THEN AND NOW: DEVELOPMENT AND STATE OF THE ART OF NEUROENDOVASCULAR THERAPY

A PERSONAL JOURNEY

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OVERVIEW

• Endovascular Therapy for Cerebrovascular Diseases Prior to DSA (1974-1991)

• Availability of DSA Introduces a New Era For Minimally Invasive Endovascular Procedures

• Full Utilization of Currently Available Imaging Tools Enhances Safety and Efficacy

• A Preview of Current and Soon to be Available Cone Beam C-arm CT Imaging Techniques

BEFORE CT AND DSA
NORWEGIAN AND SWEDISH NEURORADIOLOGIST DEVELOPED TECHNIQUES FOR CATHETER ANGIOGRAPHY. THIS RAPIDLY REPLACED PERFORMANCE OF ANGIOGRAPHY BY DIRECT NEEDLE PUNCTURE.

IN 1975-76 RUSSIAN NEUROSURGEON SERBINENKO DESCRIBES DETACHABLE BALLOON CATHETER FOR TREATMENT OF CAROTID CAVERNOUS FISTULA.
75 year old woman with 3rd nerve palsy

INVENTION OF DSA


START OF A NEW ERA!

7 Year Old Girl With Seizures

Parents told—“no possibility for treatment of AVM”
56 year old male with multiple thalamic hemorrhages
Full Utilization of Currently Available Imaging Tools Enhances Safety and Efficacy
69 year old with multiple TIA's and Left Vertebral Occlusion

IMMEDIATE POST- STENTING

Post 2.5 X 15 Gateway and 3.0 X 15 Gateway to 6 ATM
Post 2.5 X 9 Gateway (within stent) to 9 ATM
Post 2.5 X 13 Quantum Maverick to 11 ATM
Dose Reduction: VOI Imaging in CBCT

- Tube is collimated to region of interest
- X-ray beam is projected only onto the region of interest
Collimation Reduces Dose to the Patient

Protocol: 20s DynaCT
496 images
FOV: 30cm x 40cm
~ 2.7 mSv

Protocol: 20s DynaCT
496 images
FOV: 22 x 22 cm
~ 0.9 mSv

Protocol: 20s DynaCT
496 images
FOV: 5cm x 4 cm
~ 0.1 mSv
A Preview of Current and Soon to be Available Cone Beam C-arm CT Imaging Techniques
<table>
<thead>
<tr>
<th>Trial</th>
<th>Treatment Timeline</th>
<th>Imaging Selection</th>
<th>Outcome IV Only</th>
<th>Outcome IV + IA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR CLEAN</td>
<td>IV TPA by 4.5 hrs</td>
<td>CT - ASPECTS 7-10</td>
<td>MRS 0-2: 19%</td>
<td>MRS 0-2: 33%</td>
</tr>
<tr>
<td></td>
<td>Wait for response</td>
<td>CTA - Anterior clot</td>
<td>Recan: 33%</td>
<td>Recan: 75%</td>
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<tr>
<td></td>
<td>Start IA by 6 hrs</td>
<td>CTP - done in 65%</td>
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<td></td>
<td>Puncture @ 200 min</td>
<td>detaile not reported</td>
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<tr>
<td>ESCAPE</td>
<td>Symptoms 0-12 hrs</td>
<td>CT - ASPECTS 6-10</td>
<td>MRS 0-2: 29%</td>
<td>MRS 0-2: 53%</td>
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<tr>
<td></td>
<td>IV TPA by 4.5 hrs</td>
<td>CTA - Anterior clot</td>
<td>Recan: 37%</td>
<td>Recan: 72%</td>
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<tr>
<td></td>
<td>Puncture @ 165 min</td>
<td>mCTA &gt; 50% MCA</td>
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<tr>
<td>EXTEND IA</td>
<td>IV TPA by 4.5 hrs</td>
<td>CT - IV TPA criteria</td>
<td>MRS 0-2: 40%</td>
<td>MRS 0-2: 71%</td>
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<td>+/− IA by 6 hrs</td>
<td>CTA - Anterior clot</td>
<td>Recan: 34%</td>
<td>Recan: 100%</td>
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<tr>
<td></td>
<td>Puncture @ 210 min</td>
<td>CTP - 32% excluded</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td>Tmax &gt; 6 s, rCBF &lt;30%</td>
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<td>SWIFT-PRIME</td>
<td>IV TPA by 4.5 hrs</td>
<td>CT - ASPECTS 7-10</td>
<td>MRS 0-2: 35%</td>
<td>MRS 0-2: 50%</td>
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<td>+/− IA Solitaire by 6h</td>
<td>CTA - Anterior Clot</td>
<td>Recan: N/A</td>
<td>Recan: 88%</td>
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<tr>
<td></td>
<td>Puncture @ 224 min</td>
<td>CTP - Target MM 84%</td>
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<td></td>
<td>Exclude Malignant 13%</td>
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**Endovascular Trials 2015:**

Good Outcomes with Advanced Imaging Selection

But...be careful of cross trial comparisons!!

**Broad Consensus on Requirements of Imaging**

- Must Be Done As Quickly As Possible
- Must Provide Information About Extent of Infarcted and Oligemic Brain
- Must Provide Information About Collaterals
Imaging Recommendations for Acute Stroke and TIA Patients: A Joint Statement by the ASNR, ACR, SNIS

AJNR NOV 2013

Angiographic Suite With C-arm CT

- To assess for intracranial bleeding
- To assess for extent of ischemic core
- To assess location and extent of intravascular clot
- To assess carotid atherosclerotic disease
- To assess the extent of viable tissue

“One-stop-shop” Stroke Imaging: A New Workflow

Current workflow
- Arrive at hospital
- CT Suite
  - NCCT
  - CTA
  - CTP
- MRI Suite
  - MRI
  - DAI
  - PWI
- ER
- 30-60 minutes
- Angiography Suite
- Endovascular treatment/efficacy evaluation

Proposed workflow
- Arrive at hospital
- Angiography Suite
  - Single C-arm CBCT perfusion acquisition
  - NCCT Time-resolved CTA
  - CTP
- Endovascular treatment/efficacy evaluation
- At least one hour is saved per patient!

WORKFLOW FOR COMPREHENSIVE IMAGING ANGIO SUITE: THE “ONE STOP SHOP”

- Single Injection Detector
- NCCT
- CECT
- CBF
- CBV
- MTT
- TTP
- Time Resolved CTA

3 equivalent options
- NCCT + DSA for vascular imaging
- NCCT + CTA + PCT
- MRI (DWI, FLAIR, GRE,BMI, PWI, PWI ASL) + MRA

U01EB027183 June, 2015
Conclusions—Time-resolved CTAs derived from C-arm CT perfusion acquisitions provide high quality images that allowed accurate diagnosis of large vessel occlusions. Although image quality of smaller arteries in this study was not optimal ongoing modifications of the postprocessing algorithm will likely remove this limitation. Adding time-resolved C-arm CTAs to the capabilities of the angiography suite further enhances its suitability as a one-stop shop for patients with acute ischemic stroke.
CONCLUSIONS: After postprocessing methods were applied to enhance image quality for conebeam CT perfusion maps, the conebeam CT perfusion maps were not inferior to those generated from multidetector CT perfusion.

Evaluation of collaterals and clot burden using time-resolved C-arm Cone beam CT angiography I the Angio-suite: a feasibility Study.

Conclusions: Comprehensive evaluations of clot burden and collateral flow are feasible using time-resolved C-arm CBCTA data acquired in the angiosuite. This technique further enriches the imaging tools in angiography suite to enable a “One Stop Shop” imaging workflow for patients with AIS.
Major Challenges in the “One-stop shop” Workflow

Limited low contrast resolution as compared to MDCT

Limited temporal resolution as compared to MDCT
SMART-RECON in CBCT Perfusion

Pixel Intensity vs. Time

THANK YOU