STROKE SYSTEMS OF CARE:

1. Primary prevention
2. Community education
3. Emergency transport providers
4. Acute stroke Treatment
   - ER physicians
   - Neurologist
   - RN
   - Laboratory
   - Radiology
   - Pharmacy
5. Sub-Acute stroke Treatment
6. Rehab
   - Physical therapist
   - Occupational therapist
   - Speech therapist
   - Rehab MD
7. Secondary prevention
PROGRESS IN STROKE: HISTORICAL PERSPECTIVES

---Decade of the brain------
*Time is brain

*Physiology is brain

---
1. Early challenges

+ Patient
  - Stroke awareness
  - symptom recognition
  - knowledge of time sensitive treatment
  - EMS activation

+ Pre-hospital providers (EMS)
  - 911 responders to recognize stroke symptoms and rapid dispatch

+ Hospital services
  + Stroke Response team (neurologists, radiologists, ER physicians)
  + Hospital readiness and capabilities
Establishment of Stroke Systems of Care

- Objectives:
  - Promote patient-centered collaborations and interactions amongst stakeholders
  - Adoption of standardized care approach
  - Identify and track performance measures

ASA Policy Recommendations

Recommendations for the Establishment of Stroke Systems of Care
Recommendations From the American Stroke Association’s Task Force on the Development of Stroke Systems

Task Force Members
Lee H. Schwamm, MD; Arthur Pancioli, MD; Joe E. Acker III, EMT-P, MPH, MS; Larry B. Goldstein, MD; Richard D. Zorowitz, MD; Timothy J. Shephard, PhD(c), CNRN, CNS; Peter Moyer, MD, MPH; Mark Gorman, MD; S. Claiborne Johnston, MPH, MD, PhD; Pamela W. Duncan, PhD; Phil Gorelick, MD; Jeffery Frank, MD; Steven K. Stranne, MD, JD; Renee Smith, MPA; William Federspiel, BA; Katie B. Horton, RN, JD; Ellen Magnis, MBA; Robert J. Adams, MD

Stroke 2005; 36: 690-703
1. Early challenges

+ Patient
  - Stroke awareness (symptom recognition, knowledge of time sensitive treatment, EMS activation)
    - General prevention efforts (primordial, primary and secondary prevention)
    - Community education & Stroke

+ Pre-hospital providers (EMS)
  - Notification and response
EMS WITHIN STROKE SYSTEMS OF CARE

EMS communicators recognize signs and symptoms reported by callers.

Dispatch the highest level of care in the shortest time using emergency medical dispatch guidelines reflecting the current ASA/AHA guidelines.

- Field assessment & triage
- Transfer protocol
1. **Development and Progress**

   **Hospital services**
   - Response team (neurologists, radiologists, ER physicians)
     - Brain Attack Team 24/7 availability
     - Support team: neurosurgical and endovascular 24/7 availability
   - Hospital readiness and capabilities
     - Stroke Center Designations (stroke ready, primary, comprehensive stroke centers)
     - Collaborations Amongst various designated stroke centers (drip and ship, hub and spoke models)
   - Stroke Units
   - Workflow & Performance Metrics
     - Door-to-Needle Time for IV thrombolytic therapy (target goal less than 60min)
     - Secondary stroke prevention (anti-thrombotic therapy, anticoagulation)
     - Dysphagia screen & Rehabilitation
     - Education materials for patients and families
     - 90 day outcome
Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials

<table>
<thead>
<tr>
<th>Interval (min)</th>
<th>Treatment</th>
<th>n</th>
<th>Odds ratio (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adjusted</td>
</tr>
<tr>
<td>0–90</td>
<td>rt-PA</td>
<td>161</td>
<td>2.81 (1.75–4.50)</td>
</tr>
<tr>
<td></td>
<td>Placebo</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>91–180</td>
<td>rt-PA</td>
<td>302</td>
<td>1.55 (1.12–2.15)</td>
</tr>
<tr>
<td></td>
<td>Placebo</td>
<td>315</td>
<td></td>
</tr>
<tr>
<td>181–270</td>
<td>rt-PA</td>
<td>390</td>
<td>1.40 (1.05–1.85)</td>
</tr>
<tr>
<td></td>
<td>Placebo</td>
<td>411</td>
<td></td>
</tr>
<tr>
<td>271–360</td>
<td>rt-PA</td>
<td>538</td>
<td>1.15 (0.90–1.47)</td>
</tr>
<tr>
<td></td>
<td>Placebo</td>
<td>508</td>
<td></td>
</tr>
</tbody>
</table>

3-month favourable outcomes include Rankin (0–1), Barthel (95–100), and NIHSS (0–1). One, eight, nine, and six patients from NINDS part I, ECASS I, ECASS II, and ATLANTIS B, respectively, were excluded from this analysis since they were randomised after 360 min or OTT was not reported. *Odds ratios calculated from global statistical approach by ITT analysis. Adjusted odds ratios were calculated adjusting for age, baseline glucose concentration, baseline NIHSS, baseline diastolic blood pressure, previous hypertension, and interaction between age and baseline NIHSS.

Table 1: Odds ratio for a favourable outcome at 3 months after stroke

Figure 3: Model estimating odds ratio for favourable outcome at 3 months in rt-PA-treated patients compared with controls by OTT

Adjusted for age, baseline glucose concentration, baseline NIHSS measurement, baseline diastolic blood pressure, previous hypertension, and interaction between age and baseline NIHSS measurement.

Lancet 2004; 363: 768–74
GOLDEN HOUR FOR IV-TPA
WORKFLOW METRICS

Door to needle in ≤60 min\(^1,8\)

- **0 min**: Suspected stroke patient arrives at ED
- **≤10 min**: Initiate MD evaluation and labwork
- **≤15 min**: Notify stroke team (including neurologic expertise)
- **≤25 min**: Initiate imaging scan
  - Review patient history and establish time of last known well/symptom onset
  - Assess using NIHSS
- **≤45 min**: Interpret imaging scan and labs
  - Review patient eligibility for Activase\(^\text{®}\) (alteplase)*
- **≤60 min**: Give Activase bolus and initiate infusion in eligible patients*
GET-WITH-THE-GUIDELINES PROGRAM
TRACK STANDARDIZED PERFORMANCE METRICS

<table>
<thead>
<tr>
<th>Measure No.</th>
<th>Measure Name</th>
<th>Ischemic Stroke</th>
<th>TIA</th>
<th>Hemorrhagic Stroke</th>
<th>Ill-Defined Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AdmDxIS</td>
<td>AdmDxTIA</td>
<td>AdmDxSH</td>
<td>AdmDxIH</td>
</tr>
<tr>
<td>1</td>
<td>VTE Prophylaxis</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Discharged on antithrombotic therapy</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Anticoagulation for AF</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>t-PA administered</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Antithrombotic therapy by end of day 2</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Discharged on cholesterol reducing medication</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6a</td>
<td>Discharged on statin medication</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Dysphagia screening</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Stroke education</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Smoking cessation counseling</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>10</td>
<td>Assessed for rehabilitation</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
LIMITATIONS OF IV TPA
IV-TPA IN LARGE ARTERY STROKES

Recanalization rates:

✓ ICA-T 12.5% (Jansen et al., AJNR 1995)

✓ Extracranial ICA 9% (Wolpert et al., ajnr 1993)

✓ MCA 39% (Neumann-Haefelin et al., stroke 2004; Wolpert et al., AJNR 1993)
  - MCA M1 40%
  - MCA M2 66%

✓ Vertebrobasilar 40-50% (Lindsberg et al., stroke 2006)
PROGRESS IN STROKE

---Decade of the brain-----
*Time is brain

*Physiology is brain

1990 96 98
IV TPA PROACT-II

2000 03 04
PSC CERTIFICATION
CSC CERTIFICATION

05 06
MERCI RETRIEVER

08
EMERGENCY STROKE SYSTEMS OF CARE

2010 2010
SWIFT-PRIME
MR CLEAN
ESCAPE
REVASCAT
EXTEND-IA

DAWN
<table>
<thead>
<tr>
<th>TRIAL</th>
<th>SITES</th>
<th>VESSEL TARGETS</th>
<th>IMAGING SELECTION</th>
<th>MEDIAN NIHSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR CLEAN</td>
<td>Netherlands</td>
<td>ICA, M1, M1, A1, A2</td>
<td>ASPECTS 9 (IQR 7-10)</td>
<td>17 (IQR 14-21)</td>
</tr>
<tr>
<td>EXTEND-IA</td>
<td>Australia &amp; New Zealand</td>
<td>ICA, M1, M2</td>
<td>CT PERFUSION (RAPID SOFTWARE)</td>
<td>17 (IQR 13-20)</td>
</tr>
<tr>
<td>ESCAPE</td>
<td>Canada</td>
<td>ICA, M1, M2 (TANDEM ALLOWED)</td>
<td>ASPECTS 6-10 CTA ≥50% PIAL FILLING</td>
<td>16 IQR (13-20)</td>
</tr>
<tr>
<td>SWIFT-PRIME</td>
<td>International</td>
<td>ICA, M1 (NO TANDEM)</td>
<td>ASPECTS 9 (IQR 7-10) OR CT PERFUSION (RAPID SOFTWARE)</td>
<td>17 IQR (13-10)</td>
</tr>
<tr>
<td>REVASCAT</td>
<td>Spain</td>
<td>ICA, M1, M2 (TANDEM ALLOWED)</td>
<td>ASPECTS 7 (IQR 6-9)</td>
<td>17 IQR (14-20)</td>
</tr>
</tbody>
</table>
### INTRA-ARTERIAL TREATMENT TRIALS 2015

<table>
<thead>
<tr>
<th>TRIAL</th>
<th>VESSEL TARGETS</th>
<th>STROKE TO GROIN PX</th>
<th>STROKE TO REPERFUSION</th>
<th>TICI 2B-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR CLEAN</td>
<td>ICA, M1, M1, A1, A2</td>
<td>260 IQR (210-313)</td>
<td>NOT REPORTED</td>
<td>58.7%</td>
</tr>
<tr>
<td>EXTEND-IA</td>
<td>ICA, M1, M2</td>
<td>210 IQR(166-251)</td>
<td>248 IQR 204-277</td>
<td>86%</td>
</tr>
<tr>
<td>ESCAPE</td>
<td>ICA, M1, M2 (TANDEM ALLOWED)</td>
<td>185 IQR (118-315)</td>
<td>241 IQR 176-359</td>
<td>72.4%</td>
</tr>
<tr>
<td>SWIFT-PRIME</td>
<td>ICA, M1 (NO TANDEM)</td>
<td>224 IQR (165-275)</td>
<td>252 IQR 190-300*</td>
<td>88%</td>
</tr>
<tr>
<td>REVASCAT</td>
<td>ICA, M1, M2 (TANDEM ALLOWED)</td>
<td>269 IQR (201-340)</td>
<td>355 IQR 269-430</td>
<td>67%</td>
</tr>
</tbody>
</table>

*STROKE TO STENT-TRIEVER DEPLOYMENT*
## INTRA-ARTERIAL TREATMENT TRIALS 2015

<table>
<thead>
<tr>
<th></th>
<th>FUNCTIONAL INDEPENDENCE</th>
<th>SICH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MRS 90D ADJUST COMMON OR</strong></td>
<td>32.6% (VS 19.1% = 13.5%)</td>
<td>7.7% (VS 6.4%)</td>
</tr>
<tr>
<td><strong>MR CLEAN</strong></td>
<td>1.67 (1.21-2.3)</td>
<td></td>
</tr>
<tr>
<td><strong>EXTEND-IA</strong></td>
<td>2.0</td>
<td>0 (VS 6%)</td>
</tr>
<tr>
<td><strong>ESCAPE</strong></td>
<td>3.1 (2.0-4.7)</td>
<td>3.6% (VS 2.7%)</td>
</tr>
<tr>
<td><strong>SWIFT-PRIME</strong></td>
<td>NOT REPORTED</td>
<td>0 (VS 3%)</td>
</tr>
<tr>
<td><strong>REVASCAT</strong></td>
<td>1.7 (1.05-2.8)</td>
<td>1.9-4.9% *(VS 1.9%)</td>
</tr>
<tr>
<td><strong>53% (VS 29.3% = 23.8%)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* SITS-MOST VS ECASS II DEFINITIONS
STROKE OUTCOME IS DEPENDENT ON TIME TO TREATMENT

- EARLY IS BETTER
- Good clinical outcome after ischemic stroke with successful revascularization is time-dependent (Khatri et al., Neurology 2009):
  - Tissue viability $\propto \frac{1}{\text{time}}$

Khatri et al., Neurol 2009
INTERVENTIONAL STROKE TREATMENT
NEW CHALLENGES

- 1000 PSCs, 150-250 CSCs
- Regionalization of interventional stroke care
- Triage is key (either field or local hospital) and time driven
Supplemental Table 1: Comparison of patients who achieve poor outcomes versus good outcomes at 90 days following intra-arterial therapy.

<table>
<thead>
<tr>
<th>Characteristics (Total N = 193)</th>
<th>Poor (mRS 3-6) n=124</th>
<th>Good (mRS 0-2) n=69</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (STD)</td>
<td>69.1 (13.5)</td>
<td>59.8 (14.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male Sex, No. (%)</td>
<td>52 (42%)</td>
<td>42 (61%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Hypertension, No. (%)</td>
<td>98 (79%)</td>
<td>44 (64%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Diabetes, No. (%)</td>
<td>37 (30%)</td>
<td>20 (29%)</td>
<td>0.90</td>
</tr>
<tr>
<td>Atrial Fibrillation, No. (%)</td>
<td>44 (35%)</td>
<td>19 (28%)</td>
<td>0.26</td>
</tr>
<tr>
<td>Laboratory Values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HgbA1c, mean (STD)</td>
<td>6.3 (1.2)</td>
<td>6.2 (1.4)</td>
<td>0.52</td>
</tr>
<tr>
<td>LDL, mean (STD)</td>
<td>87.2</td>
<td>90.6</td>
<td>0.55</td>
</tr>
<tr>
<td>Clinical Assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre-NIHSS, median (IQR)</td>
<td>20 (17-24)</td>
<td>17 (14-21)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IV tPA given, No. (%)</td>
<td>76 (61%)</td>
<td>40 (58%)</td>
<td>0.65</td>
</tr>
<tr>
<td>Radiographic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASPECTS &gt;7, No. (%)*</td>
<td>45 (43%)</td>
<td>54 (86%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reperfusion Success, No. (%)</td>
<td>83 (67%)</td>
<td>62 (90%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Symptomatic Hemorrhage PH1/2, No. (%)</td>
<td>11 (9%)</td>
<td>2 (3%)</td>
<td>0.14</td>
</tr>
<tr>
<td>Time Metrics (in minutes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LKN to GP, median (IQR)</td>
<td>267 (222-352)</td>
<td>263 (176-324)</td>
<td>0.04</td>
</tr>
<tr>
<td>Procedure Time, median (IQR)</td>
<td>70 (51-108)</td>
<td>57 (41-85)</td>
<td>0.07</td>
</tr>
<tr>
<td>Picture to Puncture, median (IQR)</td>
<td>177 (134-255)</td>
<td>153 (90-215)</td>
<td>0.016</td>
</tr>
<tr>
<td>Transfer Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Hospital Transfer, No. (%)</td>
<td>94 (76%)</td>
<td>38 (55%)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

LKN, last known normal; GP, groin puncture; mRS, modified rankin score; PH, parenchymal hematoma; THRIVE, Totaled Health Risks in Vascular Events; *26 patients went directly to IR (no ASPECTS obtained prior to intervention)
Table S5. Binary Logistic Regression Model Identifying Factors Associated With Good Outcome After Endovascular Treatment for Acute Ischemic Stroke (Including LKN>9 hr patients, n=27)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS Score</td>
<td>0.88 (0.83-0.95)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Successful Reperfusion</td>
<td>3.80 (1.57-9.25)</td>
<td>0.003</td>
</tr>
<tr>
<td>Age</td>
<td>0.97 (0.95-0.99)</td>
<td>0.016</td>
</tr>
<tr>
<td>Picture to Puncture &quot;P2P&quot;</td>
<td>0.997 (0.993-0.999)</td>
<td>0.043</td>
</tr>
<tr>
<td>Procedure Time</td>
<td>0.994 (0.986-1.001)</td>
<td>0.096</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.58 (0.28-1.19)</td>
<td>0.136</td>
</tr>
<tr>
<td>Male Gender</td>
<td>1.38 (0.70-2.71)</td>
<td>0.352</td>
</tr>
<tr>
<td>Symptomatic Hemorrhage</td>
<td>0.48 (0.08-2.82)</td>
<td>0.417</td>
</tr>
</tbody>
</table>

CI, confidence interval; OR, odds ratio; LKN, last known normal; Hosmer-Lemeshow test depicts goodness of fit to the model (P>0.05).
TIME METRIC FOR INTRA-ARTERIAL STROKE RX PICTURE-TO-PUNCTURE TIME

**Figure 2.** A, Depiction of good outcome rates at differing time intervals of picture to puncture (P2P). Unadjusted good outcome rates and adjusted odds ratios (ORs) are shown. B, Depiction of favorable Alberta Stroke Program Early CT Score (ASPECTS) at differing time intervals of P2P. Unadjusted favorable ASPECTS percentages and adjusted ORs are shown. CI indicates confidence interval.

INTERVENTIONAL STROKE SYSTEMS OF CARE
NEW CHALLENGES

- TRIAGE OF POTENTIAL LVOs
  - Field Triage (identification of LVO)
    - Field assessment scales
    - Stroke Mobile / Ambulance
  - Local hospital Triage (hub and spoke model)
  - No RCT or head-to-head trial data
Field Triage (identification of LVO)

- NIHSS is standard stroke scale
  - NIHSS $\geq 12$ has PPV of 91% for LVO
- Field assessment scales (for predicting LVO)

<table>
<thead>
<tr>
<th>Stroke Scale</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAMS $\geq 4$</td>
<td>81%</td>
<td>89%</td>
</tr>
<tr>
<td>RACE $\geq 5$</td>
<td>85%</td>
<td>68%</td>
</tr>
<tr>
<td>CPSSS $\geq 2$</td>
<td>83%</td>
<td>40%</td>
</tr>
<tr>
<td>3ISS $\geq 4$</td>
<td>67%</td>
<td>92%</td>
</tr>
</tbody>
</table>

- Stroke Mobile / Ambulance
STROKE INTERVENTION SYSTEMS OF CARE
NEW CHALLENGES

- Pre-Hospital Care
  - Field Triage (identification of LVO)
    - NIHSS is standard stroke scale
    - Field assessment scales (for predicting LVO)
    - Stroke Mobile / Ambulance
STROKE INTERVENTION SYSTEMS OF CARE
NEW CHALLENGES

- Hospital care
  - Hospital readiness and capabilities
    - Competing time demands of iv tpa and endovascular treatments)
  - Parallel workflow process

Mehta et al., J Am Heart Ass. 2014
STROKE INTERVENTION SYSTEMS OF CARE
NEW CHALLENGES

- Hospital care
  - Hospital readiness and capabilities
    - Competing time demands of iv tpa and endovascular treatments)
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Mehta et al., J Am Heart Ass. 2014
STROKE INTERVENTION SYSTEMS OF CARE
NEW CHALLENGES

- Hospital care
  - Hospital readiness and capabilities
    - Competing time demands of iv tpa and endovascular treatments)
  - Parallel workflow process

Mehta et al., J Am Heart Ass.2014
CONCLUSIONS

- COORDINATED STROKE SYSTEMS OF CARE CRUCIAL TO SURVIVAL AND OUTCOME OF STROKE PATIENTS
- CARE PROCESS CONTINUE TO EVOLVE...
  + TIME IS BRAIN (A CONSTANT)
  + FASTER INITIATION OF TREATMENT
  + BETTER ACUTE TRIAGE (FIELD OR ER)
  - SIMPLE MARKER FOR ACUTE STROKE
STROKE STATISTICS

1. NOW THE *FIFTH* LEADING CAUSE OF DEATH IN THE U.S.
   + Better Prevention
   + Better Treatments
   + Better Infrastructure
     + Guidelines for emergency care providers (EMS)
     + Increase in certified stroke centers
     + Brain attack team
     + Organized stroke units
     + Improvement in treatment time (door-to-treatment)
     + Use of GET with the guidelines program
KNOW THE SIGNS
ACT IN TIME!