Emergency Management of the Stroke Patient:
Opportunity for Excellence

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Disclosures

- Speaker's Bureau: Genentech
- Grant Support: NIH/NINDS (STOP-IT)
- Consultant: AHA/ASA ACLS
- Off-Label Discusson:
  - IV tPA > 3 hours
  - IA Therapy

Overview

- Current Treatment Options (IV tPA)
- Role of EMS
- Importance of the ED
  - Example of Excellence (BJH/WUSM)
- Additional Therapies (IA/Endovascular)

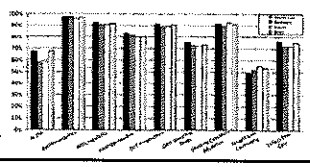
The Importance of Stroke in the United States

- 4th leading cause of adult mortality
- Approximately 800,000 strokes/year
- Almost 1 in 4 strokes are recurrent (25%)
- Highly preventable
- IV rtPA is a major evidence-based treatment for acute ischemic stroke (AIS) – Level IA
- Other new acute therapies are available

Gorelick PB, et al. Dis Mon. 2010;56(2):39-100.

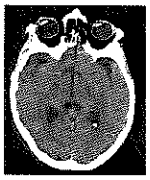
Administration of IV rtPA in the United States

- Overall, only 3%-5% receive IV rtPA
- There is regional geographic variation of administration of IV rtPA in the U.S.
- Get With the Guidelines Stroke 2003-2010
  - Midwest (58.2%)
  - South (58.8%)
  - Northeast (67.8%)
  - West (67.8%)



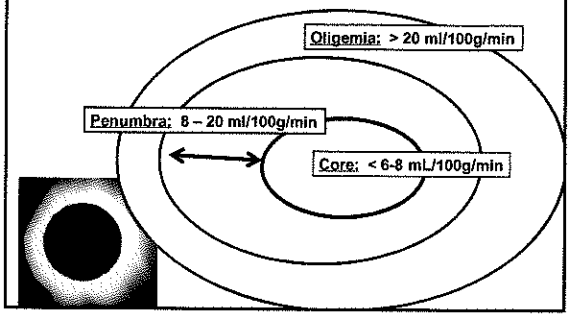
Allen NB, et al. Stroke. 2012;43(7):1858-1864.

Time is Brain



Making the Correct Diagnosis and Evaluating for Thrombolysis

The Penumbra Shrinks as Time from Onset of Ischemia Increases



Importance of Time to Diagnosis, Treatment, and Outcome

- Lost for every hour in ischemic stroke:
  - 120 million neurons
  - 830 billion synapses
  - 447 miles of myelin
- Thrombolysis is time-dependent
  - OR 2.11 (0-90 mins)
  - OR 1.69 (91-180 mins)

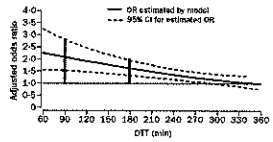


Figure 3: Model estimating odds ratio for favourable outcome at 3 months in rt-PA-treated patients compared with controls by OTT
Adjusted for age, baseline glucose concentration, baseline NIHSS measurement, baseline diastolic blood pressure, previous hypertension, and interaction between age and baseline NIHSS measurement.

Saver JL. *Stroke*. 2006;37:263-266.
Hacke W, et al. *Lancet*. 2004;363:768-774.
NINDS Study Group. *N Engl J Med*. 1995;333:1581-1587.

Importance of Time to Diagnosis, Treatment, and Outcome

- Thrombolysis is time-dependent

Treatment Time (minutes)	Adjusted Odds Ratio for benefit (95% CI)	NNT	NNH	Help-to-Harm Ratio
0 – 90	2.80 (1.74–4.50)	3.6	55	15.3
91 – 180	1.55 (1.12–2.15)	6.3	38	6.0
181 – 270	1.95 (1.05–3.65)	5.9	38	5.9
271 – 360	1.31 (0.90–1.91)	19.1	38	8.7

Hacke et al. *Lancet* 2004; 363:768-74. Lansberg et al. *Stroke* 2009; 40: 2079-84

Saver JL. *Stroke*. 2006;37:263-266.
Hacke W, et al. *Lancet*. 2004;363:768-774.
Lansberg MG, et al. *Stroke*. 2009;40:2079-2084.
NINDS Study Group. *N Engl J Med*. 1995;333:1581-1587.

Goal DNT < 60 minutes

- BAC / PSC Recommendations:
  - DNT < 60 minutes in 80% of patients
- GWTG Data (2003-2009, 25,504 patients) → Only 27% treated within 60 minutes
- Treating within 60 mins was associated with:
  - Lower In-hospital mortality
  - Less frequent sICH
  - More favorable discharge destination

Fonarow GC, et al. *Circulation* 2011;123:750-8. Adams HP Jr., del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, et al. *Circulation*. 2007;115:e478-534. Saver JL. Time is brain-- quantified. *Stroke*. 2006;37:263-266. Alberts MJ, Hademenos G, Latchaw RE, Jagoda A, Marler JR, Mayberg MR, et al. *JAMA*. 2000;283:3102-3109. Summers D, Leonard A, Wentworth D, Saver JL, Simpson J, Spilker JA, et al. *Stroke*. 2009;40:2911-2944.n.

The JAMA Network

From: **Door-to-Needle Times for Tissue Plasminogen Activator Administration and Clinical Outcomes in Acute Ischemic Stroke Before and After a Quality Improvement Initiative**

JAMA. 2014;311(16):1632-1640. doi:10.1001/jama.2014.3203

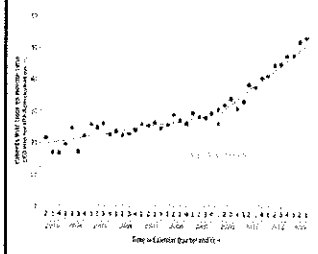


Figure Legend:

Time Trend in the Proportion of Patients with Door-to-Needle Times for Tissue Plasminogen Activator (tPA) of 60 Minutes or Less During the Preintervention and Postintervention Periods of Target: StrokeThe total number of patients included was 71 169 (per-quarter mean of 1695 patients; median, 1705; interquartile range, 583-2703; and range, 65-3450).

The JAMA Network

From: **Door-to-Needle Times for Tissue Plasminogen Activator Administration and Clinical Outcomes in Acute Ischemic Stroke Before and After a Quality Improvement Initiative**

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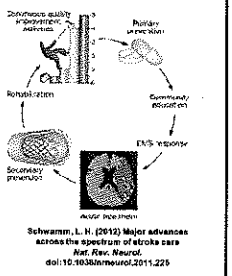
Clinical Outcomes During the Preintervention and Postintervention Periods

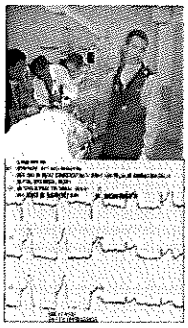
Stroke Systems of Care The Role of EMS

- End of fragmented Care
- Coordination and Cooperation
  - Primary Prevention
  - Community Education
  - **EMS**
  - ED/Hyperacute
  - Secondary Prevention
  - Rehabilitation
  - Continuous Quality Improvement



Schwamm, L. H. (2012) Major advances across the spectrum of stroke care
Nat. Rev. Neurol.
doi:10.1038/nrneurol.2011.225

System Development - Learn from Others



- Protocol development
- Centers of Excellence
- High public awareness
- Rapid access to EMS
- Pre-hospital notification, triage
- Pre-hospital ECG, interventions
- Confirmatory tests
- Strong collaboration with specialists
- Team and protocols in place in ED
- "Door to Drug/Groin - 30 Minutes" or Golden hour of trauma

Pre-Hospital Assessment: Opportunity

- Pre-hospital Assessment Scales
- Pre-hospital Actions
  - Document 'Time last seen normal'
  - Transport to nearest stroke center
  - Check glucose
  - Obtain vital signs including BP
  - Facility pre-notification (Code Stroke)

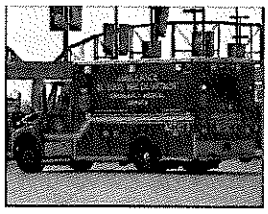
Stroke Chain of Survival

ACLS 2014

- **Detection:** **Early recognition**
- **Dispatch:** **Early EMS activation (911)**
- **Delivery:** **Transport & management**
- **Door:** **ED triage**
- **Data:** **ED evaluation & management**
- **Decision:** **Neurology input, Rx selection**
- **Drug:** **Thrombolytic & future agents**
- **Disposition:** **Rapid admission to stroke unit**

What is EMS?

- More than red lights and loud sirens
- More than fast driving in ambulances
- An integrated system of acute patient care for traumatic and medical conditions



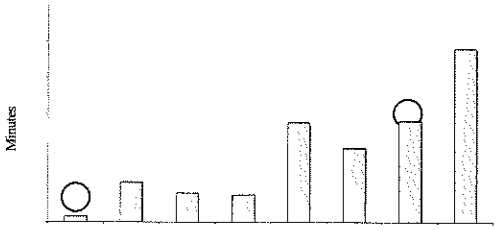
EMS: Soup to Nuts

- Pre-arrival
- On scene patient care
- Transport & transfer of care
- Data transfer

Stroke and the Golden Hour

- Narrow therapeutic time window
  - 15-60% arrive within 3 hrs
  - 14-48% arrive within 2 hours
- Early intervention critical
- Pre-hospital personnel
  - **35-70% of patients arrive by ambulance**
  - Unique position: FIRST medical professional to come in contact
  - **Often 1 hour before stroke team**!

Prehospital & ED Times

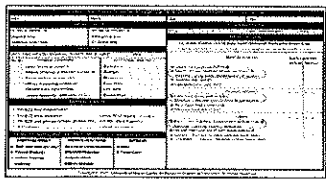


Kothari RU et al. *Stroke.* 1995;26:2238-2241.

Stroke Assessment Tools

Stroke Assessment Tools

- Cincinnati Prehospital Stroke Scale
- Los Angeles Prehospital Stroke Scale
- Miami Emergency Neurologic Deficit (MEND) Prehospital Checklist
- Houston
- Dallas



CPSS-Cincinnati Prehospital Stroke Scale

Facial Droop

Arm Drift

Speech

Widely Utilized
- 10 minutes to train
- < 1 minute to perform

EMS providers
- 59% sensitivity
- 89% specificity

Carotid strokes
- Sensitivity = 95%

Bray JE et al. *Cerebrovasc Dis* 2005;20:28-33.

L A P S S

Los Angeles Prehospital Stroke Screen

- History
  - Age >45
  - History of seizures absent
  - Duration < 24 hours
  - Not bedridden
- Evaluation
  - Blood glucose <60 to >400 mg/dL
  - Facial smile/grimace
  - Grip
  - Arm strength

- Short training video
- Sensitivity = 93%
- Specificity = 97%

Kidwell CS et al. *Stroke.* 2000;31:71-76.

EMS: Vital Link in Stroke Care

- Time Last Known Well
- Transport to Nearest/Highest Level
- Pre-notification

Feedback!

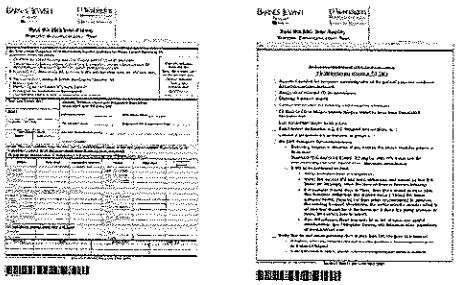
2012-13 BJH Stroke Team

ED-EMS Partnership A HUGE Success!

- 2013 Joint Commission Comprehensive Stroke Center (CSC) 1st CSC in Missouri
- 2013 AHA GWTG Gold Plus Achievement
  - The HIGHEST Level Achievable in US
- 2013 Target Stroke Honor Role (< 10% hospitals)
  - Given to hospitals treating > 50% w/ tPA patients within the 'Golden Hour' of arrival
- Nearly 50 patients treated with IV tPA in BJH ED
  - 63% Increase from 2010
  - > 100 Patients transferred into BJH ENS
- Median Door-to-Needle Time
  - ~ 35 minutes
- 87 % patients treated with IV tPA within the "Golden Hour" of 60 minutes
  - *BJH ED stroke treatment among the fastest of any ED in the US!*

Close the Loop

Inter-hospital Transport Form



Stroke Systems of Care
The Role of the ED

- End of fragmented Care
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  - EMS
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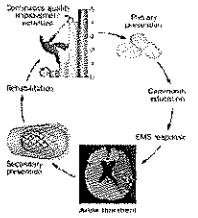
  - Rehabilitation
  - Continuous Quality Improvement



Schwamm, L. H. (2012) Major advances across the spectrum of stroke care *Nat. Rev. Neurol.* doi:10.1038/nrneurol.2011.225

Evaluation and Management of Acute Ischemic Stroke

Jauch E et al. American Heart Association/American Stroke Association Guidelines for Management of AIS
Stroke. 2013:44:870-947

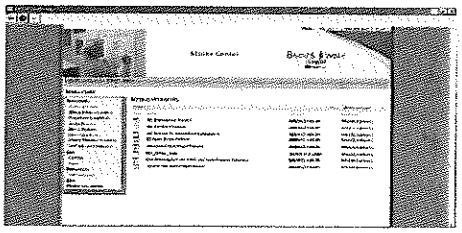
Emergency Evaluation and Diagnosis of Acute Ischemic Stroke (AIS)

Acute Stroke Protocols

Establish an organized protocol such that acute fibrinolytic therapy can be administered within 60 minutes of the patient's arrival at the hospital (Class I, LOE B)

Jauch EC, et al. *Stroke.* 2013;44(3):870-947

Protocols Available and Current



Emergency Evaluation and Diagnosis of AIS

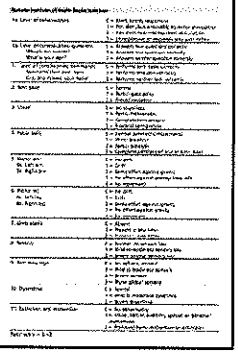
Standardized Rating Scale

Use a stroke rating scale to measure neurologic deficit (preferably the National Institutes of Health Stroke Scale [NIHSS]) (Class I, LOE B)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Emergency Evaluation and Diagnosis of AIS

1. Online NIHSS training/certification
   - Organized manner of performing exam
2. Common pitfalls:
   - Ataxia: must be *out-of-proportion* to weakness in order to score points
   - Visual fields: if you do not test it, you may not be aware of a visual field cut
   - Neglect: if you do not test it, you may not know it exists (most common in R hemisphere strokes)
3. Allows you to communicate with other providers and track symptom deficit (particularly important for Drip-n-Ship patients)
4. Scored 0-42, 11 Items



Emergency Evaluation and Diagnosis of AIS

Immediate diagnostic studies

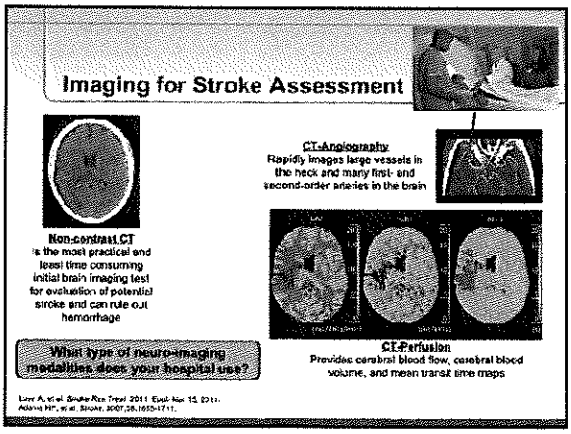
ECG, Glucose, O2 sat, Chem 7, CBC, Troponin, PT, INR, aPTT (Class I, LOE B); only blood glucose must precede IV rtPA administration, unless there is suspicion of a bleeding abnormality or coagulation abnormality (e.g, use of warfarin)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Emergency Evaluation and Diagnosis of AIS

4. Early Brain & Vascular Imaging: NC CT (usually sufficient) or brain MRI (Class I, LOE A)
   - **Brain imaging should be interpreted within 45 minutes of arrival to hospital (Class I, LOE C)**
   - Other than the presence of frank hypodensity, fibrinolytic therapy is recommended if there are early ischemic changes (Class I, LOE A); if hypodensity involves >1/3 of the middle cerebral artery territory, IV rtPA should be withheld (Class III, LOE A)
   - **If intra-arterial fibrinolysis or mechanical thrombectomy is contemplated, a non-invasive intracranial vascular study is recommended (Class I, LOE A)**
   - CT perfusion or MRI diffusion and perfusion may be considered to assist in patient selection (Class IIb, LOE B)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947



Management of Acute Ischemic Stroke (AIS) with IV Thrombolysis

1. What the Emergency Physician Needs to Know?
2. What are the Latest Data?

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

1. IV rtPA at a dose of 0.9 mg/kg, maximum dose 90 mg
   - Within 3 hours of AIS onset (Class I, LOE A)
1. Door to needle time for IV rtPA administration should be:
   - Within 60 minutes of arrival to hospital (Class I, LOE A)
2. IV rtPA is indicated at a dose of 0.9 mg/kg with the time window of **3.0 to 4.5 hours** of AIS **as long as there is no evidence of age >80 years, current use of oral anticoagulants, NIHSS >25, history of both diabetes mellitus and stroke, and ischemic injury >1/3 of the middle cerebral artery territory** (Class I, LOE B)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

BP Management for tPA Eligible Patients

IV rtPA administration is reasonable if blood pressure can be lowered safely to below 185/110 mm Hg (Class I, LOE B)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

Blood Pressure Management Strategies

- Treat Systolic BP > 185 or Diastolic BP > 110
- For mildly elevated BP (SBP 185-200) start
  - Labetalol 10-20 mg IV over 1 min, wait 5-10 min, repeat x 1-2
  - Low heart rate < 70, may substitute hydralazine 10-20 mg IV
- For moderately or severely elevated BP (SBP>200)
  - Nicardipine infusion, 5 mg/h, titrate up by 2.5 mg/h at 5-min intervals, maximum dose 15 mg/h;
- If BP remains >185/110 mm Hg, do not administer IV rtPA
- Monitor BP every 15 min
- Observe for hypotension (BP lowering > 25% initial BP)
- If neurologic worsening or hypotension occurs, consider IVF bolus, discontinuing nicardipine infusion, and/or reversing antihypertensive effects

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

Have a Plan in Advance to Address Complications

Be prepared to treat adverse effects of rtPA, such as bleeding or angioedema (Class I, LOE B)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

Seizure-Not an Absolute Exclusion

IV rtPA administration is reasonable when there is seizure at the onset of stroke as long as residual neurologic impairments are caused by stroke and not by a postictal phenomenon (Class IIa, LOE C)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

Mild Strokes or Rapidly Improving Stroke

IV rtPA may be administered in those with mild stroke deficits or rapidly improving ones, major surgery in the preceding 3 months, or recent myocardial infarction if the potential increase in risk is thoughtfully weighed against anticipated benefits (Class IIb, LOE C)

Jauch EC, et al. *Stroke*. 2013;44(3):870-947.

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

Rapidly Improving Stroke Symptoms (RISS)

- Listed as an exclusion in NINDS with intent to "*avoid unnecessary treatment of TIA*"

There has been no actual accepted definition but it is one of the most common reasons for excluding thrombolytic therapy

Consider if you would have treated the patient had they arrived with the current symptoms

Table 4. Task Force Consensus: Definition and Clinical Context of RISS as an Exclusion Criterion for IV tPA

Improvement to a mild stroke such that any remaining deficits seem nondisabling

The following typically should be considered disabling deficits:

- Complete hemianopsia (≥2 on the NIHSS question 3), or
- Severe aphasia (≥2 on NIHSS question 9), or
- Visual or sensory extinction (≥1 on NIHSS question 11), or
- Any weakness limiting sustained effort against gravity (≥2 on NIHSS question 5 or 6), or
- Any deficits that results in total NIHSS ≥5, or
- Any remaining deficit considered potentially disabling in the view of the patient and the treating practitioner; clinical judgment is required.

All neurological deficits present at the time of the treatment decision should be considered in the context of individual "net post benefit," as well as the patient's baseline functional status. IV tPA indicates intravenous tissue-type plasminogen activator; NIHSS, National Institutes of Health Stroke Scale; and RISS, rapidly improving stroke symptoms.

Levine SR, et al. *Stroke*. 2013;44:2600-2585.

Guidance about IV Thrombolysis in AIS from the AHA/ASA 2013

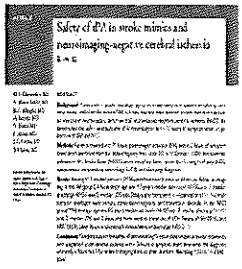
Novel Anticoagulants (NOAC)

IV rtPA may be harmful in the presence of direct oral thrombin or factor Xa inhibitors and is not recommended unless sensitive tests to measure the presence of the latter agents can be obtained or the patient has not received a dose of the latter agents for >2 days in those with normal renal function (Class III, LOE C)

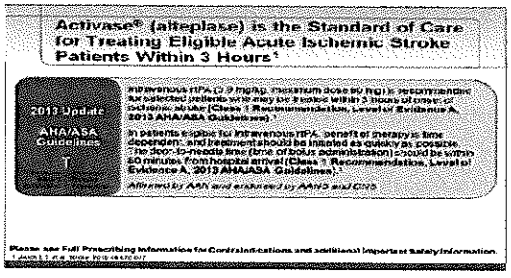
Jauch EC, et al. *Stroke*. 2013;44(3):870-947.

Stroke Mimics

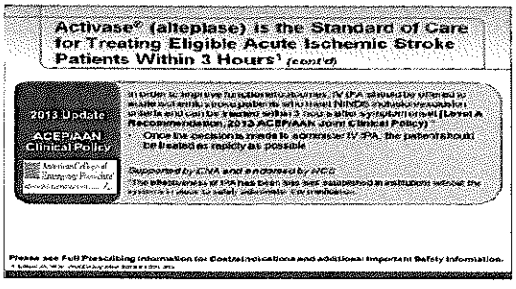
Alcohol Intoxication	Cerebral Infections
Drug Overdose	Epidural/Subdural Hematoma
Hypoglycemia	Seizure or Post-seizure
Neuropathies (e.g. Bell's Palsy)	Tumors
Metabolic Disorders	Migraine-Complicated
Conversion Disorder	Hypertensive Encephalopathy


Safety of tPA in stroke mimics and neuroimaging-negative cerebral ischemia

2013 AHA/ASA Guidelines for AIS Management



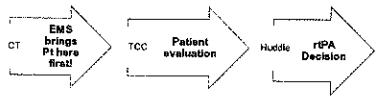
2013 ACEP/AAN Statement



Statement Under Fire: Open for Public Comment- Under re-consideration (www.acep.org)

Emergency Evaluation and Diagnosis of AIS

1. EMS involvement
   1. Depending on transportation distance, EMS may have first contact with patient almost an hour before MD contact
   2. **Pre-notification** by EMS allows for ED preperations in advance
2. Protocol-driven treatment
   1. **LEAN process improvement** experience at Barnes-Jewish Hospital
   2. EMS straight to HCT with pre-notification
   3. Reduced median door-to-needle times to 38 minutes (34% in less than 30 min)



Ford AL, et al. *Stroke*. 2012;43:3385-3388.

Accelerating Door-To-Needle Times
What we Can Learn from Toyota

- The importance of saving time in stroke
- What is Lean Manufacturing?
- Applying lean to the acute stroke protocol at Barnes-Jewish Hospital
- Lean manufacturing applied across the spectrum of stroke care

The Assembly Line (1910's-20's)

CHRYSLER

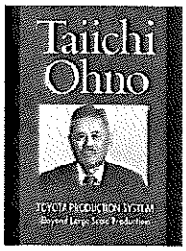
Ford

GM

Lean Manufacturing and Toyota Production System (After WWII)

- Taiichi Ohno aimed to *eliminate waste (muda)* in automobile production, leaving only the crucial steps that *add value (jidoka)* to the end product and customer

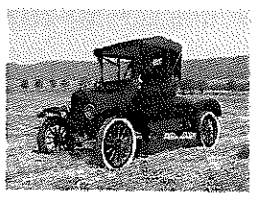
TOYOTA



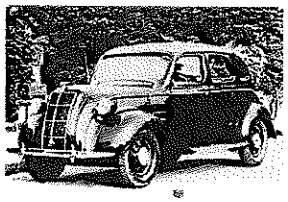
Ohno T. *The Toyota production system: Beyond large-scale production*. Portland, OR: Productivity Press; 1988.

Ford's *Assembly Line (1920s)* to Toyota Production Systems *Lean Manufacturing (1950s)*

Ford Model T



TOYOTA PRIUS

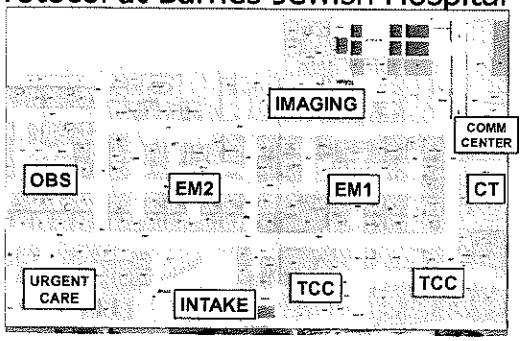


Lean Manufacturing and Toyota Production System

- Manufacturing sector x 50 years, lean principles were applied to health care
  - Shorter ED wait times [1]
  - Improved procurement of endovascular stents in radiology departments [2]
- Barnes-Jewish Hospital (BJH) has invested in Lean Thinking to Improve Numerous Processes

[1] Ng et al. Applying the lean principles of the Toyota production system to reduce wait times in the emergency department. *CJEM*. 2010;12:50-7. [2] Teichgraber et al. Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents. *Eur J of Radiology*. 2012;81:e47-52.

Applying Lean to the Acute Stroke Protocol at Barnes-Jewish Hospital



Barnes-Jewish Hospital Acute Stroke Protocol Prior to VSA

- In 2002, initiated Resident-Based Stroke Protocol
  - Empowered neurology residents as final-decision makers for tPA
  - Residents achieved faster DNTs 60 min compared to Attendings 81 min
  - No increase in sICH
- Monthly meeting to review each tPA case individually, providing direct feedback to residents and staff

Ford et al. Resident-Based Protocol is Expeditious and Safe. *Stroke*. 2009. 40(4):1412-4.

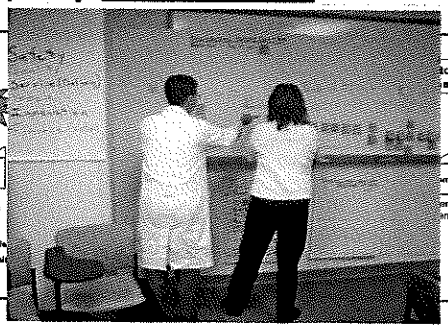
Value Stream Analysis (VSA)

- Four Step Process
  1. Current State Analysis
  2. Ideal / Future State Analysis
  3. Action Plan
  4. Feedback Loop
- Continue to Assess for "Fat" within the protocol, re-apply tools to make process "Leaner"

Value Stream Mapping (VSM) of the Acute Stroke Protocol at BJH

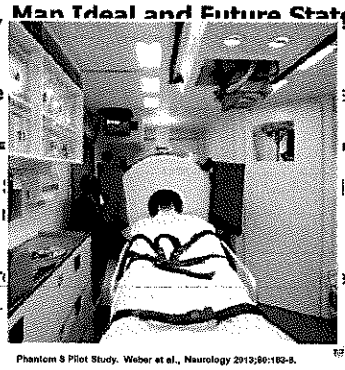
- Over two full days, a multidisciplinary team including *front-line individuals* met:
  - Lean performance engineer
  - ED and neurology physicians
  - ED nurses
  - Patient care and radiology technicians
  - ED pharmacist

Value Stream Mapping (VSM) First, Map Current State



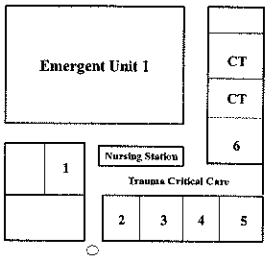
Value Stream Mapping (VSM) Second, Map Ideal and Future States

- Curre… …e board
- Ideal … resou…
- Futur… …eal-world.

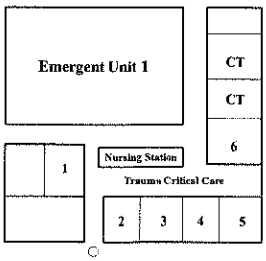


Phantom S Pilot Study. Weber et al., Neurology 2013;80:182-8.

Problem #1: Inefficient Choreography



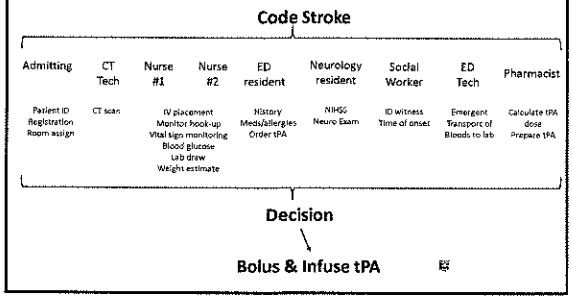
Solution #1: Streamlined Choreography



Problem #2: Overwhelming number of tasks to complete in 60 min

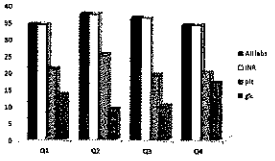
- Admitting
  - Patient identification
- Registration
  - Room assign
- EMS
  - **Delivers patient to room**
  - Reports to nursing
- Nursing
  - **IV placement**
  - **Monitor hook-up**
  - **Vital sign monitoring**
  - **Blood glucose**
  - **Lab draw**
  - **Weight estimate of patient**
- Clinical Assessment
  - History
  - Medications/allergies
  - Identification of witness
  - Time of onset/last normal
  - **Witnesses difficult to locate**
- Clinical Assessment (cont.)
  - **NIHSS**
  - **Neurological Exam**
- Labs
  - **PT/PTT, CBC, Creatinine**
  - Emergent transport of bloods to lab
- Imaging
  - **Disconnect from monitor**
  - **Transport patient to CT**
  - **CT scan**
  - **Transport from CT to room**
  - **Reconnect to monitoring**
- Drug Preparation
  - Order tPA
  - Calculate tPA dose
  - Prepare tPA
- Bolus and infuse tPA

Solution #2: Maximize Personnel Resources, Assign Pre-defined Roles, Parallel Processing



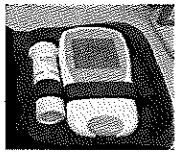
Problem #3: Labs take too long

- At times, labs are needed for tPA
  - Platelets
  - INR (PT/PTT)
  - Blood glucose
- On average, in 2010, it took **33** min to get results after ordering labs

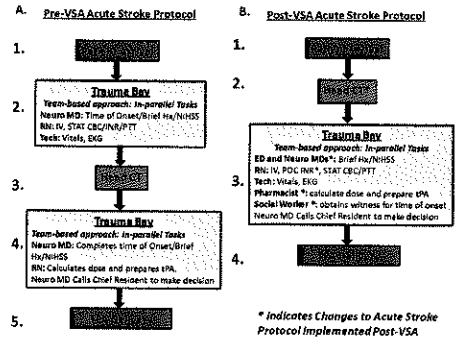


Solution #3: Point of care (POC) Labs

- Identified INR as rate-limiting lab in a subset of patients
- Initiated POC for INR
- Glucose already POC



Current and Future State



Door-to-Needle Times: Before and After VSA

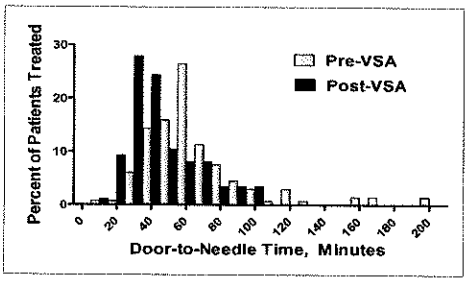
	Pre-VSA 1/1/09-2/28/11 N=132	Post-VSA 3/1/11-3/1/12 N=87	P-value *
Door-to-Needle Time, min*	60 [46, 73]	39 [27, 56]	< 0.0001
Onset-to-Needle Time, min*	131 [105, 155]	111 [72, 158]	0.016
Onset-to-Arrival Time, min	62 [43, 93]	67 [37, 96]	0.71
% Patients with DTN < 60 minutes	52%	78%	<0.0001
Door-to- Head CT Time, min*	16 [10, 22]	1 [0, 4]	<0.0001
Door-to-CBC (non-POC), min	22 [10,29]	24 [16,33]	0.13
Door-to-PTT (non-POC), min	34 [29,42]	40 [31,47]	0.14

* Wilcoxon Rank Sum Test was used for continuous data and Fisher's Exact Test was used for binary outcomes; p<0.05 for significance.
¶ For continuous data, results are presented as Median [25th quartile, 75th quartile]

* After adjustment for imbalanced baseline characteristics, the post-VSA epoch continued to demonstrate significantly lower DNTs, (F=32.4, p<0.0001).

Ford et al. Reducing Door-to-Needle Times Using Toyota's Lean Manufacturing Principles and Value Stream Analysis. *Stroke*. 2012.

Reduced Outlying DNTs After Streamlined Protocol



Ford et al. Reducing Door-to-Needle Times Using Toyota's Lean Manufacturing Principles and Value Stream Analysis. *Stroke*. 2012.

Safety and Clinical Outcomes: Before and After VSA

	Pre-VSA 1/1/09-2/28/11 N=132	Post-VSA 3/1/11-3/1/12 N=87	P-value *
Favorable Discharge Location *	76%	83%	0.24
Symptomatic ICH **	3.0%	3.4%	1.0
Stroke Mimic ***	6.8%	11.5%	0.33
90 day mRS 0-2	49%	43%	0.34
Length of Hospital Stay, days	4 [3,7]	3 [2,6]	0.056

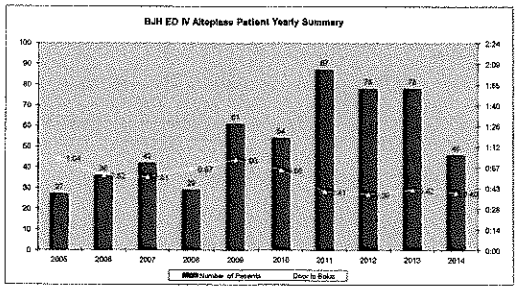
* Wilcoxon Rank Sum Test was used for continuous data and Fisher's Exact Test was used for binary outcomes; p<0.05 required for significance.
* Favorable discharge location was defined as discharge to home or inpatient rehabilitation (compared to the remainder of patients who had unfavorable discharge location defined as discharge to nursing home or in-hospital death)
** Symptomatic ICH was defined as any worsening in neurological status within 36 hrs of onset associated with hemorrhage on head CT.
*** Stroke mimic was defined as a discharge diagnosis other than stroke.

Ford et al. Reducing Door-to-Needle Times Using Toyota's Lean Manufacturing Principles and Value Stream Analysis. *Stroke*. 2012.

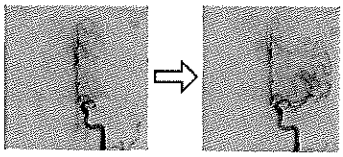
Next Steps for the BJH-Washington University Acute Stroke Protocol

- Maintain our current protocol and short treatment times via our "Feedback Loop"
- Perform mini-VSA's or Kaizen (RIE) to continue to find and eliminate waste to reduce DNTs
- Ongoing PI plans:
  - Pre-Hospital Period – EMS Cards to Family
  - Advanced Imaging
  - IV tPA in CT scan suite

Our Experience of Time Sustained



Endovascular Therapy



- Is IV tPA Effective?
- Recent Endovascular Trials
- What is the Future?

The Recanalization Rates of IV r-tPA

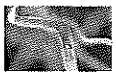
- 10% for ICA occlusion
- 30%-40% for MCA occlusion (IMS III)
- 30% for basilar artery occlusion

Recent Endovascular Trials

"No Better Than IV tPA"

1. IMS III: *Broderick JP et al. NEJM 2013;368:893-903*
2. SYNTHESIS: *Ciccone A et al. NEJM 2013;368:2433-2434*
3. MR-RESCUE: *Kidwell CS et al. NEJM 2013;368:914-923*
4. SWIFT PRIME

Endovascular Therapies



- In modest-sized clinical trials in AIS, clot retriever devices (Solitaire FR, Trevo) have been shown to be more efficacious for recanalization and reperfusion and safer than an early generation mechanical clot removal device (MERCI), but the new clot retrieval devices have not been shown to definitively improve clinical outcomes as of yet.
- These newer devices are favored over the 1st generation ones, should they be used in AIS.
- Lack of efficacy with early generation clot retrieval devices has led to a call for enrollment of AIS patients in clinical trials to determine best management of AIS patients in relation to IV rtPA and endovascular therapies.

Jauch EC, et al. Stroke. 2013;44(3):870-947
Gorelick PB. Lancet. 2012;380(9849):1208-1210.

Summary

- Time is Brain-Really
  - The Evidence for Treatment is Clear
- Stroke Care is Emergent Care
- Coordination is Everything
  - EMS, ED are **KEY** Partners
- Quality Improvement Occurs in Steps
  - Sustainment is the Challenge
- Endovascular Care is Evolving

Any Questions?