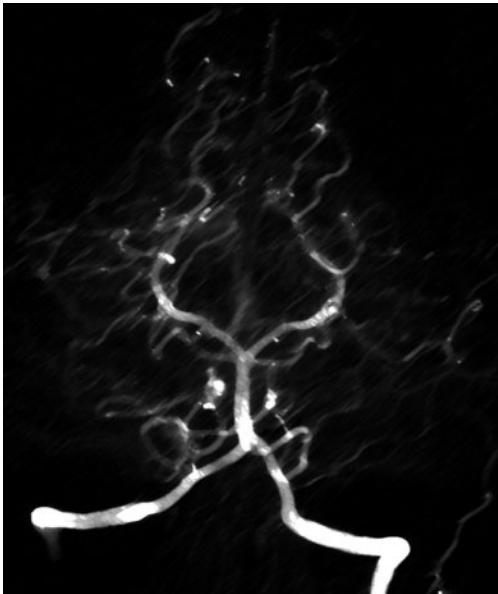
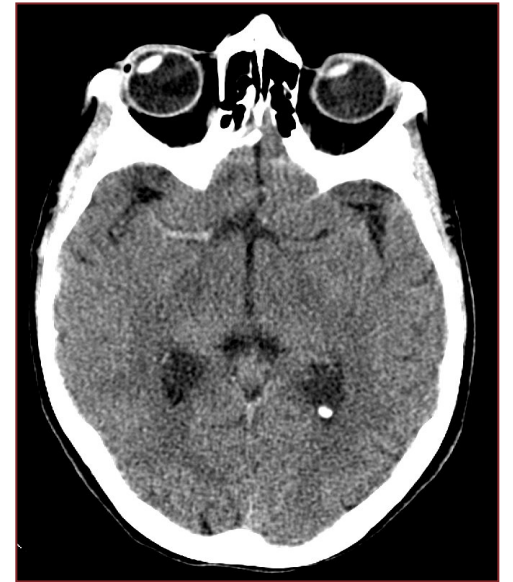


# Endovascular Revolution: Growing Role of EMS in Stroke Care



**Peter Panagos, MD, FACEP, FAHA**  
Professor of Emergency Medicine and Neurology  
Washington University School of Medicine  
St Louis, Missouri



# Disclosures

- **Employment:** Washington University (Clinical Salary)
- **Administrative:** Barnes-Jewish Hospital (Stroke Director)
- **Advisory Board:** American Stroke Association (Volunteer)
- **Research:** NIH/NINDS (PI, StrokeNet)

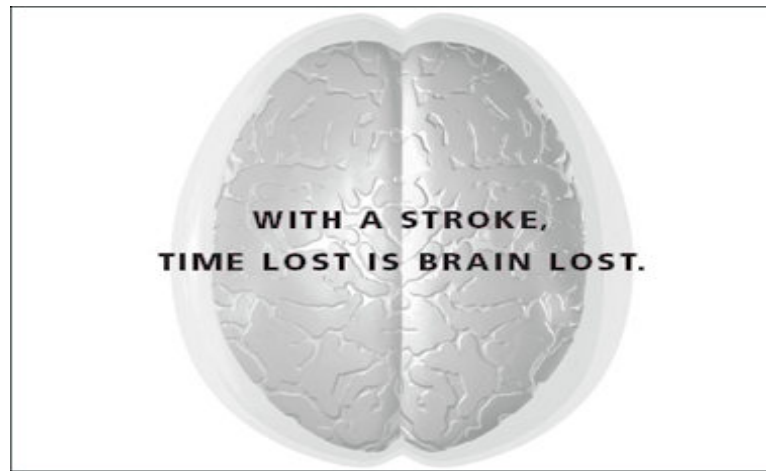
# Objectives

- Overview Stroke Epidemiology
- Pre-hospital Care: **Important**
- Brief History of Stroke Treatment Evolution
  - IV thrombolysis
  - Mechanical Thrombectomy
  - Advanced Imaging
- Discussion of Treatment for Acute Ischemic Stroke
- Recognize the Importance of EMS in Stroke Care

# Where I Practice



# Stroke Epidemiology





# Stroke Statistics: US and Worldwide

- **United States**

- Every 40 seconds someone has a stroke
- Ranked 5<sup>th</sup> in cause of death
- Each year there are 795,000 new or recurrent stroke (610,000 first attack)
- Leading cause of serious long-term disability
- 87% of all stroke are ischemic

- **World**

- Accounts for 11.8% of total deaths worldwide (6.2 million lives each year)
- 15 million new or recurrent stroke each year
- 2<sup>nd</sup> leading cause of death behind heart disease
- 80 million people have had a stroke, 50 million survivors with disability
- Leading cause of disability

World Stroke Association (2018)  
American Heart Association (2018)

# Predicted changes in Europe over next 20 years

The number of stroke survivors in the EU will rise from 3,718,785 in 2015 to 4,631,050 in 2035, an increase of almost one million or 25%.

The largest increase will be in Luxembourg (72%) and the largest absolute number increase in the UK (193,861).

3,718,785



4,631,050

**There will be a 45% increase in the number of stroke deaths from 532,321 in 2015 to 770,038 in 2035.**

This ranges from a 10% increase in Lithuania to 101% increase in Malta, with Germany having the largest absolute increase of 29,243.

**45%**  
**more deaths**

**Overall there will be a 32% increase in DALYs lost from 2015 to 2035 (609,721 to 861,878).**

The largest percentage increase is expected in Malta (63%) with almost no change in Lithuania (1%). The UK will have the largest absolute increase of DALYs from 609,721 in 2015 to 861,878 in 2035.

**32%**  
**more**  
**DALYs lost**

1.1m people have stroke in Europe each year  
3<sup>rd</sup> commonest cause of death

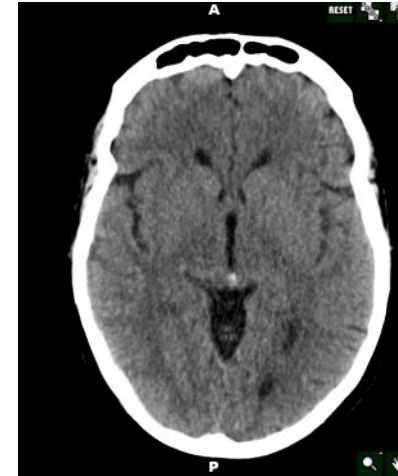


*The Burden of Stroke in Europe 2017*

# Historical Stroke Care

**(Prior to 2015)**

- 63 y/o male with "stroke symptoms"
- Found in garden
- LKW maybe 8 hours ago?
- CPSS ++ (face/arm/speech)
- FSBS 106, BP 156/87
- Brought to a Primary Stroke Center
- Stroke Team activated
- **Outside any treatment window (4.5 hrs)**
- No intervention offered
- Discharged to a Rehabilitation Hospital
- Never Able to Return to Work



**ED CT Scan**



**MRI at 36 Hours**



# Prehospital Stroke Care (EMS)



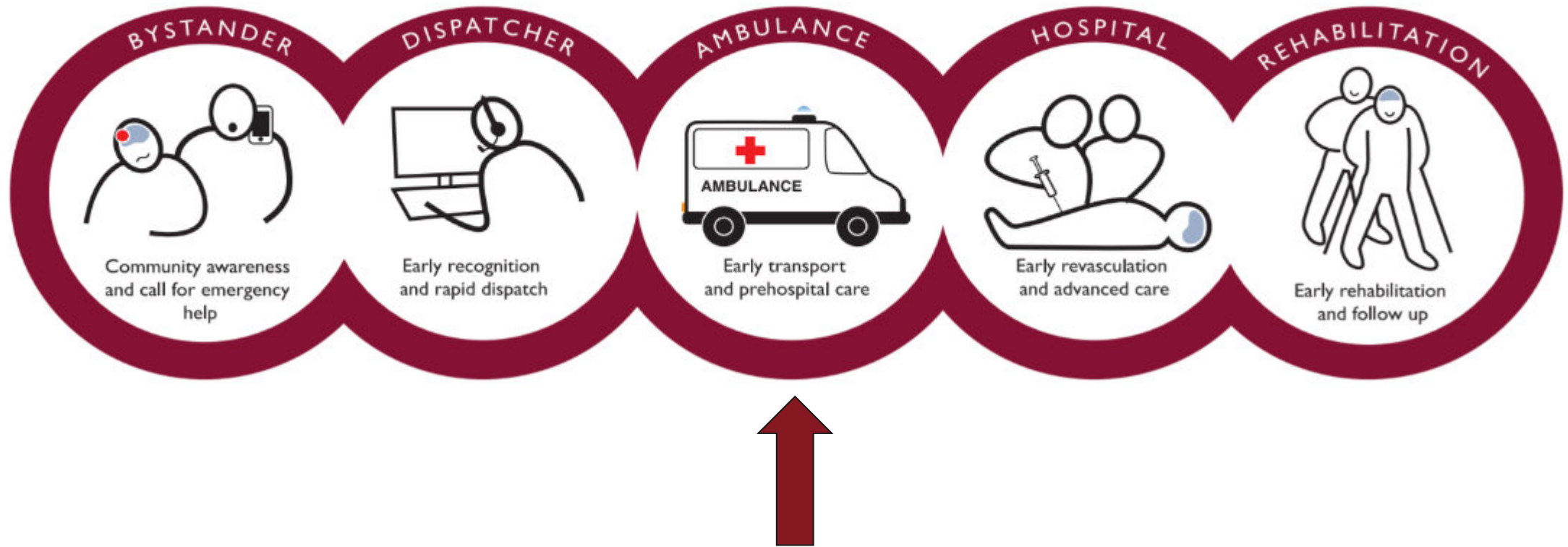
# Stroke Chain of Survival



## ACLS 2018

- **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

# Utstein Guidelines on Stroke Emergency Care Chain of Survival



# Prehospital care

## Current evidence – **DRIVE FAST, DON'T WASTE TIME**

- FAST (or equivalent) screening but if in doubt treat as stroke
- Exclude hypoglycaemia & treat if low
- Measure blood pressure
- Oxygenation (only if  $<94\%$ )
- NPO (Nothing by mouth)
- Pre-hospital alert
- Take to nearest/closest stroke center based upon regional plan



# 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.

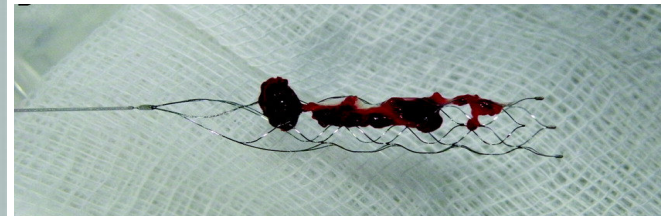
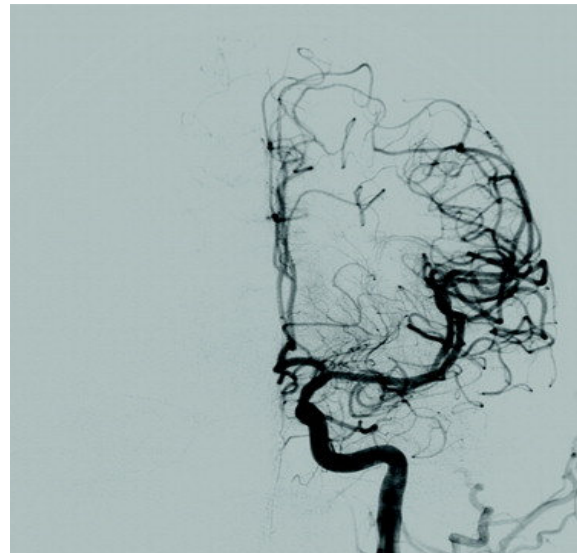
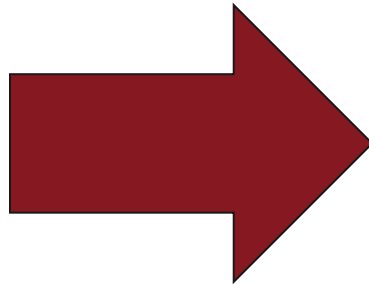


# Stroke mimics: Challenge for ED and EMS

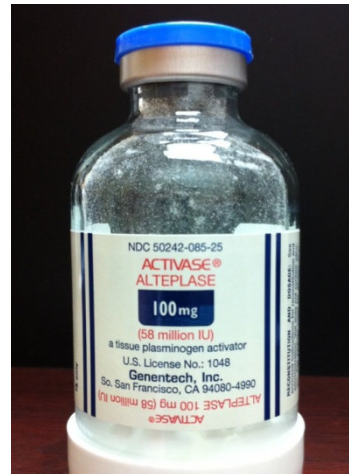
- Nearly 1 in 3 presumed strokes are mimics
- Stroke symptoms that make the diagnosis difficult for EMS and ED:
  - Posterior circulation stroke –Dizziness
  - Isolated visual abnormalities-hemianopsia
  - Isolated aphasia or dysarthria
  - Altered mental status “Found Down”

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

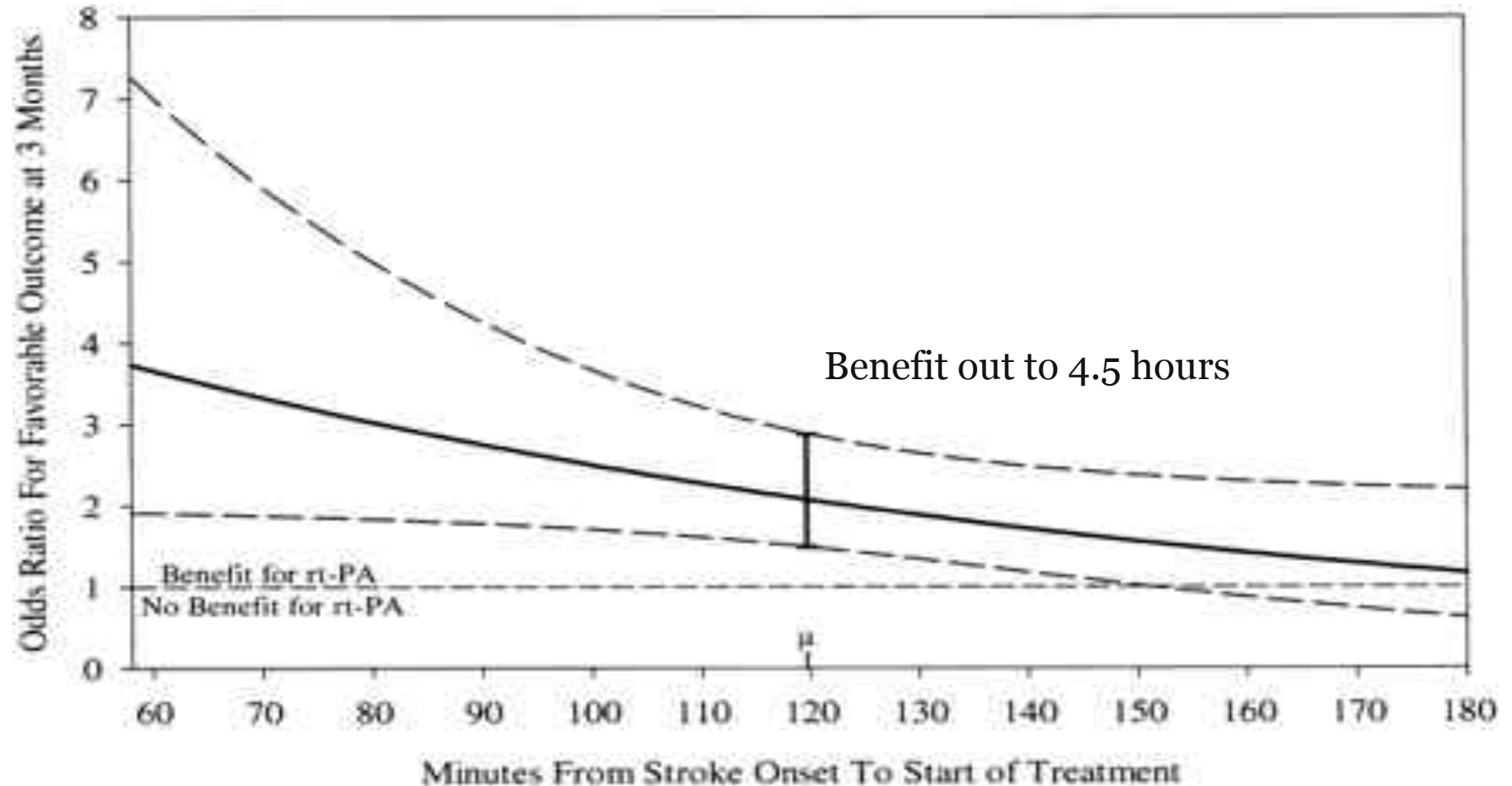
# Treatment Options 1996-Today






# Intravenous Thrombolysis 1996 (20 years)




# Time is brain: impact of IV thrombolysis



# How to communicate the risks and benefits

Onset-to-Treatment time	Number Needed to Treat to yield one additional patient with minimal disability (mRS 0-1)
0-90 mins	
91-180 mins	
181-270 mins	



**Overall, Number Needed to Treat (NNT) = 8 for IV Thrombolysis**



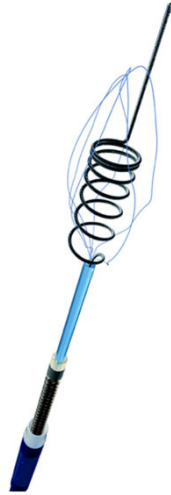
# Mechanical Thrombectomy

## 2015-Today

## Extending the Treatment Window (TIME)



# Endovascular Trends



IA  
thrombolysis

Merci snare

Early  
aspiration  
catheters

Stent-  
retrievers

Modern  
aspiration  
catheters

1998

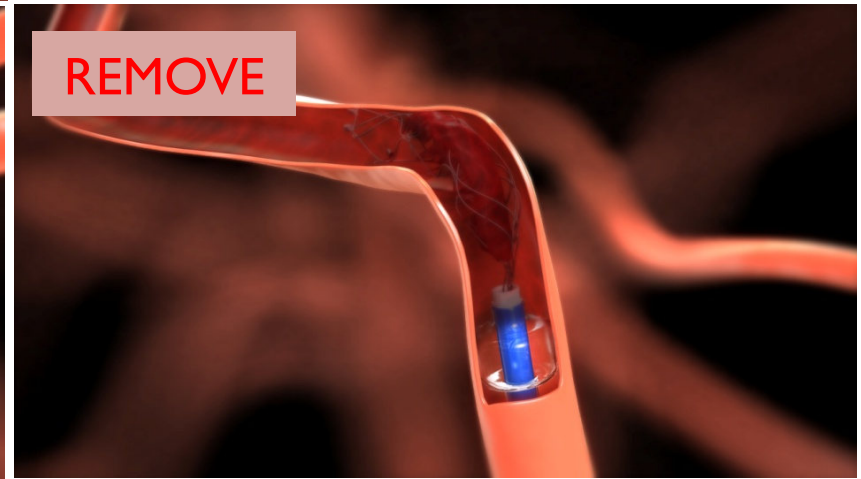
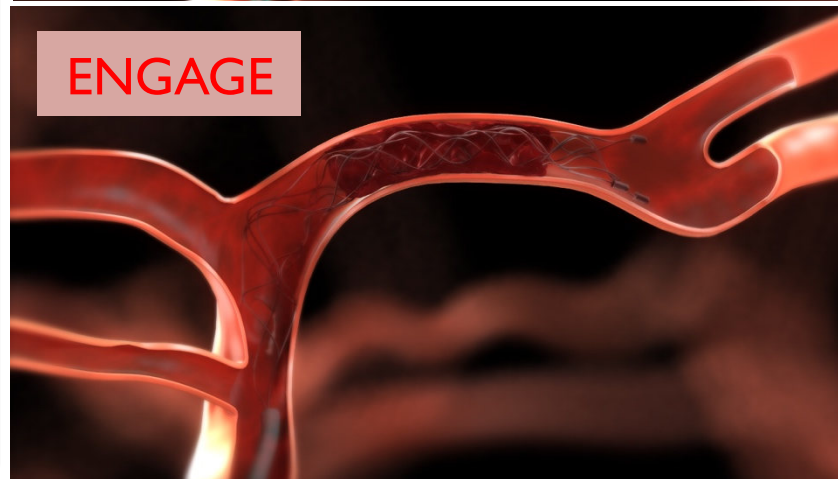
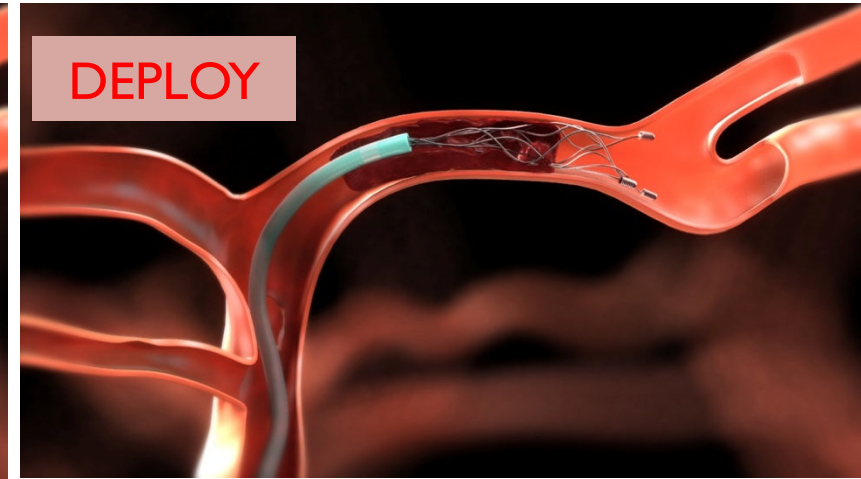
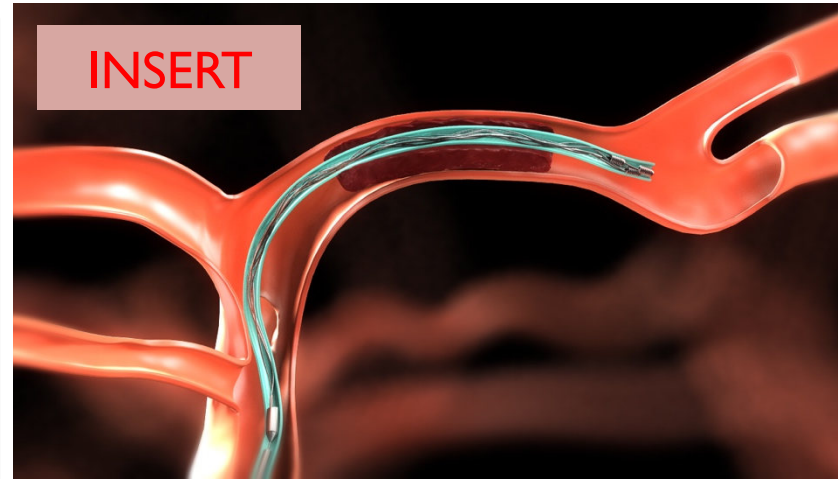
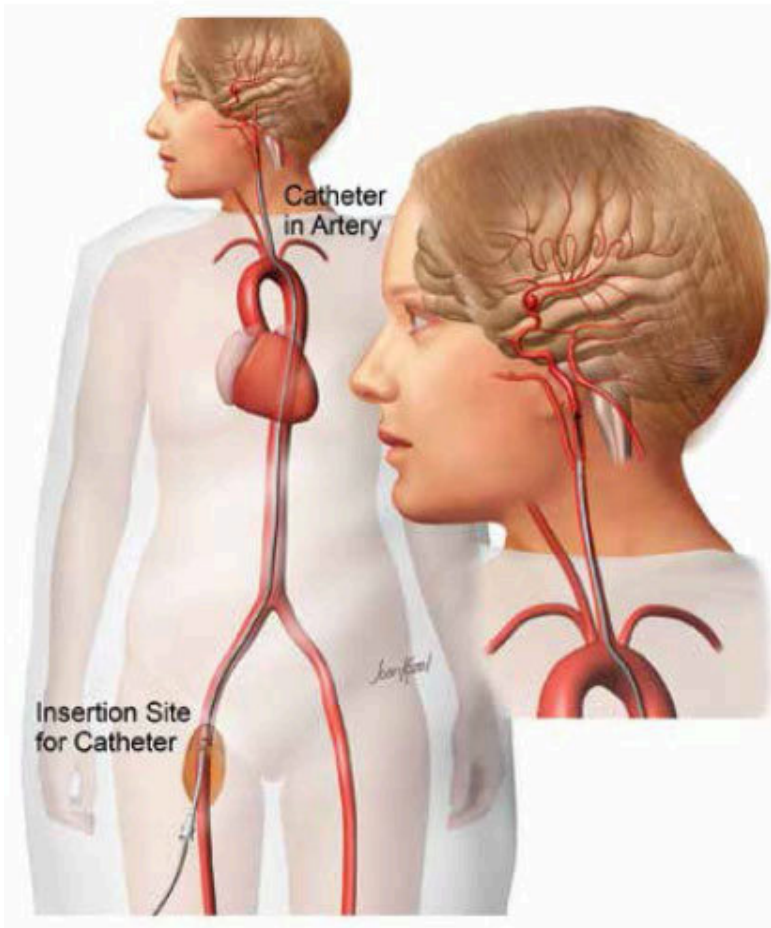
2004

2007

2009

2012

# Thrombectomy





**Evidence-based  
Review**

## HERMES collaboration<sup>1</sup>

### Thrombectomy (0-6 hours)

Outcome	Intervention (n=634)	Control (n=653)	<i>p</i>
90-day mRS 0-2	46.0%	26.5%	<0.0001
Mortality	4.4%	4.3%	0.81
sICH	15.3%	18.9%	0.16

NNT to achieve 90-day mRS 0-2 is **5.1**.

NNT to reduce 90-day mRS by 1 level is **2.6**.

<sup>1</sup>Goyal, et al. Lancet 2016;387:1723-31.

## Evidence-based Review

### Thrombectomy (6-24 hours)

### DAWN trial<sup>1</sup>

Outcome	Intervention (n=107)	Control (n=99)	<i>p</i>
90-day mRS 0-2	48.6%	13.1%	<0.0001
Mortality	13.0%	18.0%	<0.01
sICH	4.8%	3.2%	0.3

NNT to achieve 90-day mRS 0-2 is **2.8**.

NNT to reduce 90-day mRS by 1 level is **2.0**.

<sup>1</sup>Nogueira, et al. N Engl J Med 2018;378:11-21.



# Stroke Severity (Selection) Scales

## Detection of Large Vessel Occlusion (LVO)

- **RACE\*** Rapid Arterial Occlusion Evaluation scale
- **MPSS** Maria Prehospital Stroke Scale Score
- **LAMS** LA Motor Scale score
- **PASS** Prehospital Acute Stroke Severity score
- **3-ISS** 3-item Stroke Scale
- **C-STAT** Cincinnati Stroke Triage Assessment Tool
- **NIHSS** NIH Stroke Scale
- **VAN** Vision, Aphasia, Neglect
- **FAST-ED** Field Assessment Stroke Triage for Emergency Destination

\* Only published to evaluate in prehospital setting

# Severity and Time to Determine Triage Location?

- **LAMS (LA motor scale)**

- Predictive LVAO 4-5 = 100% LVO
- LAMS  $\geq 4$  was 7x positive likelihood LVO and
- 0.81 sensitivity, 0.89 specificity, 0.85 accuracy

Table. The Los Angeles Motor Scale (LAMS)

Facial droop	
Absent	0
Present	1
Arm drift	
Absent	0
Drifts down	1
Falls rapidly	2
Grip strength	
Normal	0
Weak grip	1
No grip	2

Nazliel B, Starkman S, Liebskind DS et al. Stroke 2008;39:2264-2267  
Kwok H et al. ISC 2013 (Poster)  
Allen E et al. ISC 2013 (Poster)

# Severity and Time to Determine Triage Location?

- **RACE Scale**
  - **R**apid **A**rterial **O**clusion **E**valuation
  - Based off NIHSS
  - Prospectively validated in field (357 cases)
  - Scale-Face/Arm/Leg/Gaze/Speech/Agnosia
    - Correlation with NIHSS ( $r=0.76$ ;  $P<0.001$ )
    - LVO 76 of 357 cases (21%)
    - ROC RACE vs. NIHSS (0.82 and 0.85 respectively)
    - RACE  $\geq 5$  sens 85%, spec 68%, PPV 0.42, NNP 0.94

**Perez de la Ossa N et al. *Stroke* 2014;45:87-91**

# Other Stroke Severity Scales

**Table 6** Vision, Aphasia, Neglect (VAN) screening tool<sup>68</sup>

Item	Responses
Motor arm	
Raise both arms	Mild—minor drift Moderate—severe drift Severe—flaccid or no antigravity No weakness—VAN negative
Vision	
Assessment of visual fields, vision, diplopia	Field cut Double vision New blindness None
Aphasia	
Repeat and name two objects	Expressive Receptive
Open and close eyes and fist	Mixed None
Neglect	
Gaze preference, tactile or spatial neglect	Forced gaze or inability to track to one side Unable to feel both sides at the same time or unable to identify own arm Ignores one side None

VAN+, motor involvement plus any VAN.

VAN+, 100% sensitivity, 90% specificity, 0.0 negative likelihood ratio for large vessel occlusion.

**Table 2** The 3-Item Stroke Scale (3I-SS)<sup>60</sup>

Item	Points
Consciousness disturbance	
None	0
Mild	1
Severe	2
Gaze and head deviation	
Absent	0
Incomplete	1
Complete	2
Hemiparesis	
Absent	0
Moderate	1
Severe	2
Total score	0–6

3I-SS  $\geq 4$ : 67% sensitivity, 92% specificity, 0.36 negative likelihood ratio for large vessel occlusion.

**Table 5** Cincinnati Prehospital Stroke Severity Scale (CPSSS)<sup>62</sup>

Item	Points
Gaze	
Conjugate gaze deviation ( $\geq 1$ NIHSS gaze)	2
Consciousness/commands	
Incorrectly answers one LOC question and one command on NIHSS (age, current month, close eyes, open and close hand) ( $\geq 1$ on NIHSS)	1
Motor arm	
Cannot hold arm up (left, right or both) for 10 s before it falls to bed ( $\geq 2$ on NIHSS)	1
Total score	0–4

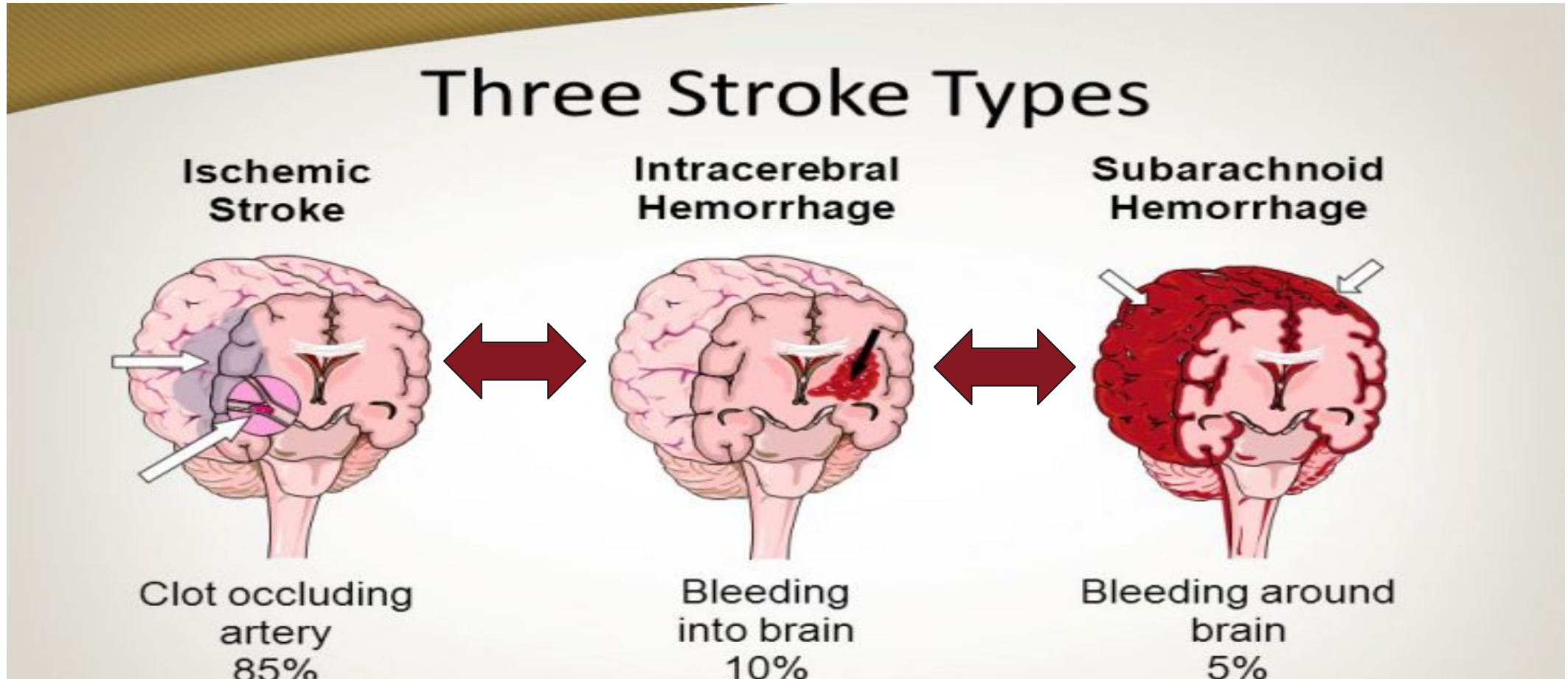
CPSSS  $\geq 2$ : 83% sensitivity, 40% specificity, 0.4 negative likelihood ratio for large vessel occlusion.

CPSSS  $\geq 2$ : 92% sensitivity, 51% specificity, 0.15 negative likelihood ratio for NIHSS score  $\geq 15$ .

LOC, level of consciousness; NIHSS, National Institutes of Health Stroke Scale.

**Singer OC et al. Stroke 2005;36:773-6; Katz BS et al. Stroke 2015;46:1508-12; Teleb MS et al. J Neurointerv Surg. 2016;0:1-5**

# Pre-hospital Stroke is Undifferentiated

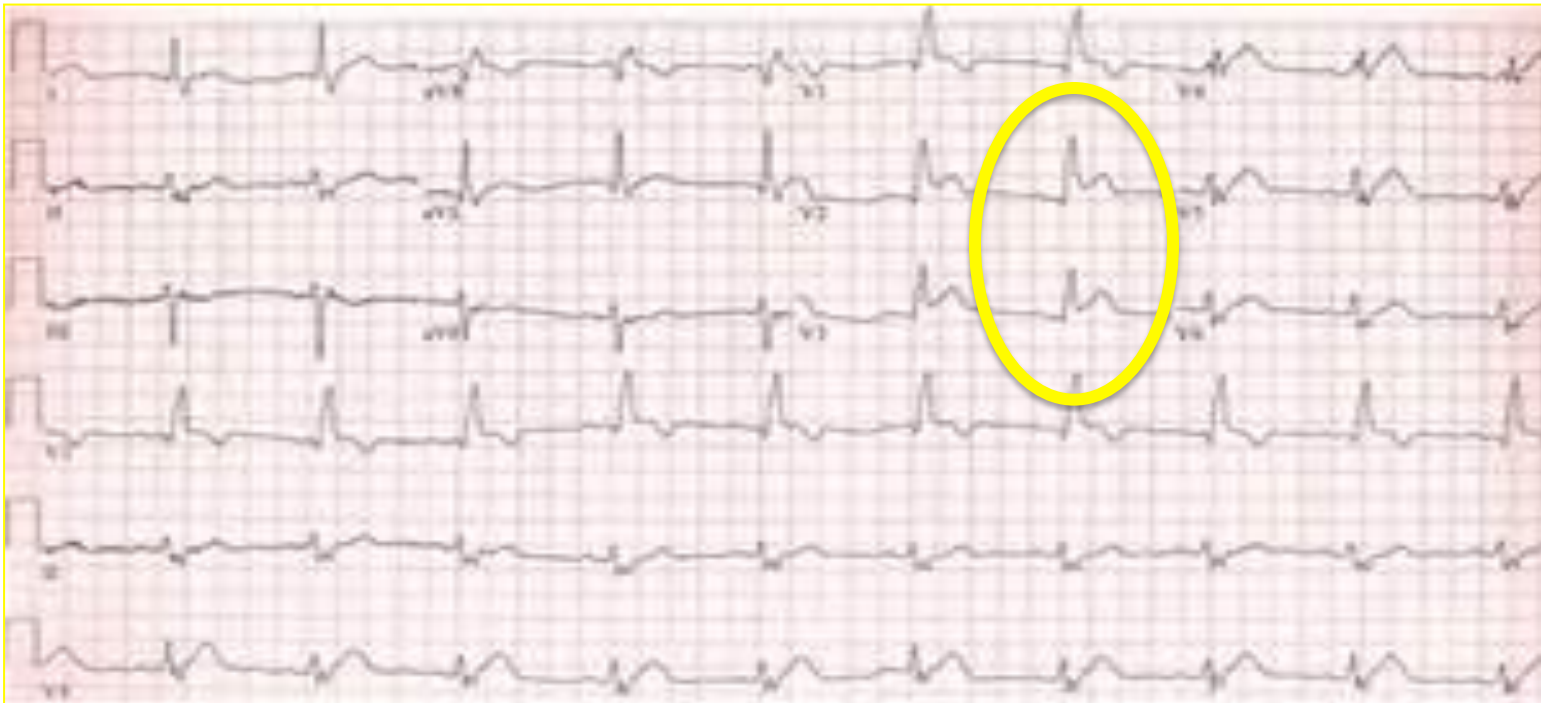




# **Imaging Selection Stroke Biomarker 2015-Today**

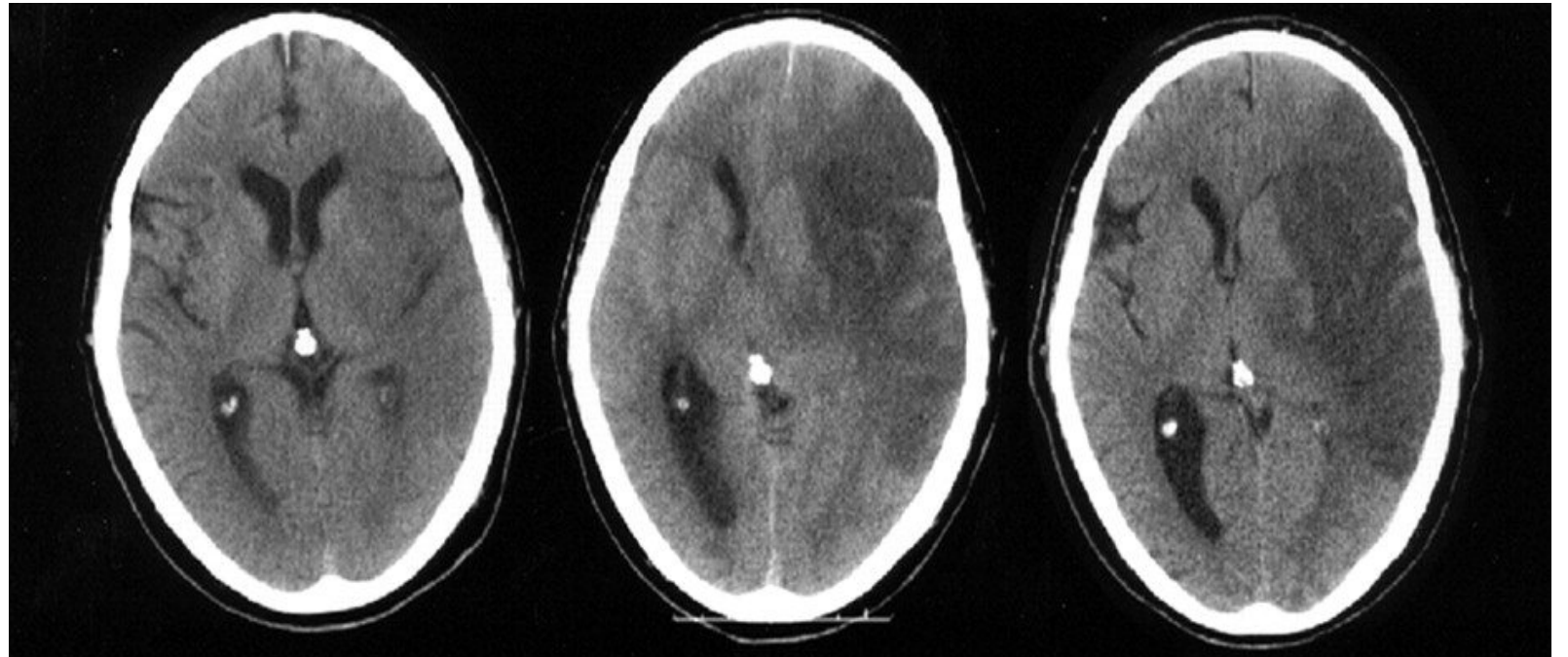
## **Destination Counts**

# Biomarkers: Other Diseases



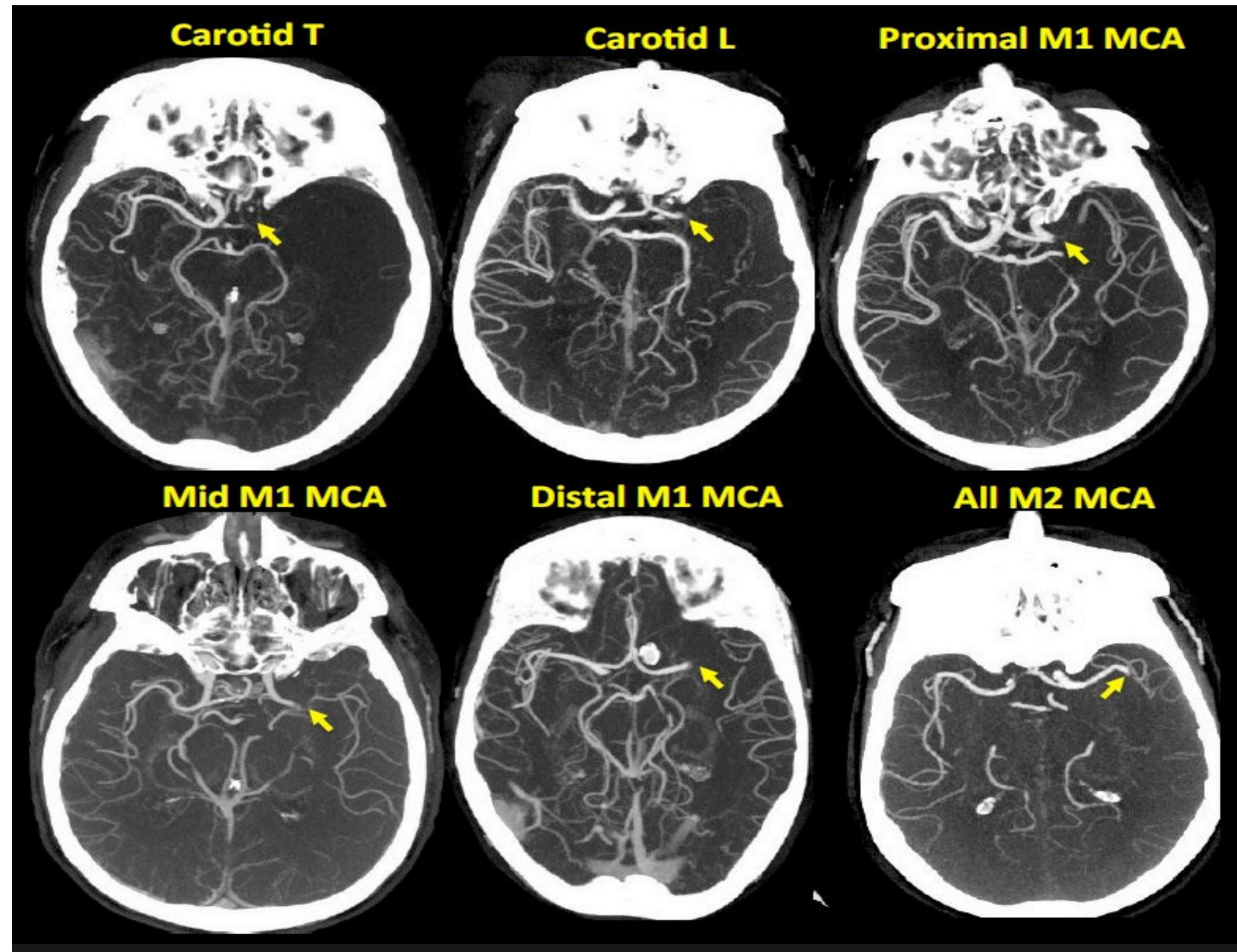
# Imaging assessment

**Non-contrast head CT**



# Imaging assessment

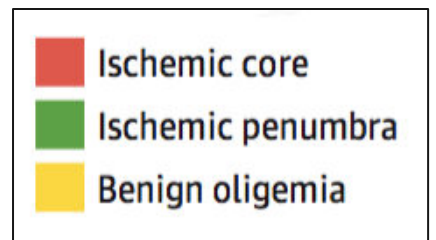
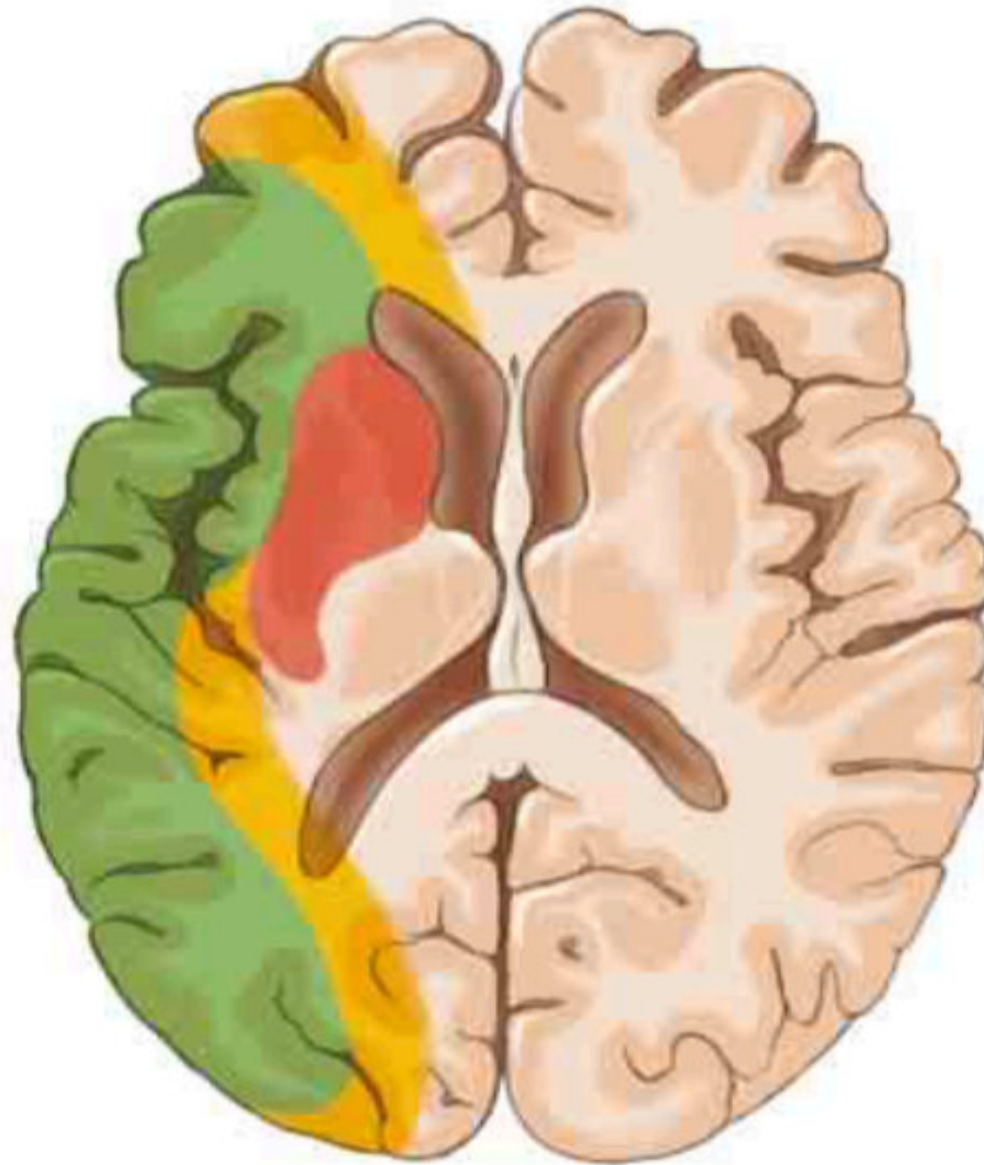
Head/neck CT  
angiography  
(With Contrast)





# Imaging assessment

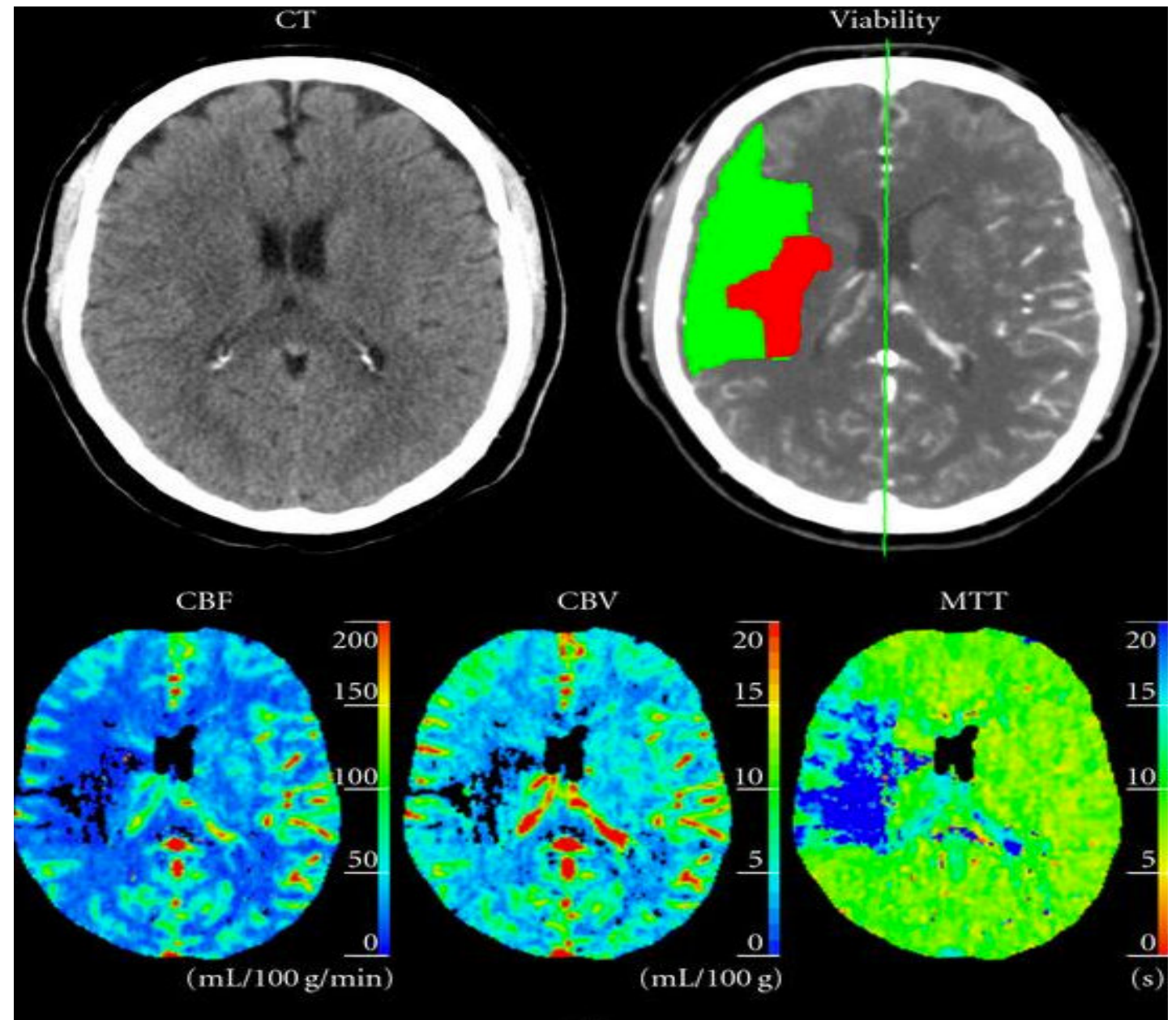
## Head CT perfusion





# Imaging assessment

## Head CT perfusion

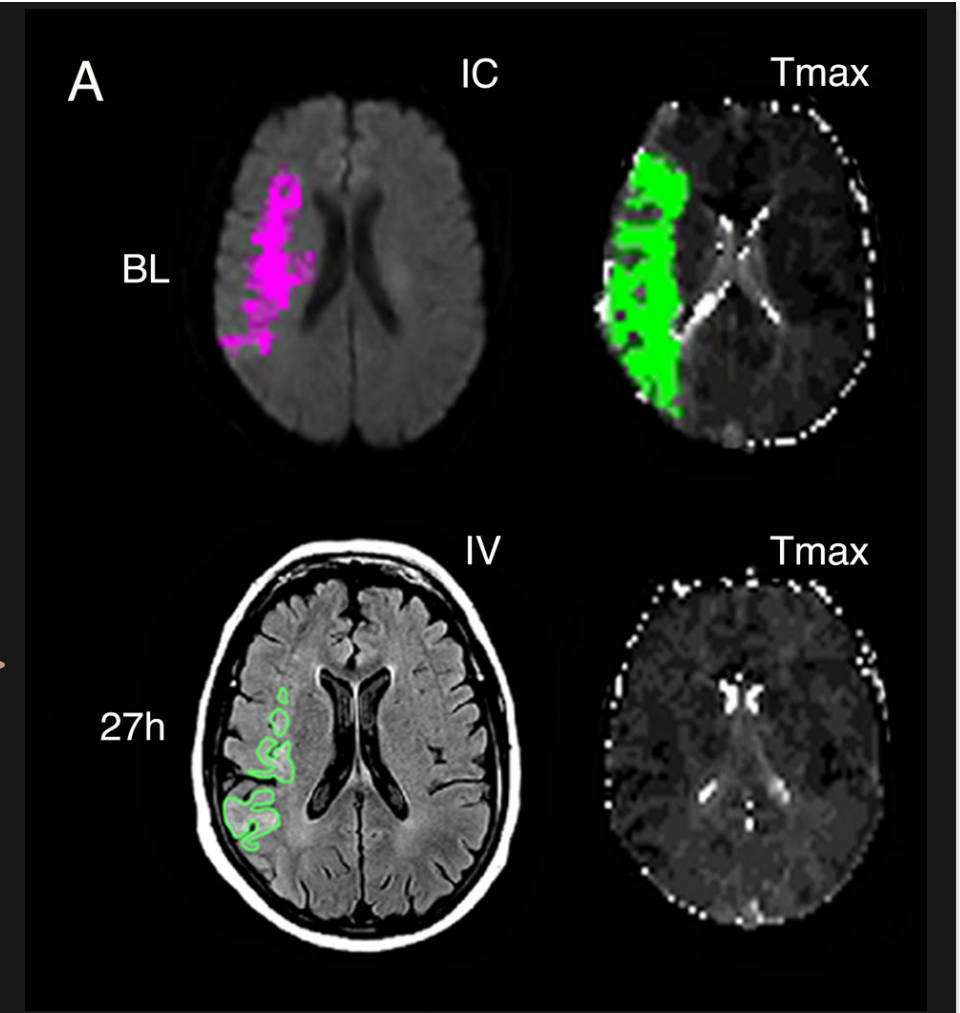


# RAPID infarct prediction

RAPID estimation of ischemic core and ischemic penumbra.

- **Ischemic core** predicted by critical flow reduction ( $\text{CBF} < 30\%$ ); infarction regardless of reperfusion.
- **Ischemic penumbra** predicted by slow flow ( $\text{Tmax} > 6$  seconds); infarction only without reperfusion.

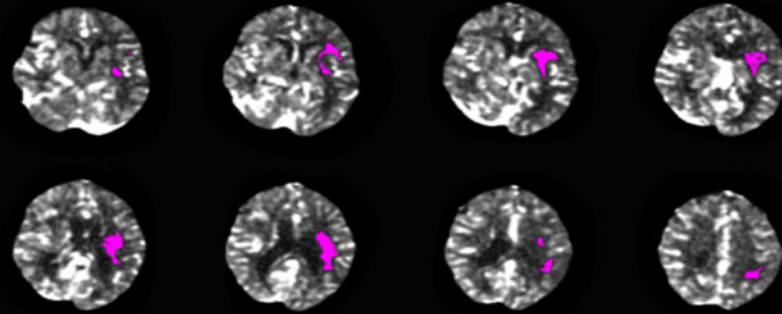
Albers GW, et al. Annals of Neurology, 2015



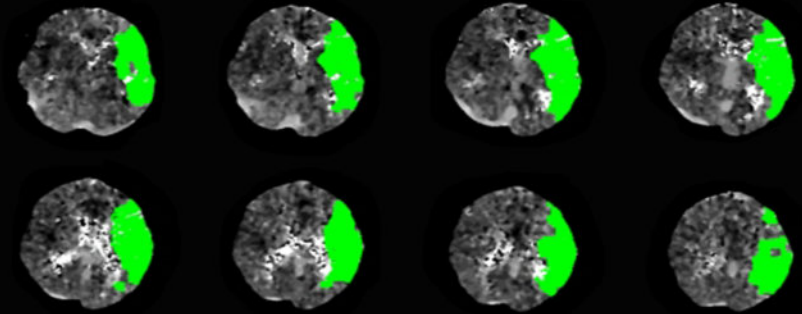
# Example

Small core with complete reperfusion

Baseline  
CTP

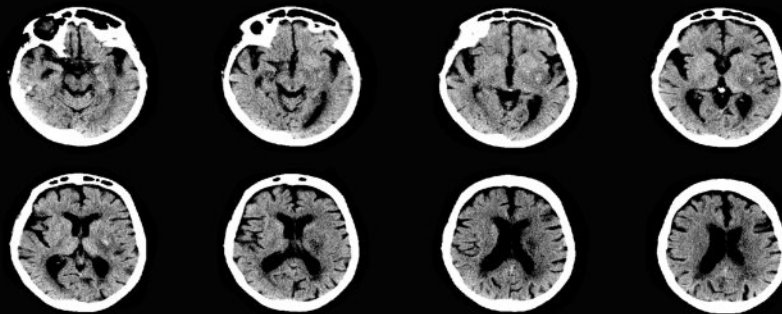


CBF (0.3 threshold) 11 ml

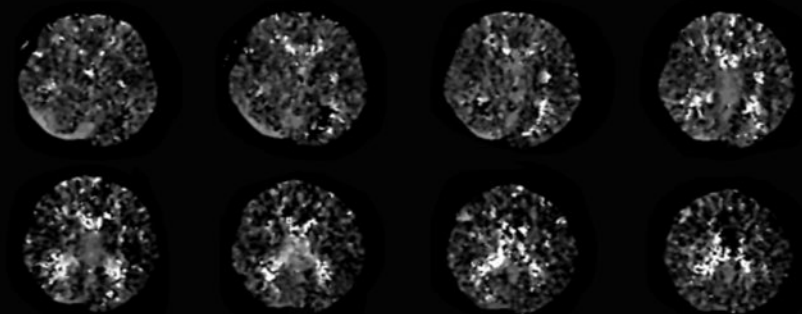


Hypoperfusion (Tmax>6s) 151 ml

24 h Follow Up  
CT/CTP



Infarct Volume 12 ml



100% Reperfusion



# Vital Role Stroke Center Care

## EMS Delivery to the Right Place

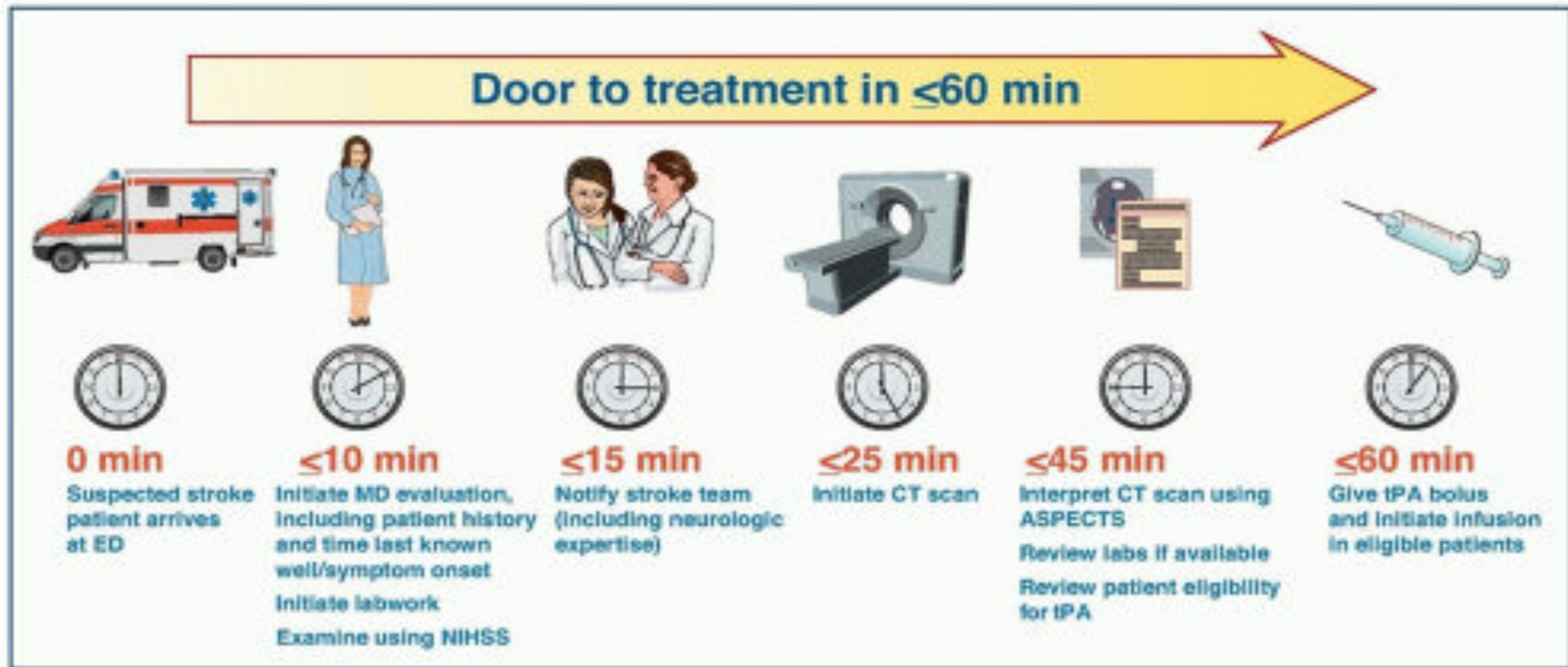


Anytime  
Day or Night



Barnes-Jewish Hospital/Washington University, St Louis, MO, USA

# HISTORICAL ED STROKE (FAST) CARE





# The Essentials of Stroke Centre Care




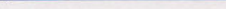
24/7/365

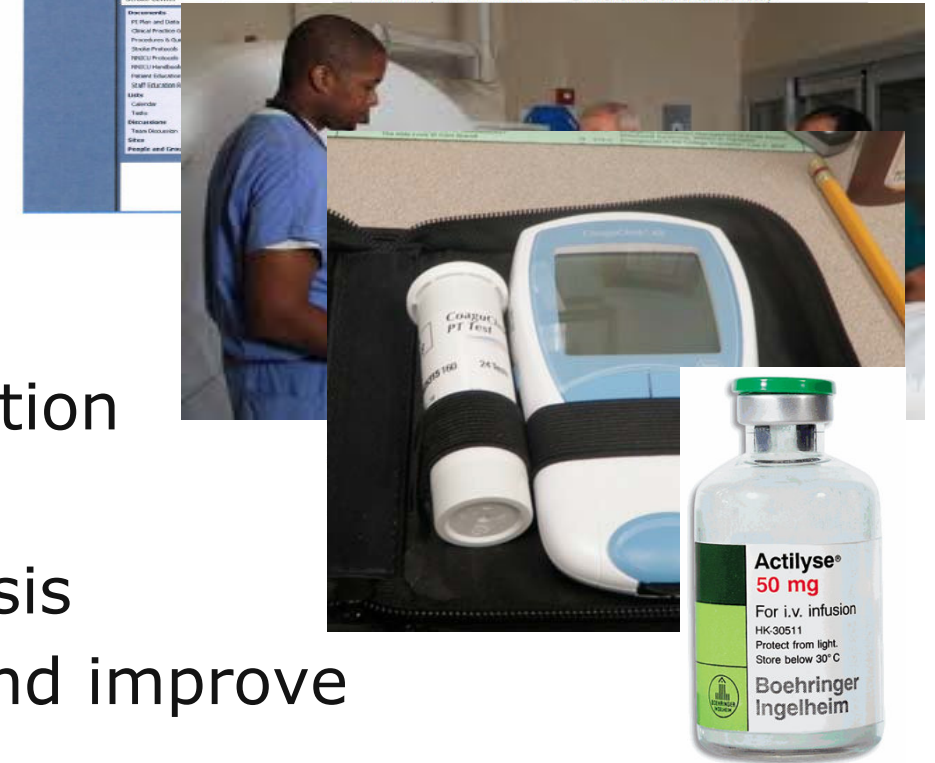
- **Specialists**– neurologists, stroke physicians, interventional neuroradiologists, neurosurgeons, nurses
- Stroke Care **Available 24** hours a day **seven days a week**, without exception
- **Advanced imaging** – CT, MRI, Angiography
- **Higher volume** – Shown to lead to Improved Outcomes
- **Culture of Quality and Transparency**



# ED Management: Simple but Effective

- Evidenced-Based Stroke Protocols
- Use inclusion/exclusion checklist
- Neurology available quickly
- Use standard rating scale (NIHSS)
- Point of Care Testing (BG, EKG, INR)
- Imaging available 24/7 with fast interpretation
- Keep Alteplase in the ED close to patients
- Control blood pressure pre/post thrombolysis
- Track time metrics so track performance and improve

	National Institutes of Health Stroke Scale score
	<p>1a. Level of consciousness</p> <p>0 = Alert; keenly responsive  1 = Not alert, but arousable by minor stimulation  2 = Not alert; requires repeated stimulation  3 = Unresponsive or responds only with reflex</p>
	<p>1b. Level of consciousness questions:  What is the month?  What is your age?</p> <p>0 = Answers two questions correctly  1 = Answers one question correctly  2 = Answers neither question correctly</p>
	<p>1c. Level of consciousness commands:  Open and close your eyes.  Grip and release your hand.</p> <p>0 = Performs both tasks correctly  1 = Performs one task correctly  2 = Performs neither task correctly</p>



# Four Levels of Stroke Care (US)

## ACUTE STROKE READY HOSPITAL (ASRH)

### TYPICAL PHASES OF CARE FOR ASRH

#### 01 PREHOSPITAL/EMS

- Check patient's airway, breathing & circulation (ABCs)
- Perform physical exam, stroke recognition, and severity assessment
- Get history (UW), medications, etc.
- Record blood pressure, heart rate, oxygen saturation and glucose
- Transport patient to the appropriate stroke center per the applicable regional stroke routing policy
- Perform pre-arrival notification to the receiving hospital

#### 02 IN THE ED

- Team is prepared for patient arrival via EMS from scene or inter-facility transfer
- Re-check ABCs
- If stable, go directly to CT or MRI per site protocol
- Establish stroke diagnosis & discuss treatment IV tPA with patient/family if indicated
- Perform additional imaging as indicated to assess eligibility for thrombectomy

#### 03 DISPOSITION

ADMIT PATIENT TO HOSPITAL (initial stroke, non-tPA per protocol)

- TRANSFER TO HIGHER LEVEL OF CARE IF THE PATIENT:
  - Received tPA and requires a stroke unit
  - Is being considered for a thrombectomy
  - Has a general need for higher level of care

Learn more at [www.heart.org/certification](http://www.heart.org/certification)

## PRIMARY STROKE CENTER (PSC)

WHEN A STROKE HAPPENS, EMERGENCY MEDICAL SERVICES CAN MEAN THE DIFFERENCE BETWEEN LIFE AND DEATH.

### TYPICAL PHASES OF CARE FOR PSC

#### 01 PREHOSPITAL/EMS

- Check patient's airway, breathing & circulation (ABCs)
- Perform physical exam, stroke recognition, and severity assessment
- Get history (UW), medications, etc.
- Record blood pressure, heart rate, oxygen saturation and glucose
- Transport patient to the appropriate stroke center per the applicable regional stroke routing policy
- Perform pre-arrival notification to the receiving hospital

#### 02 IN THE ED

- Team is prepared for patient arrival via EMS from scene or inter-facility transfer
- Re-check ABCs
- If stable, go directly to CT or MRI per site protocol
- Establish stroke diagnosis & discuss treatment IV tPA and EVT with patient/family if indicated
- Perform additional imaging as indicated to assess eligibility for thrombectomy

#### 03 DISPOSITION

- STROKE UNIT
  - Some IV tPA and most untreated stroke cases
  - Patient receives ongoing monitoring and interventions
  - Continuous monitoring for progression and bleeding
  - Establish stroke mechanism and initiate secondary prevention
  - Initiate early assessments for rehabilitation and transfer to higher level of care if the patient:
    - Has a general need for higher level of care
    - Has a general need for higher level of care

#### 04 DISCHARGE TO:

HOME / LTAC / REHAB / SNF / HOSPICE

## THROMBECTOMY-CAPABLE STROKE CENTER (TSC)

### TYPICAL PHASES OF CARE FOR TSC

#### 01 PREHOSPITAL/EMS

- Check patient's airway, breathing & circulation (ABCs)
- Perform physical exam, stroke recognition, and severity assessment
- Get history (UW), medications, etc.
- Record blood pressure, heart rate, oxygen saturation and glucose
- Transport patient to the appropriate stroke center destination per the applicable regional stroke routing policy
- Perform pre-arrival notification to the receiving hospital

#### 02 IN THE ED

- Team is prepared for patient arrival via EMS from scene or inter-facility transfer
- Re-check ABCs
- If stable, go directly to CT or MRI per site protocol
- Establish stroke diagnosis & discuss treatment IV tPA and EVT with patient/family if indicated
- Perform additional imaging as indicated to assess eligibility for thrombectomy
- Offer EVT to all eligible patients ASAP and alert the EVT team
- Expedite rapid transport to endovascular suite if EVT indicated

## 4 LEVELS OF STROKE CARE

THERE ARE FOUR LEVELS OF HOSPITAL CERTIFICATION FOR STROKE CARE:

Learn more at [www.heart.org/certification](http://www.heart.org/certification)

## COMPREHENSIVE STROKE CENTER (CSC)

### TYPICAL PHASES OF CARE FOR CSC

#### 01 PREHOSPITAL/EMS

- Check patient's airway, breathing & circulation (ABCs)
- Perform physical exam, stroke recognition, and severity assessment
- Get history (UW), medications, etc.
- Record blood pressure, heart rate, oxygen saturation and glucose
- Transport patient to the appropriate stroke center destination per the applicable regional stroke routing policy
- Perform pre-arrival notification to the receiving hospital

#### 02 IN THE ED

- Team is prepared for patient arrival via EMS from scene or inter-facility transfer
- Re-check ABCs
- If stable, go directly to CT or MRI per site protocol
- Establish stroke diagnosis & discuss treatment IV tPA and EVT with patient/family if indicated
- Offer IV tPA to all eligible patients ASAP
- Perform additional imaging as indicated to assess eligibility for thrombectomy
- Offer EVT to all eligible patients ASAP and alert the EVT team
- Expedite rapid transport to endovascular suite if EVT indicated

#### 03 DISPOSITION

- FOR THROMBECTOMY PATIENTS
  - Prepare for patient in endovascular suite
  - Coordinate anesthesia, OR, radiology and other support teams as needed
  - Perform endovascular thrombectomy
  - Admit patient to an ICU bed with vascular neurologist consultation

ADMIT TO THE NECESSARY LEVEL OF CARE:

- INTENSIVE CARE
  - All EVT cases, many IV tPA and some untreated stroke cases
  - Patient receives critical care monitoring and interventions
  - Close monitoring for complications especially in the first 24-72 hr

STROKE UNIT

- Some IV tPA and most untreated stroke cases
- Patient receives ongoing monitoring and interventions
- Continuous monitoring for progression and bleeding
- Establish stroke mechanism and initiate secondary prevention
- Initiate early assessments for rehabilitation and begin the plan

#### 04 DISCHARGE TO:

HOME / LTAC / REHAB / SNF / HOSPICE

## 4 LEVELS OF STROKE CARE

THERE ARE FOUR LEVELS OF HOSPITAL CERTIFICATION FOR STROKE CARE:

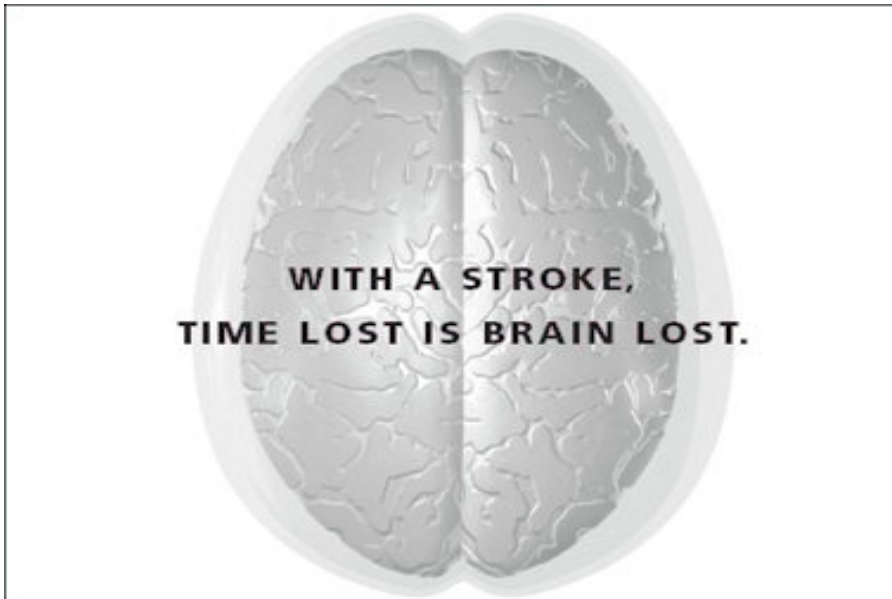
Learn more at [www.heart.org/certification](http://www.heart.org/certification)

ACUTE STROKE READY HOSPITALS  
PRIMARY STROKE CENTERS  
THROMBECTOMY-CAPABLE  
STROKE CENTERS  
COMPREHENSIVE STROKE CENTERS



# Time Is Brain

*Patients treated within 60 minutes experience improved outcomes, including lower in-hospital mortality and reduced long-term disability*



GC Fonarow et al. *JAMA*. 2014;311(16):1632-1640  
Saver et al. *JAMA*. 2013;309(23):2480-8

# The New Challenge in Stroke: Reducing stroke to needle times

- Better public education of stroke symptoms
- **Better recognition of stroke symptoms by dispatchers**
- **Reducing on scene time by paramedics**
- **Taking patients to the right hospital first time**
- **Pre-alert stroke team and improve efficiency of registering the patient**
- **Take patient direct to scanner**
- **Possibly 'scan in van' and telemedicine from ambulance** linking to stroke team
- **Measuring efficiency by call to needle time** (or scan time for non thrombolysable patients) not just 'call to door time'



# Better Times



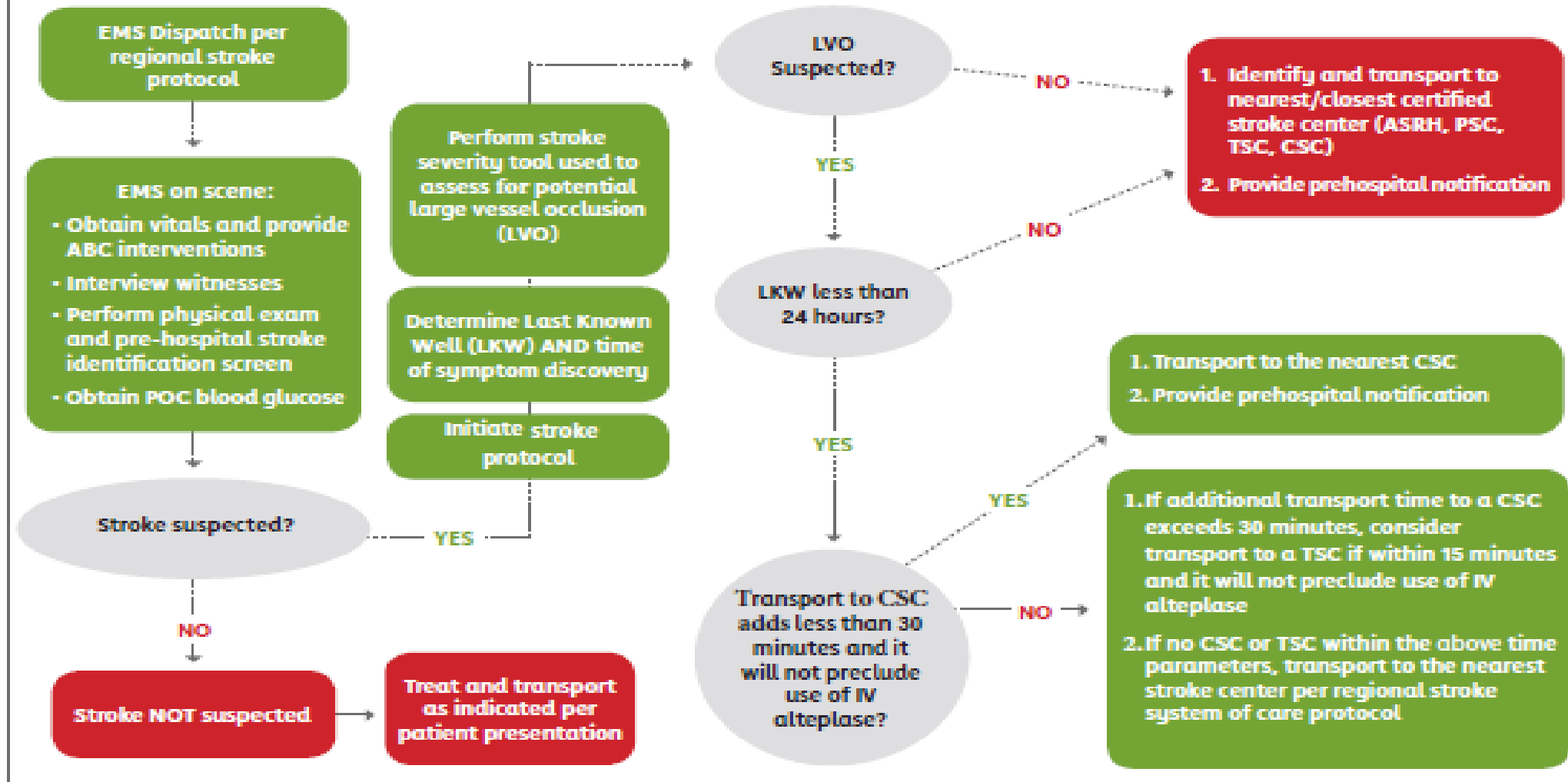
Last one in  
the Angio  
Suite is a  
rotten egg!

©BBC Sport

# Severity-Based Stroke Triage Algorithm for EMS (2019 UPDATE)



American Heart Association  
Mission: Lifeline®  
Stroke



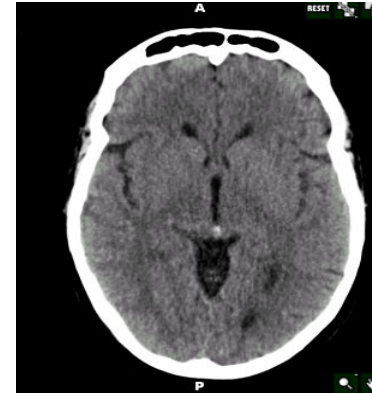


# Teamwork and Collaboration

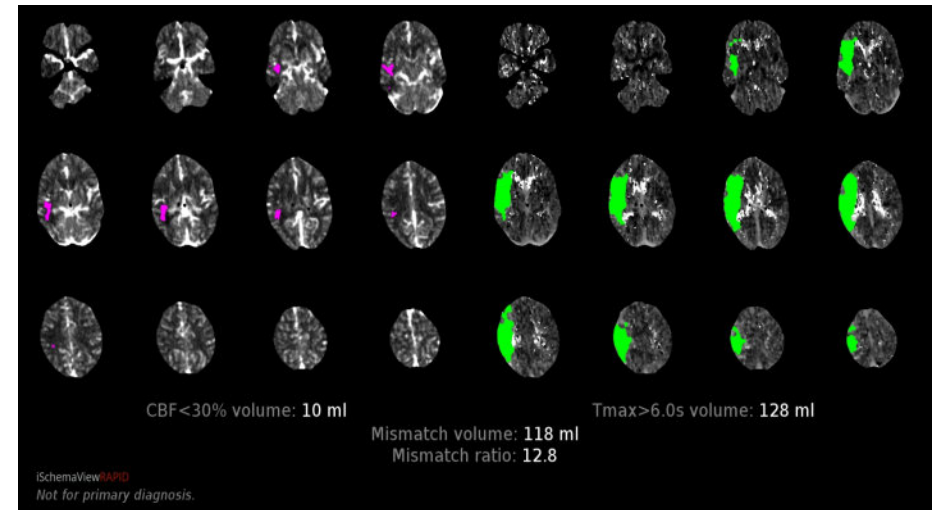


# Stroke Care 2018 and Beyond

- 63 y/o male with "stroke symptoms"
- Found in back yard
- LKW maybe 8 hours ago?
- CPSS ++ (face/arm/speech)
- FSBS 106, BP 156/87
- EMS to Local PSC
- Stroke Team activated (NIHSS 13)
- Rapid transfer to CSC (1 hour DIDO)
- **Within new extended treatment window**
- **RAPID CT Performed (favorable)**
- **Mechanical Thrombectomy performed**
- **Discharged to Home (NIHSS 1)**
- **Returns to Work in a Week**



ED CT Scan



# Summary

- Stroke is common Worldwide
- Pre-hospital Care of the Stroke Patient is Important
- Acute treatment of stroke care can transform a patients life from death or disability to independence
- Technology and treatment options are growing rapidly
- EMS is the link from the community to the stroke centre
- Destination Counts!



# Still Many Questions:

**What is the Best Stroke Severity Scale?**

**Should We Triage All Strokes to Thrombectomy Centers?**

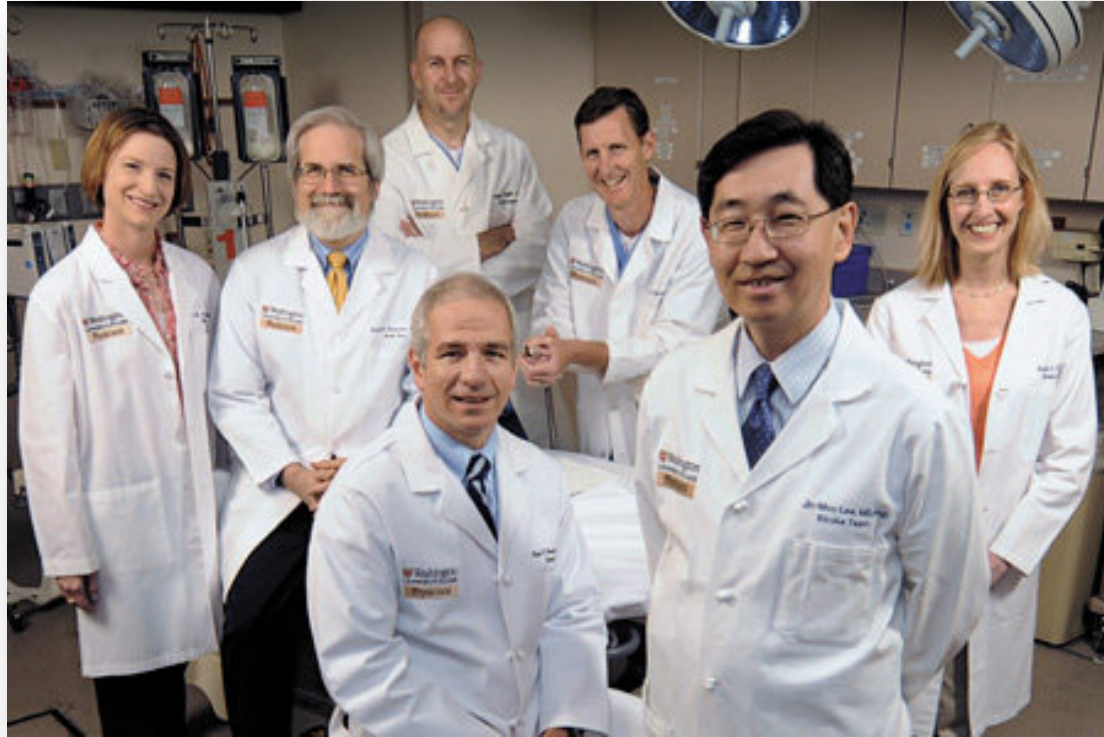
**If We Go First to a Primary Stroke Center, What Should be Done and How Quickly Should They Be Transferred?**

**What Would be the Implications for the Stroke System of Care if All Patients Went to the Larger Stroke Centers?**

**How does EMS Know Which Hospital is Providing the Best Stroke Care?**

# Thank You

- Neurosurgery
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