

Heparinized patient: have protamine on hand

Consider circulatory arrest with Adenosine
Complications of AVM / Onyx

Unintended distal embolization

Normal perfusion pressure breakthrough after procedure

Most delicate of NIR procedures – beware!
Saving the Penumbra
Acute Ischemic Stroke (AIS)
“New research has found that 97.5% of Scots are likely to be either cigarette smokers, heavy drinkers, fat, have a bad diet, and never do any exercise.” The Telegraph 2010

Pathway to reperfusion

Recognize stroke – public education

Present to hospital

Urgent Imaging – CT / CT angiography

Recognition of target thrombus

TRANSFER TO STROKE CENTRE
What can be done for stroke?

1. Nothing
2. Thrombolysis
3. Thrombectomy
Nothing – happens a lot

National Inpatient Sample of 563,087 patients (median age 74) 2005 and 2011 – ONLY 3.8% receive tPA

Stroke belt phenomenon
African-Americans 38% ↓ vs Whites to receive tPA
Hispanics 25% ↓ vs Whites to receive tPA
Women 6% ↓ vs Men to receive tPA
Private insurance 29% ↑ more likely to receive tPA vs Medicare

Lexicon of Acute Ischemic Stroke

Severity – NIHSS

Timing – history

Co-morbidity and resource implications

Outcome - modified Rankin Scale
10 minute time burden
0 – 42 score

>15 = bad

>20 = very bad

Treatment threshold based on likely impact rather than an absolute number
# MODIFIED RANKIN SCALE (MRS)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No symptoms at all</td>
</tr>
<tr>
<td>1</td>
<td>No significant disability despite symptoms; able to carry out all usual duties and activities</td>
</tr>
<tr>
<td>2</td>
<td>Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance</td>
</tr>
<tr>
<td>3</td>
<td>Moderate disability; requiring some help, but able to walk without assistance</td>
</tr>
<tr>
<td>4</td>
<td>Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance</td>
</tr>
<tr>
<td>5</td>
<td>Severe disability; bedridden, incontinent and requiring constant nursing care and attention</td>
</tr>
<tr>
<td>6</td>
<td>Dead</td>
</tr>
</tbody>
</table>

**TOTAL (0–6): _____**

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*References:*
- Rankin J. “Cerebral vascular accidents in patients over the age of 60.” *Scand Med J* 1957;2:200–15
History of Neuro-intervention for Acute Ischemic Stroke

Systemic IV tPA - 1995

Then targeted intra-arterial tPA - 1998

Thrombectomy devices invented and developed – 2004 onwards
The beginning: Thrombolysis

IV r-tPA 0.9 mg/kg – up to 4.5 hours post onset

259/787 good outcome versus 176/762

32.9% versus 23.1%

Number Needed to Treat (NNT) 5 at <90 minutes

NNT 9 at 3 to 4.5 hours

Evolution of endovascular thrombolysis techniques

Neurosurgical Focus 2014;36(1):E5
Mechanical Embolus Removal in Cerebral Ischemia
46% success at opening vessel
Acute M1 occlusion

Courtesy of Dr. Aditya Pandey
M1 Occlusion
Catheter advanced past clot
Injection past clot

 Courtesy of Dr. Aditya Pandey
MERCI retrieval catheter in place
Recanalization of middle cerebral artery
<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No perfusion</td>
</tr>
<tr>
<td>1</td>
<td>Perfusion past the initial obstruction but limited distal branch filling with little or slow distal perfusion</td>
</tr>
<tr>
<td>2a</td>
<td>Perfusion of less than half of the vascular distribution of the occluded artery</td>
</tr>
<tr>
<td>2b</td>
<td>Perfusion of half or greater of the vascular distribution of the occluded artery</td>
</tr>
<tr>
<td>3</td>
<td>Full perfusion with filling of all distal branches</td>
</tr>
</tbody>
</table>

TICI Score (Thrombectomy In Cerebral Infarction)
Penumbra Max System

Penumbra Aspiration catheter
The Penumbra Pivotal Stroke Trial
Safety and Effectiveness of a New Generation of Mechanical Devices for Clot Removal in Intracranial Large Vessel Occlusive Disease

The Penumbra Pivotal Stroke Trial Investigators

Background and Purpose—The purpose of this clinical evaluation was to assess the safety and effectiveness of the Penumbra System in the revascularization of patients presenting with acute ischemic stroke secondary to intracranial large vessel occlusive disease.

Methods—In this prospective, multicenter, single-arm study, 125 patients with neurological deficits as defined by a National Institutes of Health Stroke Scale score ≥8, presented within 8 hours of symptom onset, and an angiographic occlusion (Thrombolysis In Myocardial Infarction [TIMI] Grade 0 or 1) of a treatable large intracranial vessel were enrolled. Patients who presented within 3 hours from symptom onset had to be ineligible or refractory to recombinant tissue plasminogen activator therapy. All patients were followed clinically for 90 days postprocedure.

Results—A total of 125 target vessels in 125 patients were treated by the Penumbra System. Postprocedurally, 81.6% of the treated vessels were successfully revascularized to TIMI 2 to 3. There were 18 procedural events reported in 16 patients (12.8%), 3 patients (2.4%) had events that were considered serious. A total of 35 patients (28%) were found to have intracranial hemorrhage on 24-hour CT of which 14 (11.2%) were symptomatic. All cause mortality was 32.8% at 90 days with 25% of the patients achieving a modified Rankin Scale score of ≤2.

Conclusions—These results suggest the Penumbra System allows safe and effective revascularization in patients experiencing ischemic stroke secondary to large vessel occlusive disease who present within 8 hours from symptom onset. (Stroke. 2009;40:2761-2768.)
2013 – not a great year for NIR

Interventional Management of Stroke (IMS III)
Mechanical Retrieval and Canalization of Stroke Clots Using Embolectomy (MR RESCUE)

ALL 3 SUGGESTED THROMBECTOMY WAS NOT SUPERIOR TO THROMBOLYSIS
MR CLEAN, SWIFTPRIME & REVASCAT 2015

2015: 1st time Thrombectomy is superior to Tpa
1 in 3 can live independently versus 1 in 5
Stent-Retriever Thrombectomy after Intravenous t-PA vs. t-PA Alone in Stroke


NEJM 2015; 372: 2285 - 95
59% independent versus 33%
Thrombectomy within 8 Hours after Symptom Onset in Ischemic Stroke

Figure 1. Distribution of Functional Scores at 90 Days (Intention-to-Treat Population).

45% independent versus 29%

NEJM 2015; 372: 2296 - 306
2015 AHA/ASA Focused Update of the 2013 Guidelines for the Early Management of Patients With Acute Ischemic Stroke Regarding Endovascular Treatment

A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association

The American Academy of Neurology affirms the importance of this guideline as an educational tool for neurologists.

Endorsed by the American Association of Neurological Surgeons (AANS); Congress of Neurological Surgeons (CNS); AANS/CNS Cerebrovascular Section; American Society of Neuroradiology; and Society of Vascular and Interventional Neurology

Patients should receive endovascular therapy with a tent retriever if they meet all the following criteria (Class I; Level of Evidence A). New recommendation:

(a) prestroke mRS score 0 to 1,
(b) acute ischemic stroke receiving intravenous t-PA within 4.5 hours of onset according to guidelines from professional medical societies,
(c) causative occlusion of the internal carotid artery or proximal MCA (M1),
(d) age ≥ 18 years,
(e) NIHSS score of ≥6,
(f) ASPECTS of ≥6, and
(g) treatment can be initiated (groin puncture) within 6 hours of symptom onset.
Is mechanical thrombectomy cost effective?

One study 76 modelled the hyperacute management of stroke using intravenous thrombolysis and mechanical thrombectomy in the UK (compared with intravenous thrombolysis alone) using Markov simulations of estimated lifetime costs and quality-adjusted life years (QALYs) derived on pooled outcome data from randomised controlled trials. This study found an incremental cost per QALY gained of mechanical thrombectomy over a 20 year period of £11,652 (€17,061). A more recent study that modelled the intervention in a US setting found an incremental cost-effectiveness ratio for endovascular treatment (compared with standard care) of $3110/QALY (about £2500 per QALY) in all simulations, although cost effectiveness was lower in more distal (M2) occlusion and with established ischaemic injury (ASPECTS score ≤5). Both
Current issues in 2018

1. Making thrombectomy happen

2. Mode of Anesthesia for thrombectomy

3. Service and workforce implications as the indications for thrombectomy expand
Time is brain

Practicalities dominate proceedings

Protocols may help flow and communication

Larger organizations may have larger protocols!

Role of automatic paging and regular drills
Evidence of Michigan Medicine tPA protocol success

2014 & 2015

>50% of patients were treated within 45 minutes
>75% of patients were treated within 60 minutes

Last 18 months 100%

State of Michigan <60 minute average is 65%
National average < 60 minute average 86.5%

http://www.uofmhealth.org/conditions-treatments/brain-neurological-conditions/stroke
How should I anesthetize a stroke patient?

No sedation?

MAC?

General anesthetic?
Why should we have to anesthetize a stroke patient?

“We are never there for a cardiac cath!”

Risk of airway loss and need for urgent intubation

Risk of catastrophic complications

Because the brain is more important than the heart
Anesthesia for mechanical thrombectomy

Traditionally used “there there” anesthesia

Perhaps MAC at most

Allows for immediate assessment of neurology

“GA has been associated with worse outcomes”
Anesthetic Management and Outcome in Patients during Endovascular Therapy for Acute Stroke.

Anesthesiology 2012;116(2):396

Retrospective review: 48 GA/48 LA patients
Primary outcome Rankin Score of 0-2
Independent predictors of good outcome:
- Local anesthesia
- SBP > 140 mmHg
- Low baseline NHSS
Impact of General Anesthesia on Safety and Outcomes in the Endovascular Arm of Interventional Management of Stroke (IMS) III Trial

by Alex Abou-Chebl, Sharon D. Yeatts, Bernard Yan, Kevin Cockroft, Mayank Goyal, Tudor Jovin, Pooja Khatri, Phillip Meyers, Judith Spilker, Rebecca Sugg, Katja E. Wartenberg, Tom Tomsick, Joe Broderick, and Michael D. Hill

Stroke
Volume 46(8):2142-2148
July 27, 2015
Distribution of modified Rankin Scale scores of disability at 3 months.

BLAME ANESTHESIA

Alex Abou-Chebl et al. Stroke. 2015;46:2142-2148
Recommendation: Embolectomy procedures should be performed with conscious sedation or MAC whenever possible. GETA should be reserved for patients who are not considered able to protect their airways for the procedure while supine or who are too uncooperative for the procedure to be performed safely (AHA Class IIb, Level of Evidence C).

McTaggart J Neurointervent Surg 2015
Questions regarding GA being worse

Biased patient selection?

Greater hypotension associated with GA?
Baseline NHSS and anesthetic technique

Stroke patients undergoing GA are more sick
Anesthetic technique, BP and Outcome
Advantages of General Anesthesia?

Paralyzed patient – easier surgical palette

“Neuroprotection”

Airway protection
Advantages of Conscious Sedation?

More rapid start

More robust blood pressure

Immediate clinical exam
3rd European Stroke Organisation Conference (ESOC) 2017

2017 NEW EVIDENCE FOR ANESTHESIA!

ANSTROKE

GOLIATH
General Anesthesia Versus Conscious Sedation for Endovascular Treatment of Acute Ischemic Stroke: The AnStroke Trial (Anesthesia During Stroke)
Pia Löwhagen Hendén, Alexandros Rentzos, Jan-Erik Karlsson, Lars Rosengren, Birgitta Leiram, Henrik Sundeman, Dennis Dunker, Kunigunde Schnabel, Gunnar Wikholm, Mikael Hellström and Sven-Erik Ricksten

### Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>GA</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n=45</strong></td>
<td><strong>n=45</strong></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>73 (65–80)</td>
<td>72 (66–82)</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>26 (58)</td>
<td>23 (51)</td>
</tr>
<tr>
<td>Comorbidities, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>27 (60)</td>
<td>22 (49)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>18 (40)</td>
<td>18 (40)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>9 (20)</td>
<td>5 (11)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>9 (20)</td>
<td>7 (16)</td>
</tr>
<tr>
<td>Smoker</td>
<td>4 (9)</td>
<td>8 (18)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>5 (11)</td>
<td>7 (16)</td>
</tr>
<tr>
<td>Premorbid modified Rankin Scale ≤2, n (%)</td>
<td>44 (98)</td>
<td>44 (98)</td>
</tr>
</tbody>
</table>

CS indicates conscious sedation; and GA, general anesthesia.

### Table 2. Stroke Characteristics

<table>
<thead>
<tr>
<th></th>
<th>GA</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n=45</strong></td>
<td><strong>n=45</strong></td>
<td></td>
</tr>
<tr>
<td>NIHSS score</td>
<td>20 (15.5–23)</td>
<td>17 (14–20.5)</td>
</tr>
<tr>
<td>Intravenous thrombolysis treatment, n (%)</td>
<td>33 (73.3)</td>
<td>36 (80)</td>
</tr>
<tr>
<td>Occlusion site, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotid-T occlusion</td>
<td>15 (33)</td>
<td>9 (20)</td>
</tr>
<tr>
<td>Distal ICA</td>
<td>0 (0)</td>
<td>1 (2.2)</td>
</tr>
<tr>
<td>First segment of MCA (M1)</td>
<td>26 (58)</td>
<td>26 (58)</td>
</tr>
<tr>
<td>First segment of MCA (M1)+distal branches (A2, A3, M2, and M3)</td>
<td>4 (9)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Second segment of MCA (M2)</td>
<td>0 (0)</td>
<td>8 (18)</td>
</tr>
<tr>
<td>Left hemisphere, n (%)</td>
<td>26 (68)</td>
<td>17 (38)</td>
</tr>
<tr>
<td>ASPECTS score, 1–10</td>
<td>10 (8–10)</td>
<td>10 (9–10)</td>
</tr>
<tr>
<td>Collateral circulation, 1–5</td>
<td>2 (1–4)</td>
<td>1 (1–3)</td>
</tr>
</tbody>
</table>

ASPECTS indicates Alberta Stroke Program Early CT score; CS, conscious sedation; GA, general anesthesia; ICA, internal carotid artery; MCA, middle cerebral artery; and NIHSS, National Institutes of Health Stroke Scale.

*Stroke. 2017;48:1601-1607*
General Anesthesia Versus Conscious Sedation for Endovascular Treatment of Acute Ischemic Stroke: The AnStroke Trial (Anesthesia During Stroke)

Pia Löwhagen Hendén, Alexandros Rentzos, Jan-Erik Karlsson, Lars Rosengren, Birgitta Leiram, Henrik Sundeman, Dennis Dunker, Kunigunde Schnabel, Gunnar Wikholm, Mikael Hellström and Sven-Erik Ricksten

Figure 2. Neurological outcome expressed as modified Rankin Scale (mRS) score. GA indicates general anesthesia.

Conclusions—In endovascular treatment for acute ischemic stroke, no difference was found between general anesthesia and conscious sedation in neurological outcome 3 months after stroke.
GOLIATH

Aarhus. 65 GA, 63 MAC

GA = Propofol / remi vs. MAC Propofol / fentanyl

SBP > 140 mmHg, MAP > 70 mmHg targets

MAP drop > 20% higher in GA group

Infarct GROWTH 8.2 mls GA vs 19.4 mls MAC (p 0.10)

Modified Rankin was better scores in GA group

Signal in favor of GA (starting infarct < 70 mls)
So GA is now OK for thrombectomy?

YES!

Patient factors more important than GA vs MAC
Local preference shapes practice
GA *lengthens start* by 9 minutes (p=0.0555)
BUT GA related with *faster revascularization* by 19 minutes (p=0.6572)
16. It is reasonable to select an anesthetic technique during endovascular therapy for AIS on the basis of individualized assessment of patient risk factors, technical performance of the procedure, and other clinical characteristics. Further randomized trial data are needed.

Conscious sedation (CS) was widely used in the recent endovascular trials (90.9% of ESCAPE, 63% of SWIFT PRIME) with no clear positive or negative impact on outcome. In MR CLEAN, post hoc analysis showed a 51% (95% CI, 31–86) decrease in treatment effect of general anesthesia (GA) compared with CS. In THRACE, 51 of 67 patients receiving GA and 43 of 69 patients receiving CS achieved TICI 2b/3 ($P=0.059$) with no impact on outcome. Thirty-five of 67 patients with GA and 36 of 74 with CS had mRS scores of 0 to 2 at 90 days. Although several retrospective studies suggest that GA produces worsening of functional outcomes, there are limited prospective randomized data. Two small ($\leq150$ participants) single-center RCTs have compared GA with CS. Both failed to show superiority of either treatment for the primary clinical end point. Until further data are available, either method of procedural sedation is reasonable.
Workforce implications of an acute stroke thrombectomy service
Increasing numbers of cases

Michigan 12 cases annually 2014

Michigan 58 cases in 2016

Michigan 68 cases in 2017; 75 stroke team activations
Urgency and acuity of cases

Time expectations as part of stroke service

60 minutes “door to groin” target
(30 minutes for TpA for comparison)

Current Michigan Medicine metrics

OSH transfer 38 minutes arrival to arterial access
ED presentation 104 minutes arrival to arterial access
Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct


DOI: 10.1056/NEJMoa1706442
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Thrombectomy Group</th>
<th>Control Group</th>
<th>Absolute Difference (95% CI)</th>
<th>Adjusted Difference (95% Credible Interval)</th>
<th>Posterior Probability of Superiority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary end points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score on utility-weighted modified Rankin scale at 90 days</td>
<td>2.1±3.1</td>
<td>4.4±3.1</td>
<td>2.1 (1.2–3.1)</td>
<td>2.0 (1.1–3.0)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Functional independence at 90 days — no. (%)</td>
<td>52 (49)</td>
<td>13 (13)</td>
<td>36 (24–47)</td>
<td>33 (21–44)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Secondary end points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early response, m (%)</td>
<td>5 (43)</td>
<td>1 (1)</td>
<td>2 (16–21)</td>
<td>2 (12–29)</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td>Recanalization, 2a–3a, n (%)</td>
<td>8 (77)</td>
<td>0 (0)</td>
<td>8 (57–100)</td>
<td>2 (12–29)</td>
<td>0.001**</td>
</tr>
<tr>
<td>Change from baseline in infarct volume at 24 hr — ml††</td>
<td>1</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>0–28</td>
<td>0–42</td>
<td></td>
<td></td>
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<tr>
<td>Interquartile range</td>
<td></td>
<td></td>
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<tr>
<td>Infarct volume at 24 hour — ml††</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>8</td>
<td>22</td>
<td></td>
<td>&lt;0.001††</td>
<td></td>
</tr>
<tr>
<td>Interquartile range</td>
<td>0–48</td>
<td>8–68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade of 2b or 3 on mTICI scale — no. (%)§§</td>
<td>90 (84)</td>
<td>NA</td>
<td></td>
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</tr>
</tbody>
</table>

Trevo® device

NIHSS 17 in both groups
38 US hospitals
Including Michigan Medicine
Diffusion mismatch, 6-24 hours post stroke >15mls penumbra, <70mls infarct
45% functional independence vs 17%
Consider thrombectomy up to 24 hours.
Summary of the future state

Robust protocols are vital to success

More cases:
1. Underserved population
2. Time window enlarging x4 to 24 hours

General anesthesia ≈ MAC
Learning Objectives

1. Review the evolution, advances and likely changes in neuro-interventional and anesthetic management of patients with cerebrovascular disease; aneurysm, arteriovenous malformation and acute stroke

2. Discuss the anesthetic management of the patient with acute ischemic stroke
Questions?