New generation of Endovascular Treatment of Stroke and Brain Aneurysms

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• The following presentation includes the discussion of commercial products as they are used in clinical practice

• Off-label and investigational products and treatments will be discussed as part of clinical trials

• The author does not have any conflict of interest to disclose
Ischemic Stroke

Area deprived of blood

Hemorrhagic Stroke

Area of bleeding
Antiplatelet Agents for Acute Ischemic Stroke
Benefits in NNT

1 in 79 were helped (death, dependency avoided)
1 in 143 were helped (prevented repeat stroke)


IV tPA for Acute Ischemic Stroke
Benefits in NNT

Time to treatment: < 3 hours
1 in 8 for ‘favorable’ outcomes


Time to treatment: 3-4.5 h
1 in 15 for ‘favorable’ outcomes


Acute thrombectomy for Acute Ischemic Stroke
Benefits in NNT
1 in 6 for ‘favorable’ outcome = independent
UCLA Interventional Neuroradiology research and development

First device therapy for acute ischemic stroke
MERCI Retriever - Invented at UCLA

Leading device therapies for cerebral aneurysms
Guglielmi detachable coil, Matrix coil - Invented at UCLA

Leading catheter therapy for intracranial arteriovenous malformations and fistulae
Onyx as liquid embolic agent for intracranial arteriovenous malformations and fistulae - Developed at UCLA
MERCI (2004) 1st GENERATION
Engage the thrombus with deployment of a 'corkscrew' distal tip then remove en bloc. Proximal balloon inflation allows device retrieval into the guide while minimizing the risk of emboli.

STENTRIEVER (early 2012) 3rd GENERATION
Engage the thrombus with stent retrieve deployment, which also temporarily restores flow across the occlusion. Proximal balloon inflation allows device retrieval into the guide while minimizing the risk of emboli.

ADAPT (2013)
A large caliber aspiration catheter that is advanced up to the thrombus. Direct aspiration is employed to engage and then remove the thrombus.

PENUMBRA (2009) 2nd GENERATION
The penumbra aspiration system involves maceration of the thrombus with a separator under direct aspiration to prevent showering of fragments. Once the catheter system is delivered to the target vessel, ongoing clot maceration is performed without the need to re-access.

DAC (2010)
The DAC is positioned immediately adjacent to the thrombus and aspiration is applied to minimize emboli and optimize the vectors during pulling of the device.

SOLUMBRA (late 2012)
To minimize the distance the stent retriever must travel while engaging the thrombus and mitigate the possibility of losing purchase of the clot, the stent retriever is then pulled directly into a large bore intermediate catheter while maintaining aspiration.

- 46-year-old woman
- found down by a neighbor
- severe R hemiparesis and aphasia, NIHSS 25 (severe stroke is >20)

CT: no new large infarct
CTA: L MCA - M1 segment occlusion
A Randomized Trial of Intraarterial Treatment for Acute Ischemic Stroke

Endovascular Therapy for Ischemic Stroke with Perfusion-Imaging Selection

Stent-Retriever Thrombectomy after Intravenous t-PA vs. t-PA Alone in Stroke

Randomized Assessment of Direct Angioplasty Versus Thrombectomy in Ischemic Stroke

Thrombectomy within 8 Hours after Symptom Onset in Ischemic Stroke

ORIGINAL ARTICLE

ORIGINAL ARTICLE

ORIGINAL ARTICLE

ORIGINAL ARTICLE
Cerebral Angiogram – Acute Thrombectomy

L Middle Cerebral Artery occlusion

Post thrombectomy - open

Presented as severe stroke NIHSS 25

On the table improved to NIHSS 1
MRI at discharge

Clinical follow-up at 90 days

Back to baseline

NIHSS = 1

Minimal aphasia
MRI at discharge

Clinical follow-up at 90 days

Back to baseline

NIHSS = 1

Minimal aphasia
RAPID processing: finished successfully

ADC < 620.0 volume = 26 ml
Tmax > 6.0 s volume = 124 ml

Review results on the RAPID server

Institution: UCLA Radiology Ronald Reagan Med Ctr
RAPID AnonID: 101_333
Patient Gender: Male
Patient Age: 066Y
Diffusion series: #2 ep2d_diff_3scan_trace, 2017/09/18 07:47:49 (84 files)
Perfusion series: #15 ep2d_Perf Post, 2017/09/18 08:02:10 (900 files)
Station: SIEMENS, Avanto

ADC/Tmax Mismatch

ADC < 620 volume: 26 ml
Mismatch volume: 98 ml
Mismatch ratio: 4.8

Tmax > 6.0 s volume: 124 ml
Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct

Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging


Figure 2. Scores on the Modified Rankin Scale at 90 Days.
Patients in the endovascular-therapy group received endovascular therapy plus standard medical therapy. Patients in the medical-therapy group received standard medical therapy alone. Scores on the modified Rankin scale range from 0 to 6, with 0 indicating no symptoms, 1 no clinically significant disability, 2 slight disability, 3 moderate disability, 4 moderately severe disability, 5 severe disability, and 6 death. There was a significant difference favoring the endovascular-therapy group over the medical-therapy group in the overall distribution of scores (unadjusted common odds ratio, 2.77; 95% CI, 1.63 to 4.70; P<0.001).
Brain Aneurysm

- MCA bifurcation
- Anterior communicating artery
- Internal carotid artery
- Basilar artery
Statistics and Facts

• 6.5 million people in the United States have an unruptured brain aneurysm, or 1 in 50 people.

• The annual rate of rupture is approximately 8 – 10 per 100,000 people.

• About 30,000 people in the United States suffer a brain aneurysm rupture each year. A brain aneurysm ruptures every 18 minutes.

• Women are more likely than men to have a brain aneurysm (3:2 ratio).

• Ruptured brain aneurysms are fatal in about 50% of cases. Of those who survive, about 66% suffer some permanent neurological disability.

• Approximately 15% of people with a ruptured aneurysm die before reaching the hospital.

• Most aneurysms are small — about 1/8 inch to nearly one inch — and an estimated 50-80% of all aneurysms do not rupture.

• Among patients evaluated in an emergency department for headaches, approximately 1-4 in 100 has a ruptured aneurysm.

• 20% of people diagnosed with a brain aneurysm have more than one aneurysm.
BRAIN ANEURYSMS

- prevalence : 3.2% \(^1\)

- most aneurysms are clinically silent ... until rupture ... which is unpredictable

- past 3 decades: improved management strategies (endovascular/surgical) and neurocritical care

- however, case fatality of aneurysm rupture is high: up to 44% \(^2\)

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- feasibility 95%
- procedure 1.4%
- periproced 8%

Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage
A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association

The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists.

Endorsed by the American Association of Neurological Surgeons and Congress of Neurological Surgeons; and by the Society of NeuroInterventional Surgery

(Stroke. 2012;43:1711-1737.)
Surgical clipping or endovascular coiling of the ruptured aneurysm should be performed as early as feasible in the majority of patients to reduce the rate of rebleeding after aSAH (Class I; Level of Evidence B).

For patients with ruptured aneurysms judged to be technically amenable to both endovascular coiling and neurosurgical clipping, endovascular coiling should be considered (Class I; Level of Evidence B).
The durability of endovascular coiling versus neurosurgical clipping of ruptured cerebral aneurysms: 18 year follow-up of the UK cohort of the International Subarachnoid Aneurysm Trial (ISAT)

![Graph showing Kaplan Meier cumulative mortality to 7 years](image)

**Figure 2: Kaplan Meier cumulative mortality to 7 years**

<table>
<thead>
<tr>
<th>Survival at 10 years</th>
<th>Independence at 10 years</th>
<th>Independent survival at 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alive</strong></td>
<td><strong>Dead</strong></td>
<td><strong>OR (95% CI)</strong></td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Endovascular coiling group</td>
<td>674/809 (83%)</td>
<td>135/809 (17%)</td>
</tr>
<tr>
<td>Neurosurgical clipping group</td>
<td>657/835 (79%)</td>
<td>1/835 (21%)</td>
</tr>
</tbody>
</table>

Data are n/N with available data (%), unless otherwise stated. OR = odds ratio. mRS = modified Rankin scale. *Calculated by multiplication of probability of being alive and probability of good mRS (0–2).

**Table 1: Death and dependency at 10 years**

Published online October 28, 2014
1989-1999
research, development and first clinical use at UCLA

Development of 1st detachable platinum coil using electrothrombosis and electrolysis
RUPTURED INTRACAVERNOUS ANEURYSM
FIRST GDC CASE
MARCH 6, 1990
CAROTID OPHTHALMIC ANEURYSM

FRAMER

FILLERS

FINISHERS
Dissecting microscope

GDC coils observed through the transparent wall of the aneurysm wall
Aneurysm Embolization - Technology Advances in wide neck aneurysms

Balloon –Assisted technique: temporary neck remodeling
BALLOON ASSISTED TECHNIQUE: LARGE, WIDE NECK ANEURYSM
RUPTURED BASILAR TIP ANEURYSM. DOUBLE CATHETER TECHNIQUE
COMPLEX BLOOD FLOW DYNAMICS.
JIKEI UNIVERSITY
<table>
<thead>
<tr>
<th></th>
<th>&lt;7 mm</th>
<th></th>
<th>7–12 mm</th>
<th></th>
<th>13–24 mm</th>
<th></th>
<th>≥25 mm</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavernous carotid artery (n=210)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.0%</td>
<td>6.4%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC/MC/IC (n=1037)</td>
<td>0</td>
<td>1.5%</td>
<td>2.6%</td>
<td>14.5%</td>
<td>40%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-P comm (n=445)</td>
<td>2.5%</td>
<td>3.4%</td>
<td>14.5%</td>
<td>18.4%</td>
<td>50%</td>
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<td></td>
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</tr>
</tbody>
</table>

AC=anterior communicating or anterior cerebral artery. IC=internal carotid artery (not cavernous carotid artery). MC=middle cerebral artery. Post-P comm=vertebrobasilar, posterior cerebral arterial system, or the posterior communicating artery.

Table 4: **5-year cumulative rupture rates according to size and location of unruptured aneurysm**

PHASES Score for the Management of Intracranial Aneurysm

To calculate the PHASES risk score for an individual, the number of points associated with each indicator can be added up to obtain the total risk score. For example, a 55-year-old North American man with no hypertension, no previous SAH, and a medium-sized (8 mm) posterior circulation aneurysm will have a risk score of 0+0+0+3+0+4+7 points. According to figure 3, this score corresponds to a 5-year risk of rupture of 2.4%. SAH=subarachnoid haemorrhage. ICA=internal carotid artery. MCA=middle cerebral artery. ACA=anterior cerebral arteries (including the anterior cerebral artery, anterior communicating artery, and pericallosal artery). Pcom=posterior communicating artery. Posterior=posterior circulation (including the vertebral artery, basilar artery, cerebellar arteries, and posterior cerebral artery).

Table 4: Predictors composing the PHASES aneurysm rupture risk score

Figure 3: Predicted 5-year risk of aneurysm rupture according to PHASES score
INTRACRANIAL STENTS: Hybrid technology (stents + coils)

- Stents are made from Nitinol
INTRACRANIAL STENT TELESCOPING FOLLOWED BY COIL EMBOLIZATION

COIL EMBOLIZATION 1 MONTH POST-STENTING
PERMANENT ARTERIAL RECONSTRUCTION WITH STENT FLOW DIVERTERS: UNKNOWN BLOOD FLOW BIOMECHANICAL CHANGES.
Flow diversion

A

B

Maldonado IL and Bonafe A, 2012
http://dx.doi.org/10.5772/51295

Pipeline:
https://www.youtube.com/watch?v=cBtvPzLyrtM
Large Left carotid-ophthalmic aneurysm Pipeline IMM/3/10 months

3 months

10 months
Large Right carotid-ophthalmic aneurysm. Pipeline + BAT IMMEDIATE
Future of the Endovascular aneurysm treatment

- safe implementation of new technology
- design and efficient recruitment to randomized controlled trials
- focus on patient outcomes (small aneurysm observation vs treatment)
- Understanding of antiplatelet and anticoagulation management
- Understanding and prediction of asymptomatic aneurysm rupture