Advances in Endovascular Treatment of Large Vessel Occlusion

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Diagnosis and endovascular treatment of cerebrovascular disease

- Ischemic and hemorrhagic stroke
- Cerebral aneurysms
- Intra and extracranial steno-occlusive disease
- Brain AVMs and dural fistulas
- Spinal vascular malformations

Minimally invasive treatment of diseases of the head, neck, and spine

- Vertebral augmentation
- MMA embolization
- Preoperative tumor embolization
- Pulsatile tinnitus
- Epistaxis

Undergraduate degree from the University of Virginia
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Medical Societies:

- American Society of Neuroradiology
- Society of Neurointerventional Surgery
- Southeastern Neuroradiological Society
- American College of Radiology

Financial Disclosure

- No pertinent disclosures

Objectives

- Identify recent advances in the care and treatment of vascular disease.

- Recognize opportunities for APPs in interventional and vascular surgery

- Determine when it is appropriate to refer patients to vascular surgery

Stroke – Clinical Context

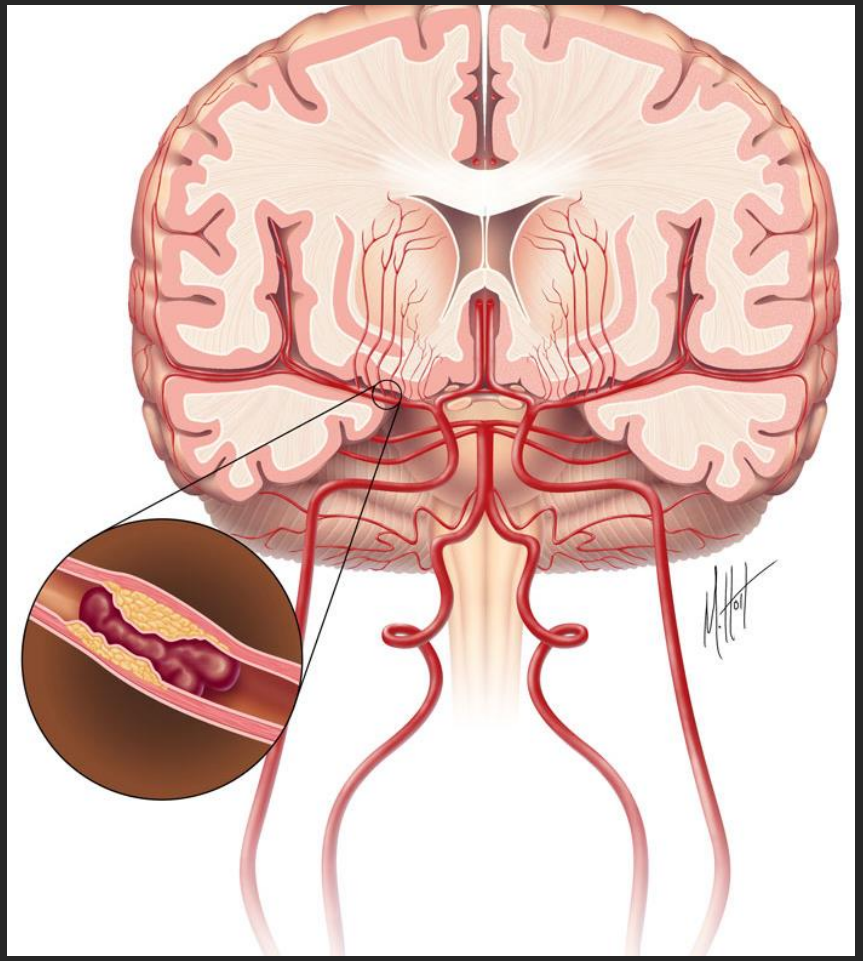
- Stroke is a clinical syndrome
  - Ischemic
  - Hemorrhagic
  - “Stroke mimickers”
- 80% of acute strokes are ischemic.
- Majority of mortality results from large vessel occlusions and cardio-embolic sources.

Acute Ischemic Stroke

- Fifth leading cause of death and leading cause of adult disability in the US.
- 795,000 new strokes per year, resulting in 128,000 deaths.
- One stroke every 40 seconds and one stroke death every 4 minutes.
- $34 billion in US health care dollars per year.

Emergent Large Vessel Occlusion

- ELVO
- Higher stroke severity
- Higher mortality
- ICA, MCA, basilar



- This subset of ischemic stroke comprises blockages in the:
  - Internal Carotid Artery (ICA)
  - Middle Cerebral Artery (MCA)
  - Vertebral / Basilar Artery

- Patient prognosis with these types of stroke is poor

Vessel	Mortality Rate
ICA	53%[1]
MCA	27%[2]
Basilar Artery	89-90%[3]

1. Jansen O, et al.
2. Furlan A et al. PROACT II Trial
3. Brückmann H et al.

Appropriate Vascular Surgery Involvement in Acute Stroke

- Acute ischemic stroke usually does not require vascular surgery involvement
- Increasing role for neurointervention in acute stroke for treatment of intracranial occlusions, as well as tandem cervical vascular disease

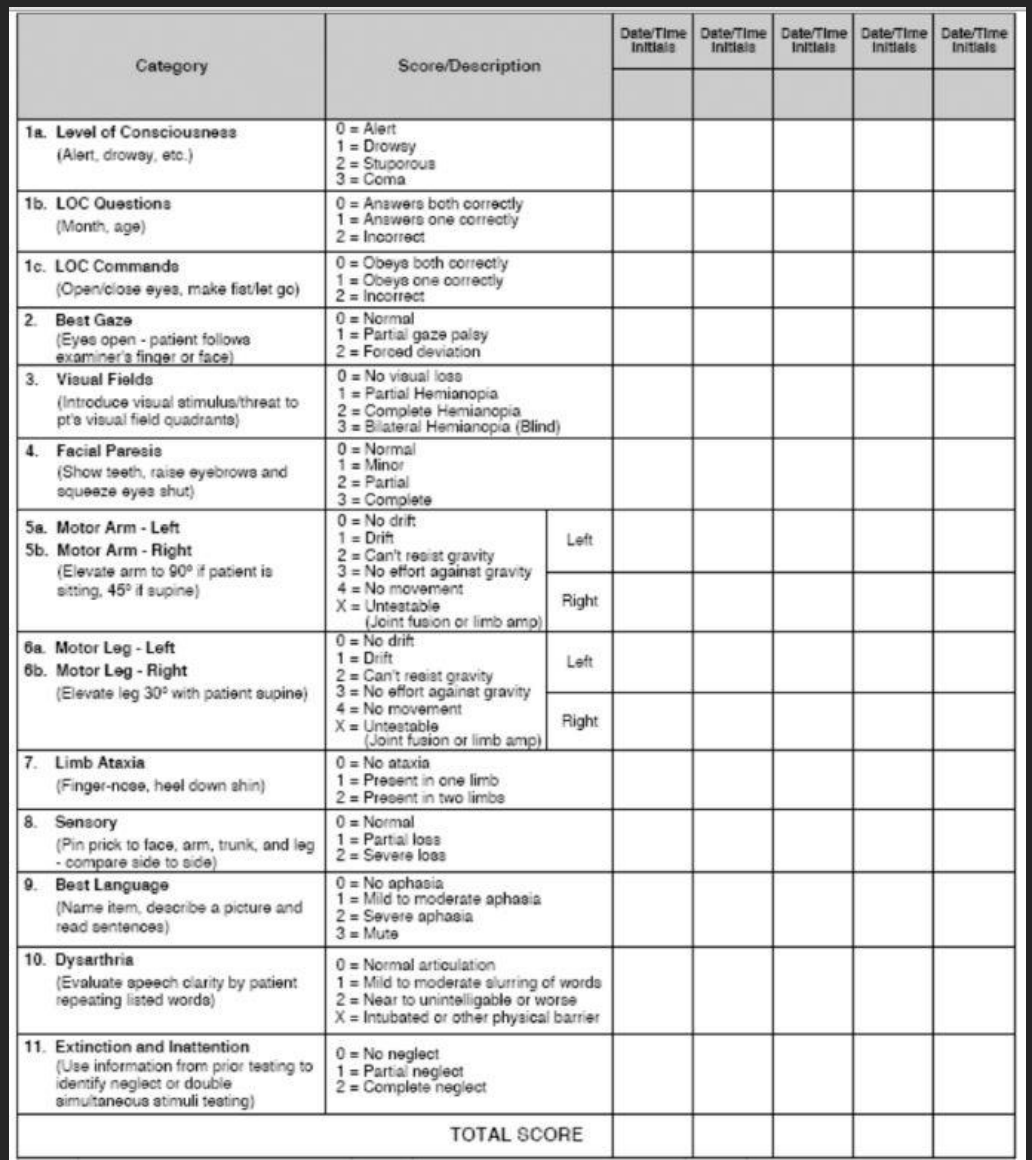
Terminology

- NIH Stroke Scale
- Modified Rankin Score
- Thrombolysis in Cerebral Infarction (TICI) scale

NIH Stroke Scale

15 item scale
0 - 42

Score	Stroke Severity
0	No Stroke Symptoms
1-4	Minor
5-15	Moderate
16-20	Moderate to Severe
21-42	Severe



Category	Score/Description		Date/Time Initials	Date/Time Initials	Date/Time Initials	Date/Time Initials	Date/Time Initials
1a. **Level of Consciousness** (Alert, drowsy, etc.)	0 = Alert 1 = Drowsy 2 = Stuporous 3 = Coma						
1b. **LOC Questions** (Month, age)	0 = Answers both correctly 1 = Answers one correctly 2 = Incorrect						
1c. **LOC Commands** (Open/close eyes, make fist/let go)	0 = Obeys both correctly 1 = Obeys one correctly 2 = Incorrect						
2. **Best Gaze** (Eyes open - patient follows examiner's finger or face)	0 = Normal 1 = Partial gaze palsy 2 = Forced deviation						
3. **Visual Fields** (Introduce visual stimulus/threat to pt's visual field quadrants)	0 = No visual loss 1 = Partial Hemianopia 2 = Complete Hemianopia 3 = Bilateral Hemianopia (Blind)						
4. **Facial Paresis** (Show teeth, raise eyebrows and squeeze eyes shut)	0 = Normal 1 = Minor 2 = Partial 3 = Complete						
5a. **Motor Arm - Left** 5b. **Motor Arm - Right** (Elevate arm to 90° if patient is sitting, 45° if supine)	0 = No drift 1 = Drift 2 = Can't resist gravity 3 = No effort against gravity 4 = No movement X = Untestable (Joint fusion or limb amp)	Left					
		Right					
6a. **Motor Leg - Left** 6b. **Motor Leg - Right** (Elevate leg 30° with patient supine)	0 = No drift 1 = Drift 2 = Can't resist gravity 3 = No effort against gravity 4 = No movement X = Untestable (Joint fusion or limb amp)	Left					
		Right					
7. **Limb Ataxia** (Finger-nose, heel down shin)	0 = No ataxia 1 = Present in one limb 2 = Present in two limbs						
8. **Sensory** (Pin prick to face, arm, trunk, and leg - compare side to side)	0 = Normal 1 = Partial loss 2 = Severe loss						
9. **Best Language** (Name item, describe a picture and read sentences)	0 = No aphasia 1 = Mild to moderate aphasia 2 = Severe aphasia 3 = Mute						
10. **Dysarthria** (Evaluate speech clarity by patient repeating listed words)	0 = Normal articulation 1 = Mild to moderate slurring of words 2 = Near to unintelligable or worse X = Intubated or other physical barrier						
11. **Extinction and Inattention** (Use information from prior testing to identify neglect or double simultaneous stimuli testing)	0 = No neglect 1 = Partial neglect 2 = Complete neglect						
TOTAL SCORE							

NIH Stroke Scale

- Stroke severity scale
- 0 - 42
- < 6 strong predictor of good outcome
- > 16 strong predictor of death
- Each point increase equals 17% reduction in good outcome
- Five strongest predictors: Gaze, visual fields, language, arm motor, leg motor

Modified Rankin Scale

- 0 - No symptoms.
- 1 - No significant disability. Able to carry out all usual activities, despite some symptoms.
- 2 - Slight disability. Able to look after own affairs without assistance, but unable to carry out all previous activities.
- 3 - Moderate disability. Requires some help, but able to walk unassisted.
- 4 - Moderately severe disability. Unable to attend to own bodily needs without assistance, and unable to walk unassisted.
- 5 - Severe disability. Requires constant nursing care and attention, bedridden, incontinent.
- 6 - Dead.

mRS

- Functional outcome
- Usually measured at 90 days

Thrombolysis in Cerebral Infarction (TICI)

1 – contrast past site of occlusion but minimal filling of normal territory

2a – partial reperfusion, less than 50% of expected territory

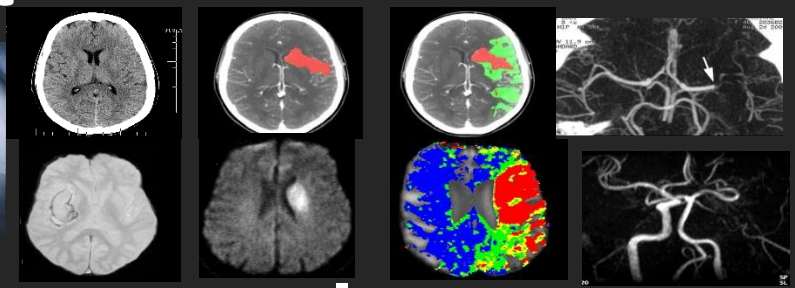
2b – partial reperfusion, 50-99%

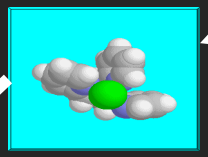
2c – complete perfusion but delayed run off

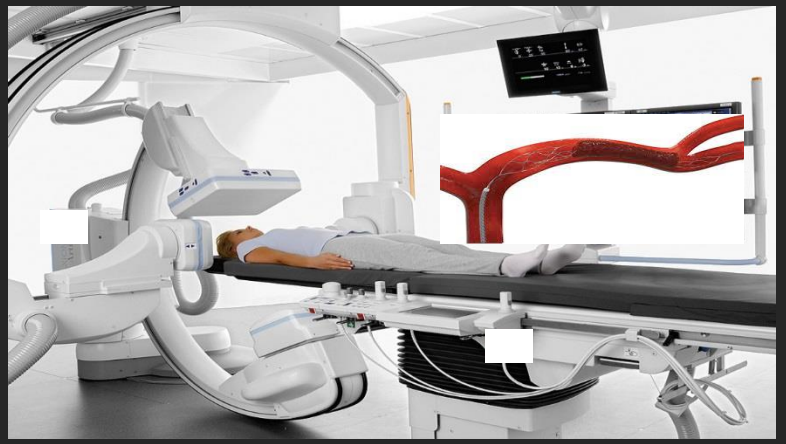
3 – normal

Mechanical Thrombectomy

MODERN work-up of an acute stroke patient







Ischemic Stroke Devices

Thrombectomy History

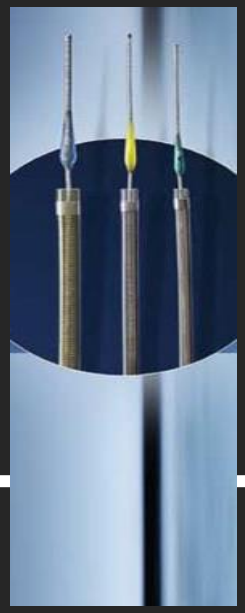
BAOCHE
ATTENTION
ANGEL ASPECTS
SELECT 2

MR CLEAN
SWIFT PRIME
EXTEND IA
ESCAPE
REVASCAT

DAWN
DEFUSE 3

IMS III
MR RESCUE

2004 — Merci



2008 — Penumbra

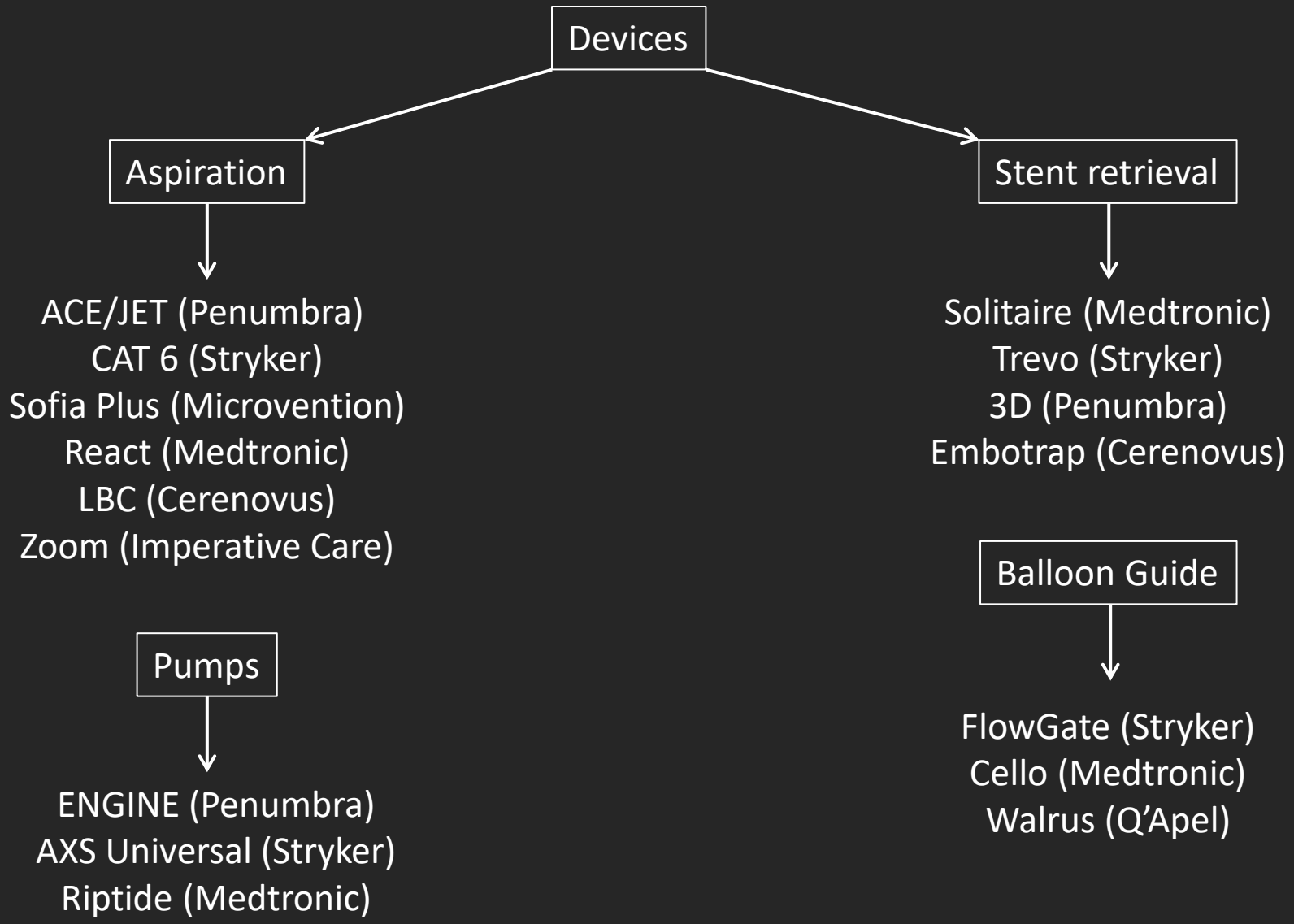
2012 — Solitaire
Trevo

2013

2015

2017 — Penumbra 3D

2018 — Sofia
Jet
AXS
Zoom


Devices
Aspiration
Stent retrieval
ACE/JET (Penumbra)
CAT 6 (Stryker)
Sofia Plus (Microvention)
React (Medtronic)
LBC (Cerenovus)
Zoom (Imperative Care)
Solitaire (Medtronic)
Trevo (Stryker)
3D (Penumbra)
Embotrap (Cerenovus)
Balloon Guide
FlowGate (Stryker)
Cello (Medtronic)
Walrus (Q'Apel)
Pumps
ENGINE (Penumbra)
AXS Universal (Stryker)
Riptide (Medtronic)

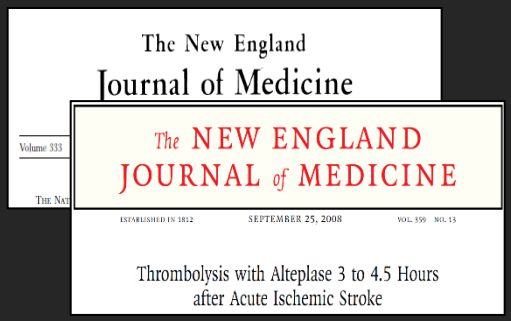
Clinical evidence for stroke treatment up to 24 hours

0 – 4.5 hours

0 – 6 hours

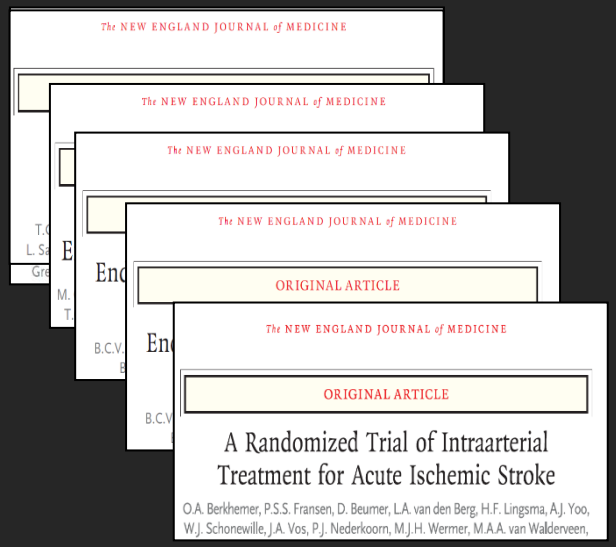
6 – 24 hours

NINDS Trial: IV tPA
0 - 3 hours

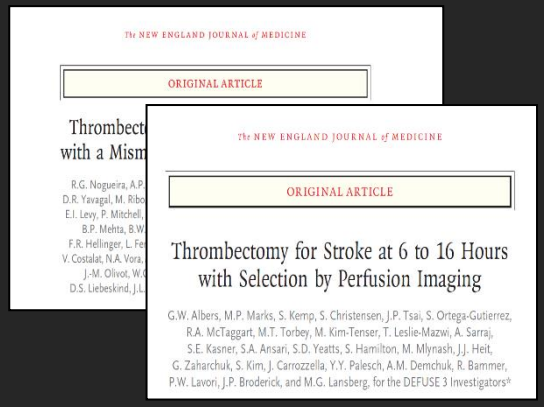


ECASS III: IV tPA
3 – 4.5 hours

5 RCTS: stent retriever
0-6 hours

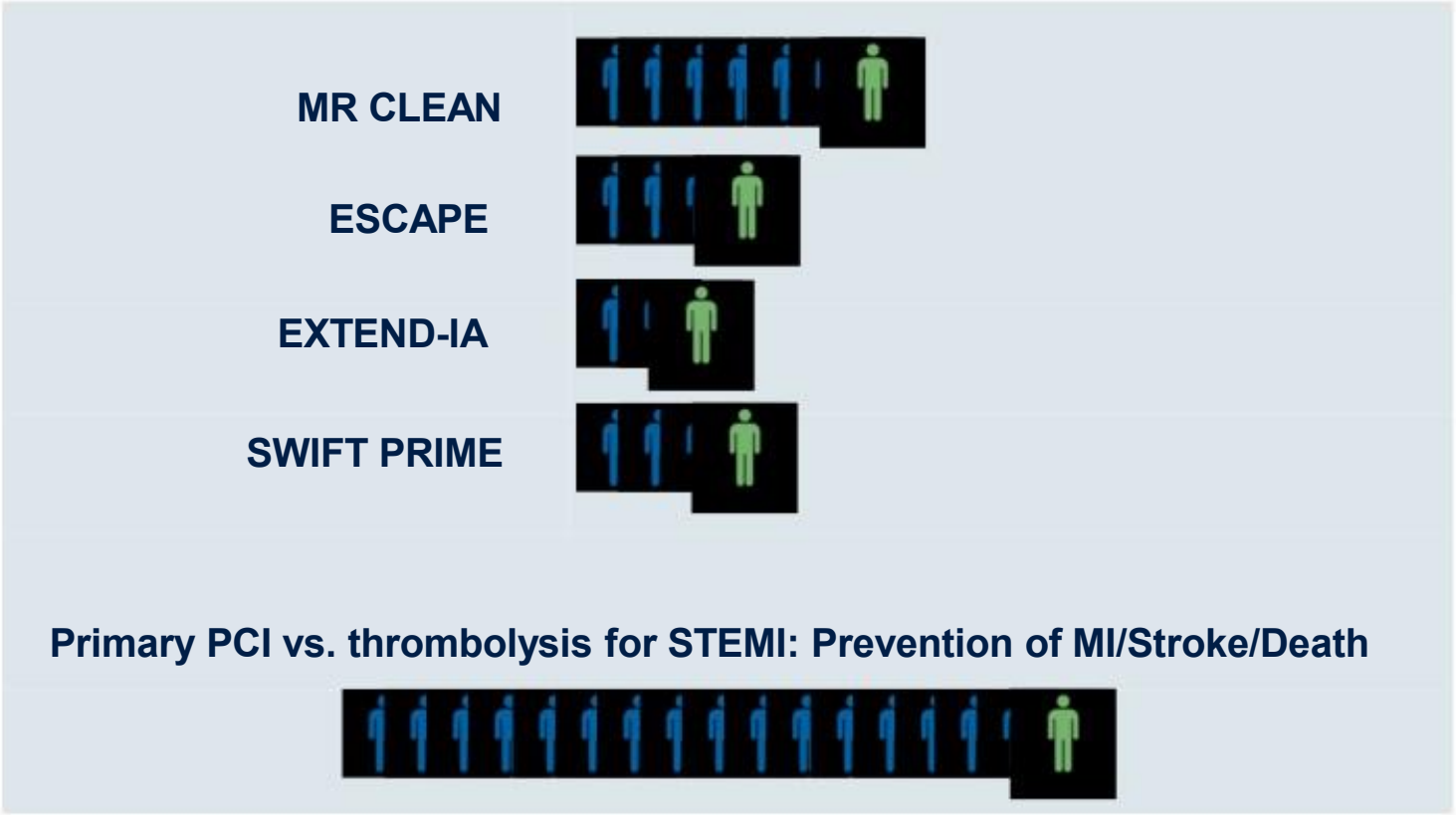


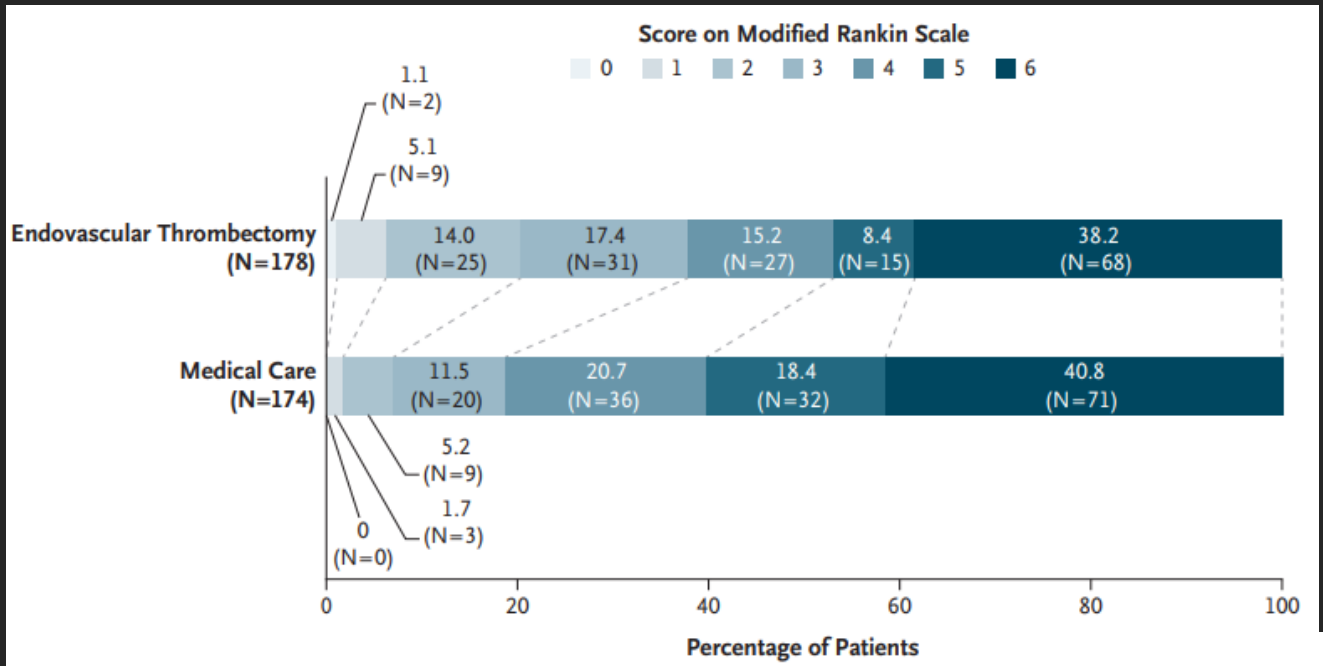
DAWN Trial: stent retriever
6 - 24 hours

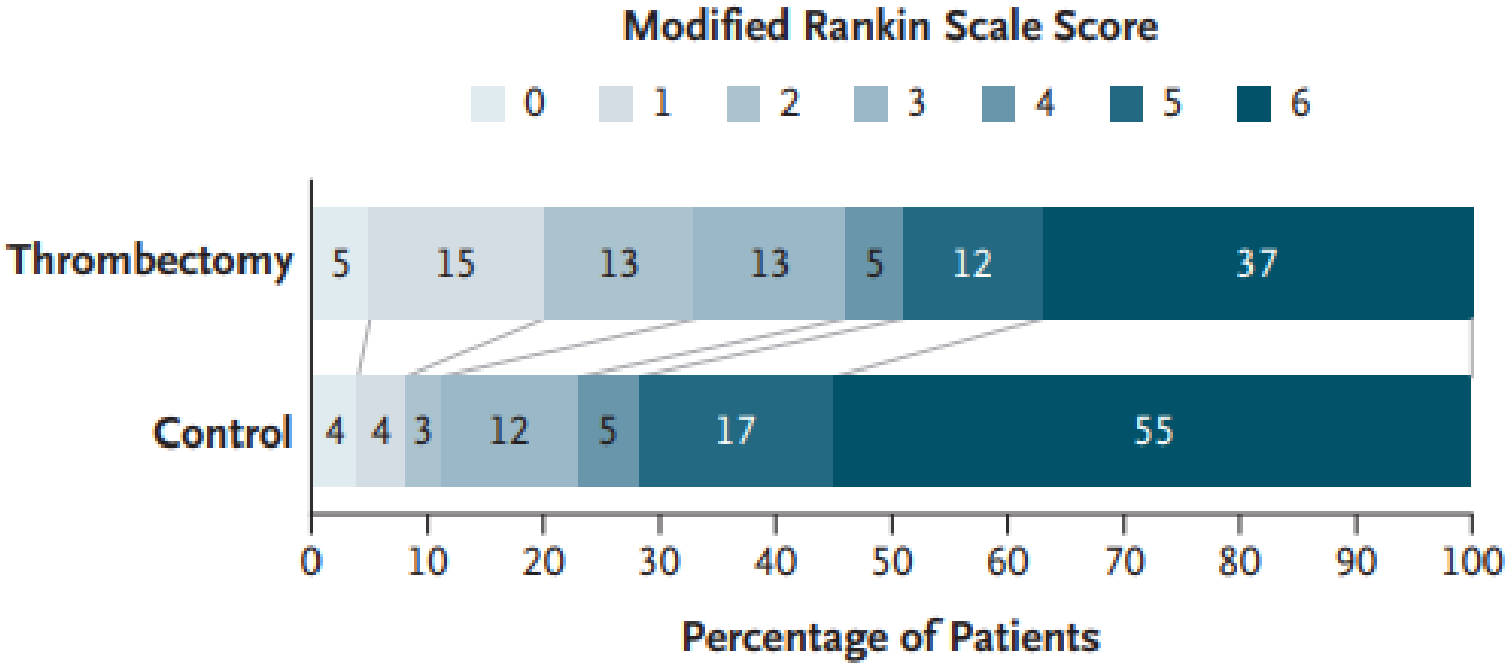


DEFUSE 3: thrombectomy
6-16 hours

NUMBER NEEDED TO TREAT




Score on Modified Rankin Scale
0
1
2
3
4
5
6
1.1
(N=2)
5.1
(N=9)
Endovascular Thrombectomy
(N=178)
14.0
(N=25)
17.4
(N=31)
15.2
(N=27)
8.4
(N=15)
38.2
(N=68)
Medical Care
(N=174)
11.5
(N=20)
20.7
(N=36)
18.4
(N=32)
40.8
(N=71)
5.2
(N=9)
1.7
(N=3)
0
(N=0)
0
20
40
60
80
100
Percentage of Patients


Modified Rankin Scale Score
0
1
2
3
4
5
6
Thrombectomy
5
15
13
13
5
12
37
Control
4
4
3
12
5
17
55
0
10
20
30
40
50
60
70
80
90
100
Percentage of Patients

SELECT2

- Randomized Controlled Trial to Optimize Patient's Selection for Endovascular Treatment in Acute Ischemic Stroke
- Prospective RCT (US, Canada, Europe, Australia, and New Zealand)
- ICA, M1
- 24h
- ASPECTS 3-5
- Core infarct >50 cc (RAPID)
- Randomization 1:1 (stopped early)
  - 178 patients thrombectomy group
  - 174 patients medical-care group

ASPECTS

- Alberta Stroke Program Early CT score (ASPECTS) is a 10-point quantitative topographic CT scan score

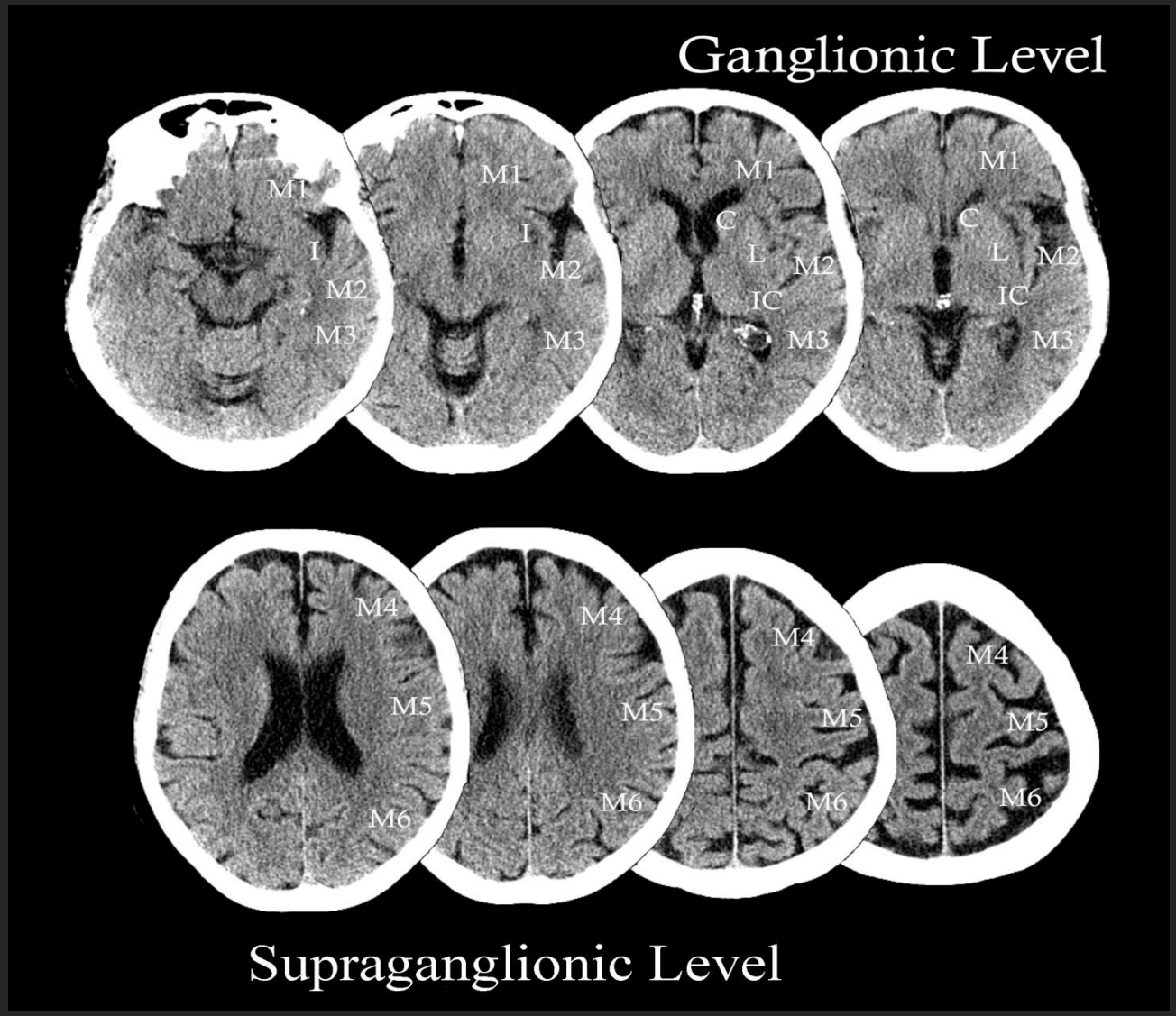
- ASPECTS was developed to offer the reliability and utility of a standard CT examination with a reproducible grading system to assess early ischemic changes on pretreatment CT studies in patients with acute ischemic stroke of the anterior circulation

- ASPECTS CT score is simple and reliable

How to compute ASPECTS

- Two regions of the MCA territory:
  - Basal ganglia
  - Supraganglionic level (corona radiata and centrum semiovale)
- The abnormality should be visible on at least two consecutive cuts
- One point for each normal segment
- Normal = 10
- Entire MCA infarct = 0

ASPECTS

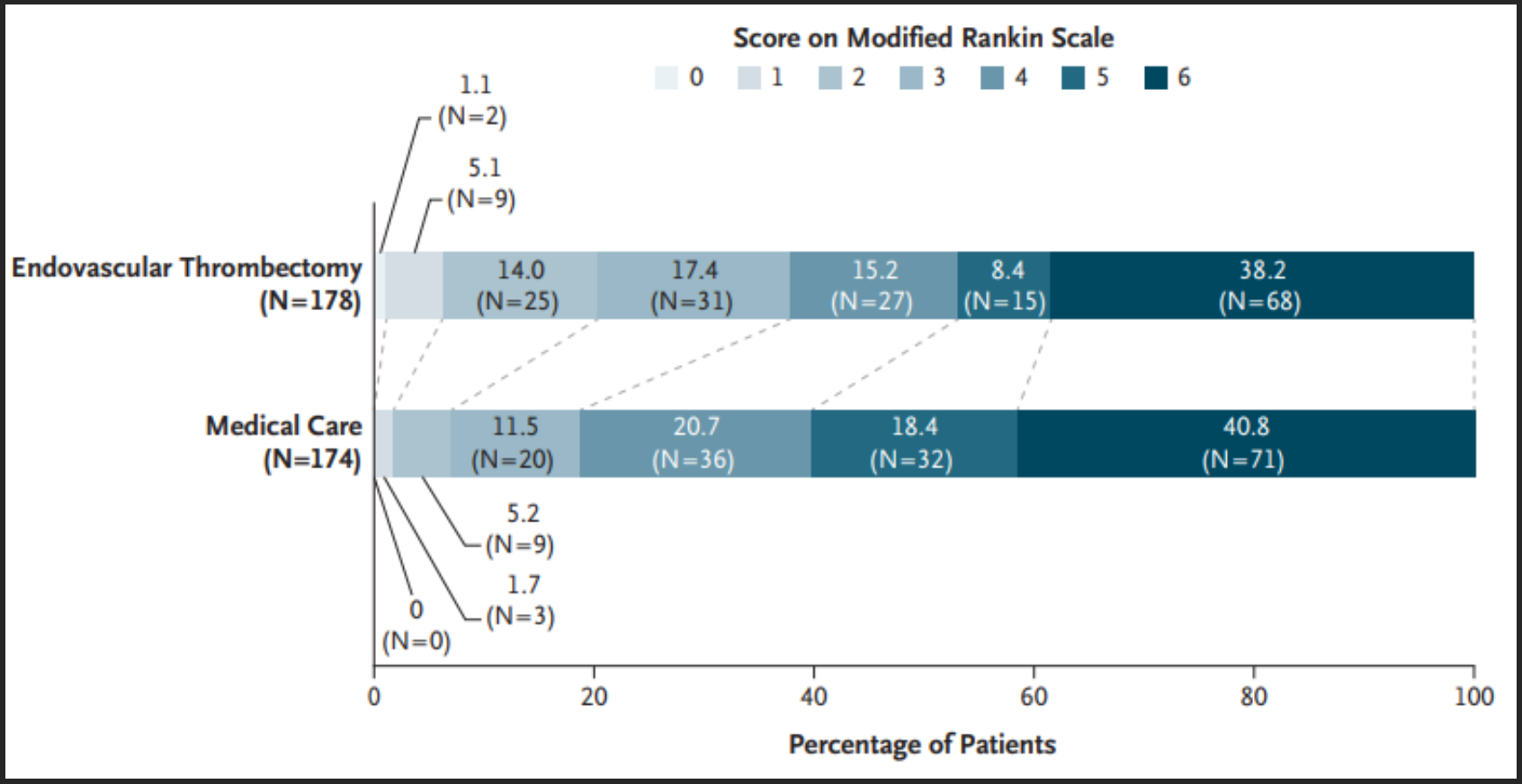

Ganglionic Level
M1
I
M2
M3
M1
I
M2
M3
M1
C
L
M2
IC
M3
M1
C
L
M2
IC
M3
M4
M5
M6
M4
M5
M6
M4
M5
M6
M4
M5
M6
Supraganglionic Level

Outcomes

- mRS 5 and 6 merged
- Primary outcome was ordinal score on mRS
- mRS 0-2 secondary outcome at 90 days
- mRS 0-3 secondary outcome at 90 days
- Etc…
- Predefined subgroups

Outcomes

- mRS measured at 24h, 5-7d, 30d, 90d
- Primary outcome
  - mRS 4 for thrombectomy
  - mRS 5 for medical
- Secondary outcome
  - mRS 0-2 20% for thrombectomy
  - mRS 0-2 7% for medical


Score on Modified Rankin Scale
0
1
2
3
4
5
6
Endovascular Thrombectomy (N=178)
Medical Care (N=174)
1.1 (N=2)
5.1 (N=9)
14.0 (N=25)
17.4 (N=31)
15.2 (N=27)
8.4 (N=15)
38.2 (N=68)
11.5 (N=20)
20.7 (N=36)
18.4 (N=32)
40.8 (N=71)
5.2 (N=9)
1.7 (N=3)
0 (N=0)
0
20
40
60
80
100
Percentage of Patients

Other outcomes

- Early neurologic worsening
  - 44 patients (24.7%) in the thrombectomy group
  - 27 patients (15.5%) in the medical-care group
- sICH
  - One patient (0.6%) in the thrombectomy group
  - Two patients (1.1%) in the medical-care group
- Procedural complications occurred in 33 patients (18.5%) in the thrombectomy group.
  - Arterial access site included occlusion (in 3 patients [1.7%]) hematoma (in 1 patient [0.6%]), and infection (in 1 patient [0.6%]).
  - 10 patients (5.6%) had vascular dissections
  - 7 (3.9%) had arterial perforation
  - 11 (6.2%) had intraprocedural vasospasm

RESCUE Japan LIMIT

- Recovery by Endo-vascular Salvage for Cerebral Ultra-acute Embolism Japan Large IscheMIc core Trial (RESCUE Japan LIMIT)
- RCT 202 patients
- 90-day mRS 0–2 was twice as high in the MT compared with the medical management (MM) group (14% vs 7.8%, respectively)
- MRS 0–3 (that is, ambulatory) in the MT group was 31% compared with 12.7% in the MM group.
- MT yielded higher lifetime benefits (2.20 QALYs vs 1.41 QALYs) despite marginally higher lifetime healthcare costs per patient ($285 861 vs $272 954). The difference of 0.79 QALYs equated to 288 additional days of healthy life per patient.

ANGEL-ASPECT

- Endovas- cular Therapy in Acute Anterior Circula- tion Large Vessel Occlusion Patients with a Large Infarct Core (ANGEL-ASPECT) trial
- RCT 456 patients from 46 centers in China with large infarct core
  - including those with ASPECTS 0–2
  - including core volume of 70–100mL)
  - ELVO within 24 hours.
- Terminated early due to efficacy
  - mRS 0–2 of 30% for EVT
  - mRS 0-2 11.6% for MM
  - shift in distribution of mRS scores towards better outcomes with thrombectomy
- sICHwas higher in the MT group (6.1% vs 2.7%)
- MT reduced the number of mRS 5 patients by nearly half

Expanding the Treatable Stroke Pool
SELECT-2 Trial

Case Presentation

ED Triage Evaluation

BEFAST

Date and Time Last seen Normal 4/21 0200

Date, Time, and Name of MD Notified 4/21 0427- upon arrival to ED.

BALANCE
Trouble Walking

EYES
Trouble seeing in one or both eyes.

FACE
Facial Droop/numbness

Arm & Leg
Difficulty walking

Speech
Slurred

Time
Date and Time of Onset of Symptoms 0235

Glucose: EMS 127
POC 149

Get MD quick evaluation within 10-minutes of arrival

Per family arriving at hospital, family member saw patient watching TV, acting his normal self around 0200. Pt heard "coughing" and maybe a thump around 0235. Pt found slumped half way out of chair at time of EMS call. Pt arrived in ED at 0427.

Teleneurology Consult

SUBJECTIVE:

Time of Stroke Alert Notification: 0430 Time of Initial Neurology Response: 0432
Hospital Setting: Emergency Department

Reason for Stroke Alert: 66 year old male with A fib (on plavix) presents with acute onset R MCA syndrome
Last Seen Normal Date: 04/21/23
Last Seen Well Time: 0245

OBJECTIVE:

BP 177/98 | Temp 96.3 °F (35.7 °C) | Resp 16 | Wt 93.3 kg (205 lb 11 oz) | SpO2 95%

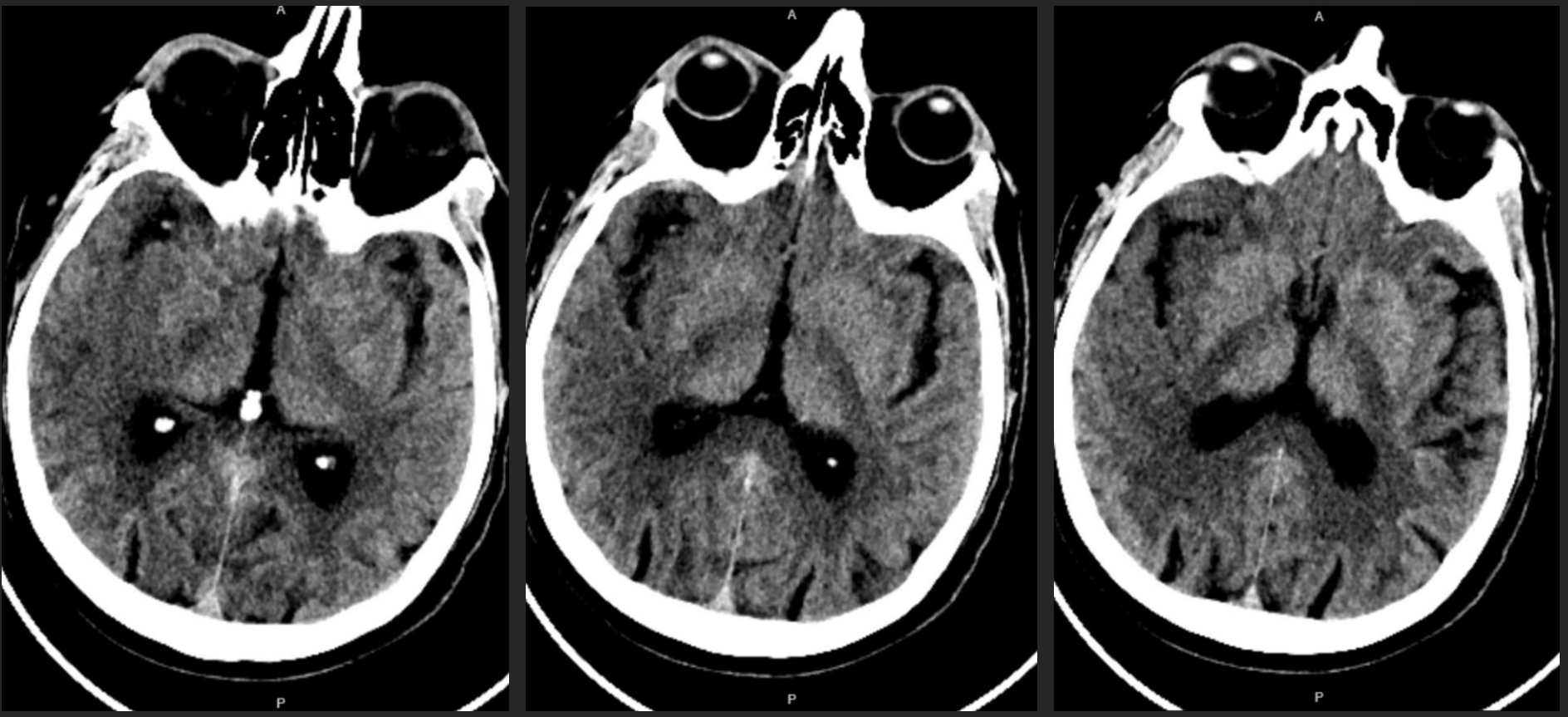
Exam Info:
Televideo Exam Performed? Yes
Time of Televideo Connection: 0445

NIH Stroke Scale
1a. Level of Consciousness: 0-->Alert, keenly responsive
1b. LOC Questions: 0-->Answers both questions correctly
1c. LOC Commands: 0-->Performs both tasks correctly
2. Best Gaze: 2-->Forced deviation, or total gaze paresis not overcome by the oculocephalic maneuver
3. Visual: 2-->Complete hemianopia
4. Facial Palsy: 2-->Partial paralysis (total or near-total paralysis of lower face)
5a. Motor Arm, Left: 4-->No movement
5b. Motor Arm, Right: 0-->No drift, limb holds 90 (or 45) degrees for full 10 secs
6a. Motor Leg, Left: 4-->No movement
6b. Motor Leg, Right: 0-->No drift, leg holds 30 degree position for full 5 secs
7. Limb Ataxia: 0-->Absent
8. Sensory: 2-->Severe to total sensory loss, patient is not aware of being touched in the face, arm, and leg
9. Best Language: 0-->No aphasia, normal
10. Dysarthria: 2-->Severe dysarthria, patients speech is so slurred as to be unintelligible in the absence of or out of proportion to any dysphasia, or is mute/anarthric
11. Extinction and Inattention (formerly Neglect): 2-->Profound hemi-inattention/extinction more than 1 modality
Total (NIH Stroke Scale): 20

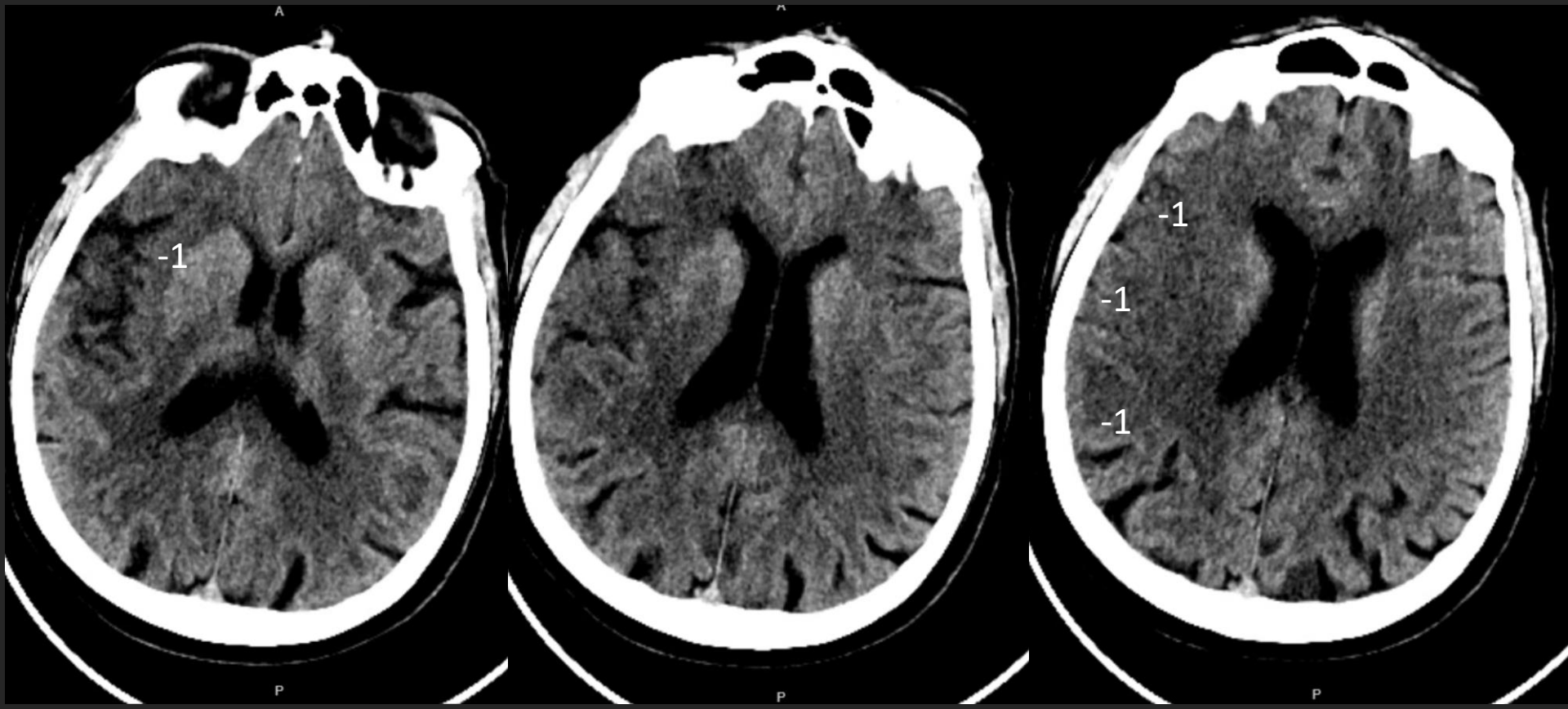
Glucose Value: 124 mg/dL
Pre-treatment BP: 177/98

Head CT Findings: Dense right MCA sign

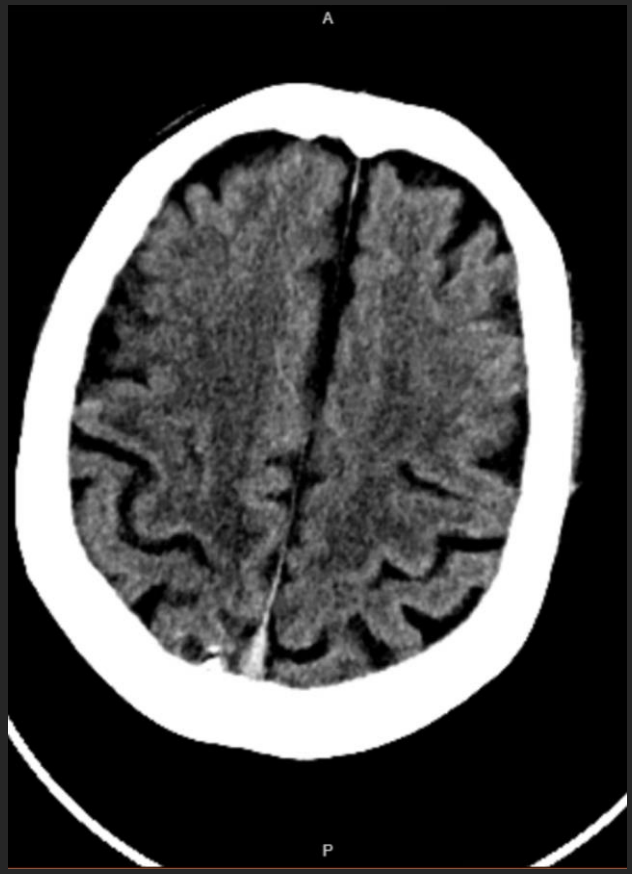
Initial Non-Contrast Head CT



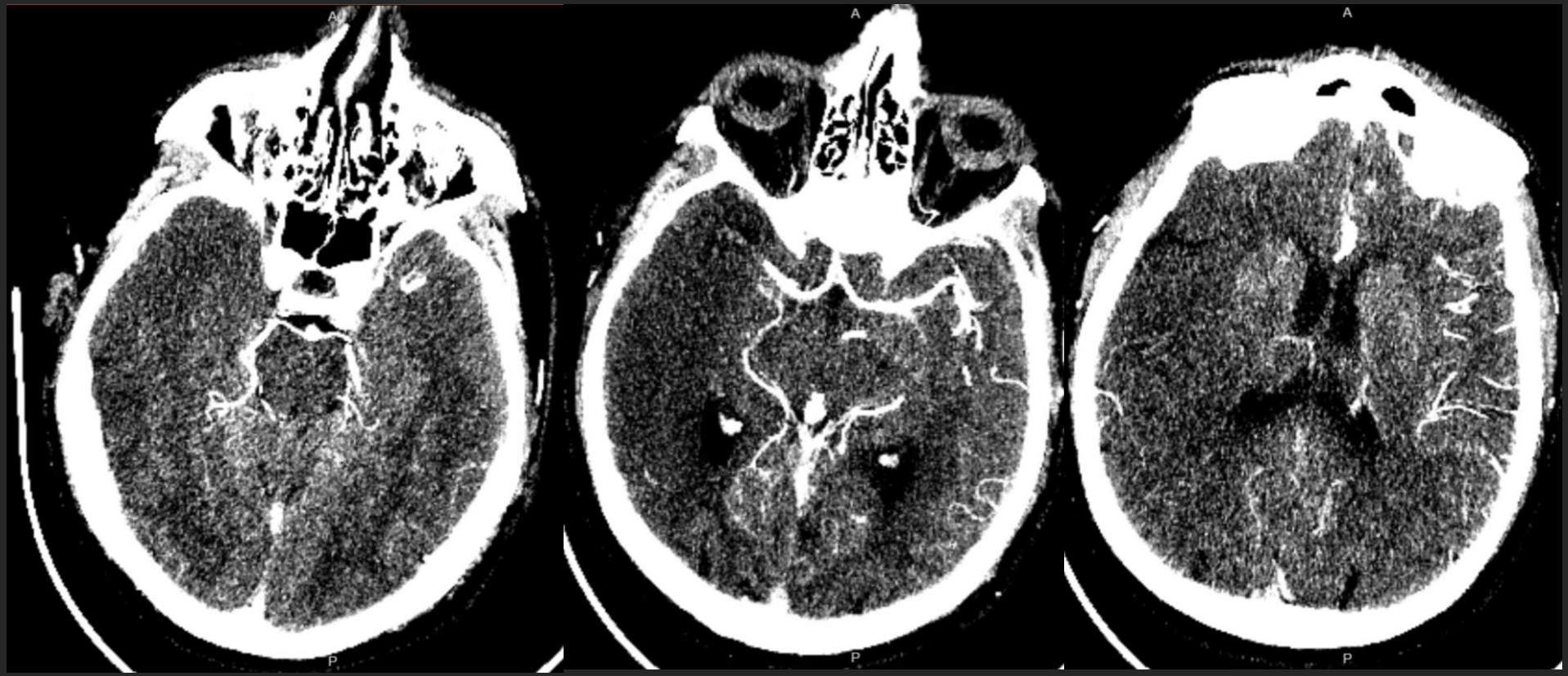
Initial Non-Contrast Head CT



Initial Non-Contrast Head CT



Selected CTA Source Images



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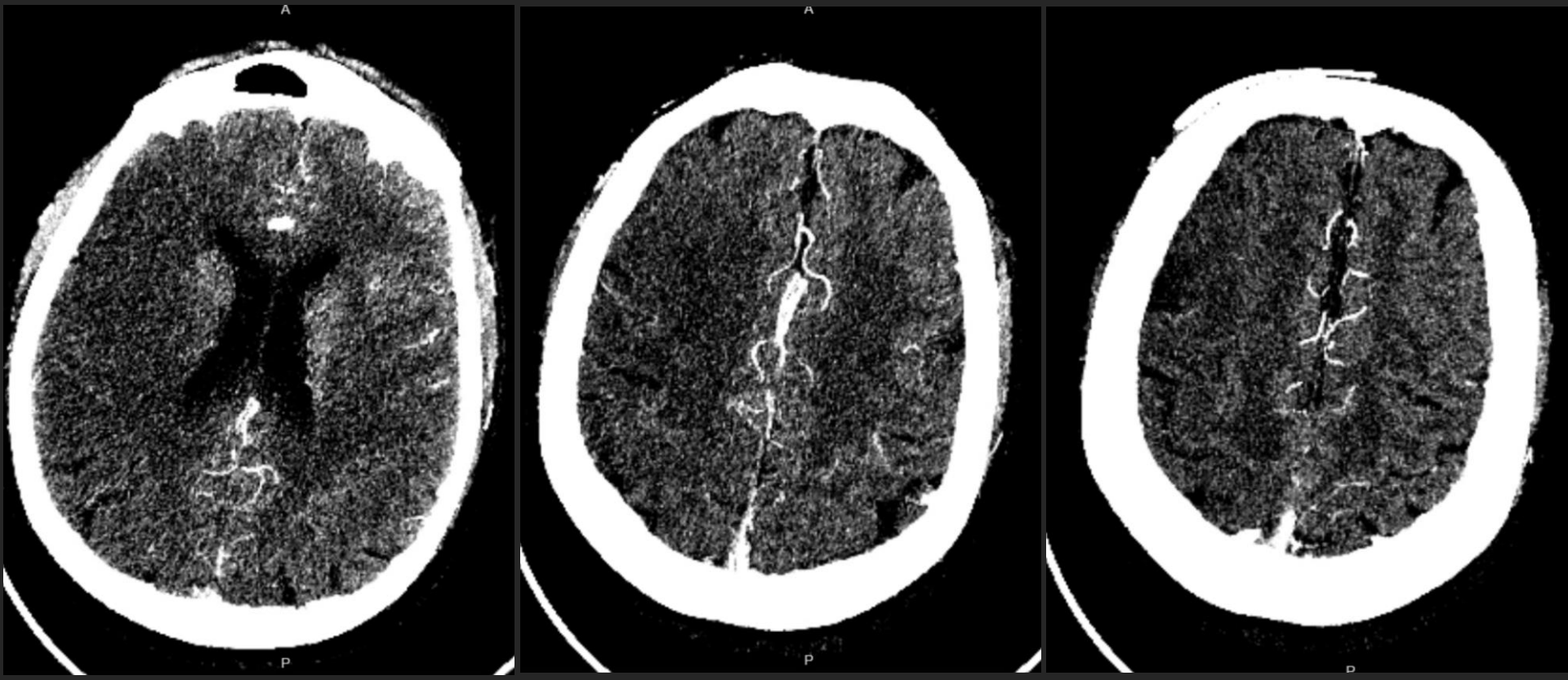
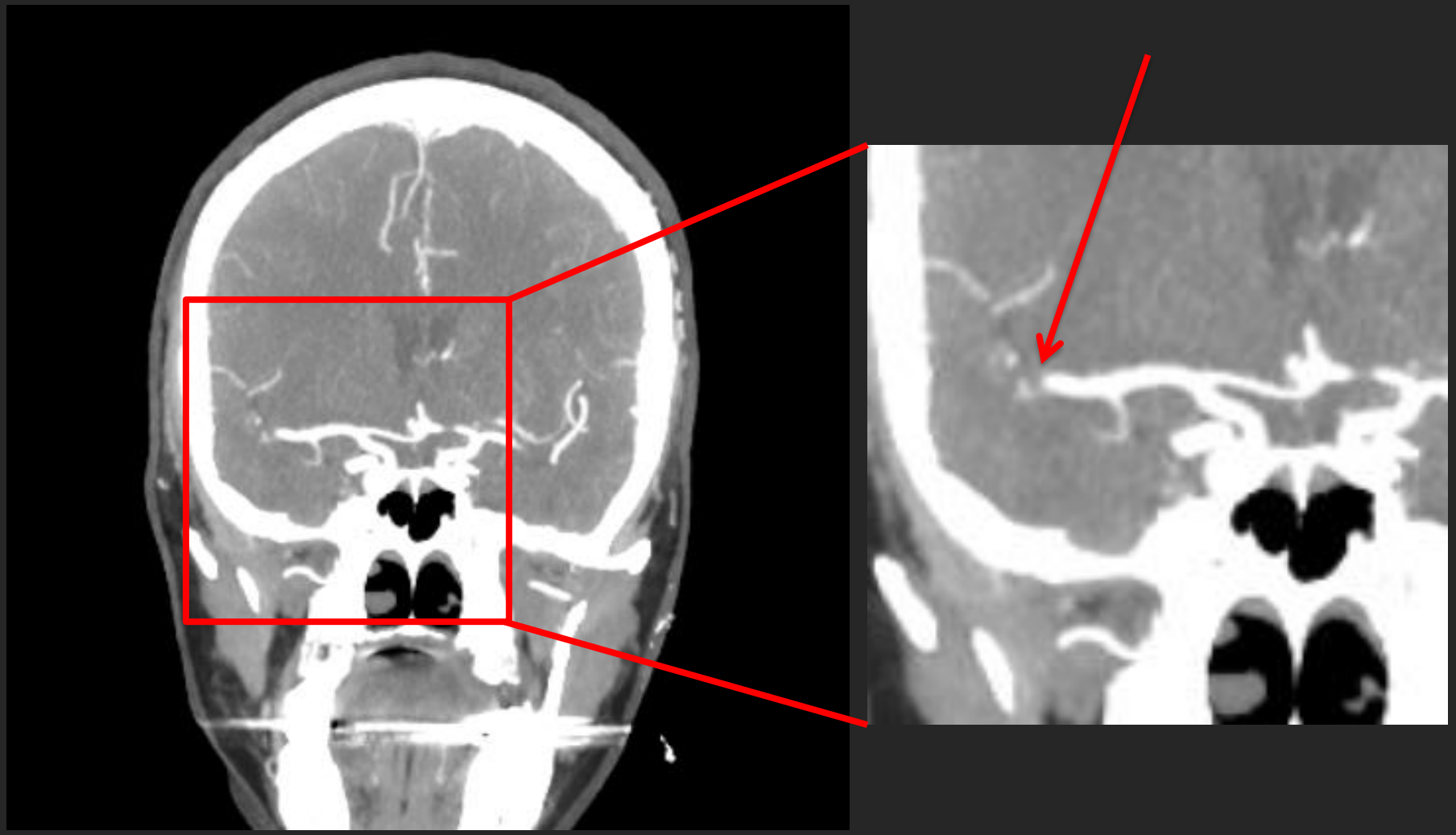
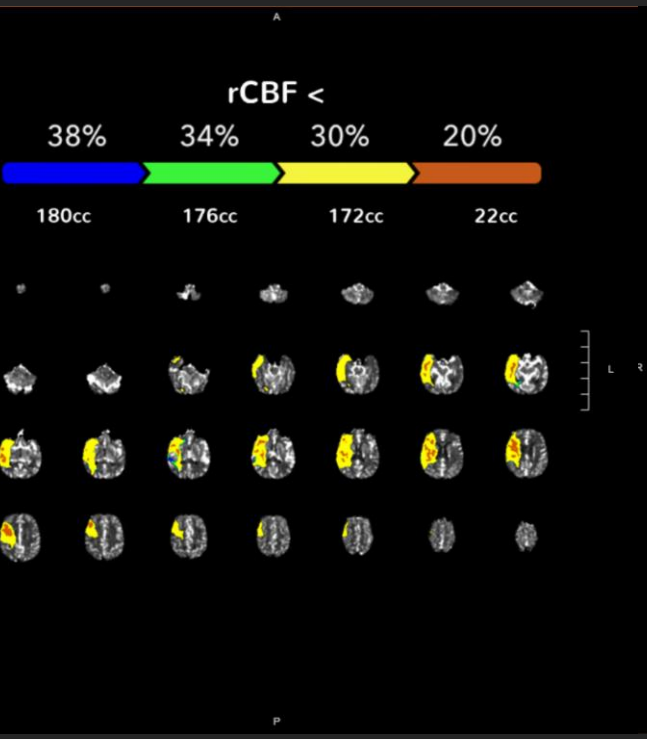
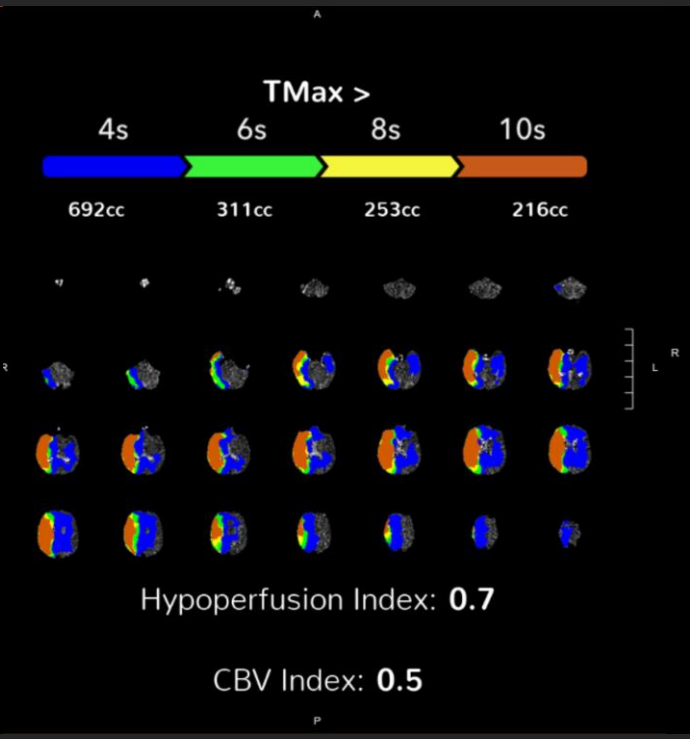


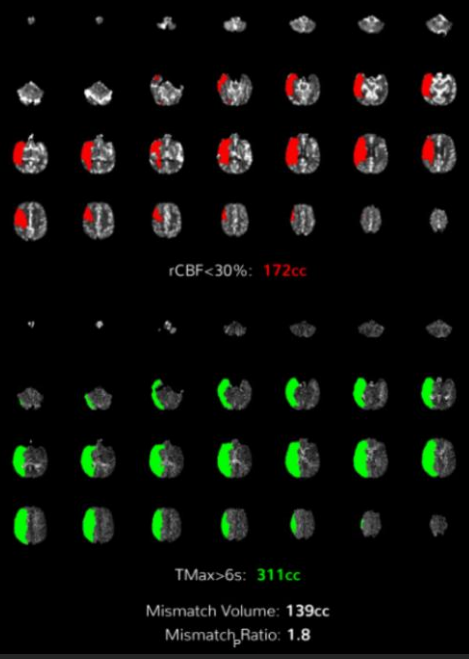

436/631
WW/WL: 600/300
Suspected LVO
RECORD. INFORMATIONAL PURPOSES ONLY. NOT FOR DIAGNOSTIC USE.



CT Perfusion Data







INR Consult

Neurointerventional Surgery Consultation Note

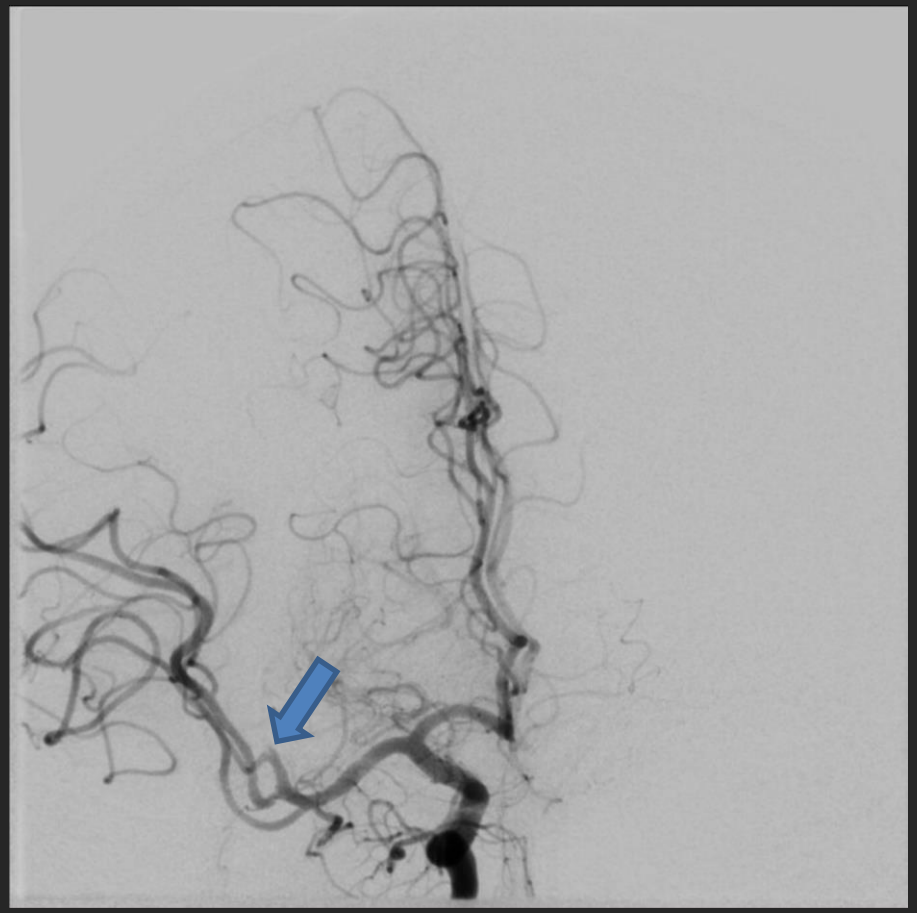
Consult Date: 4/21/2023, 5:55 AM

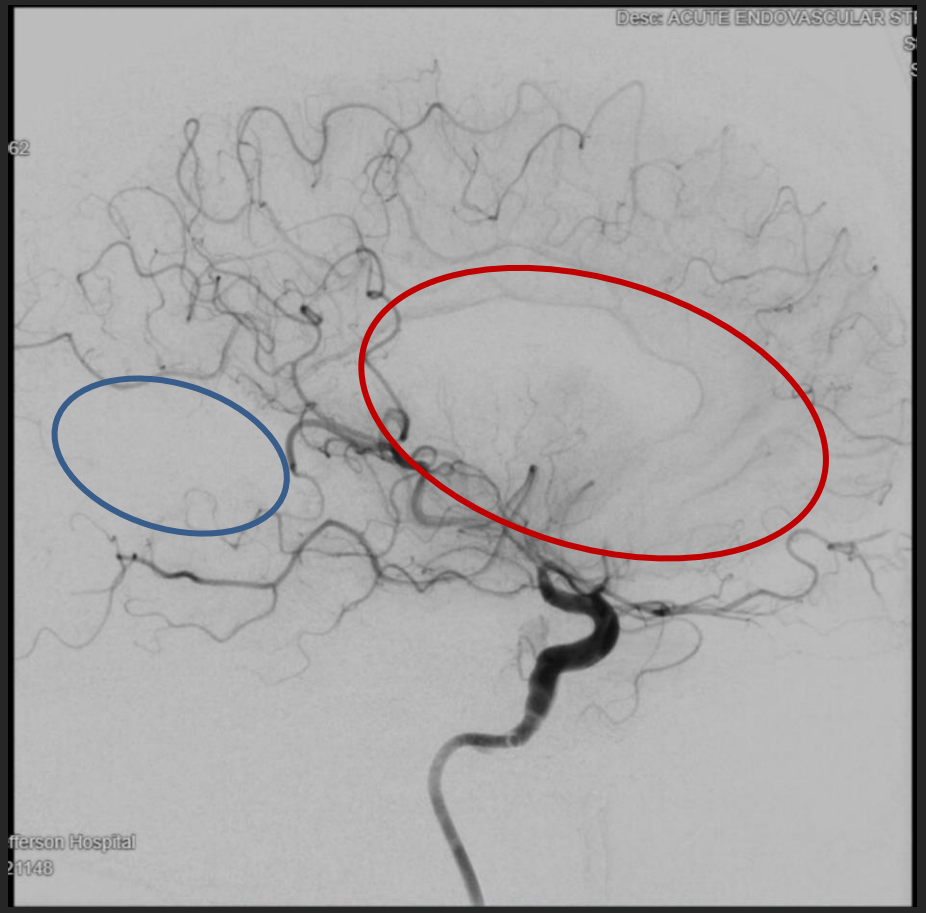
PCP: None

Chief Complaint: Stroke

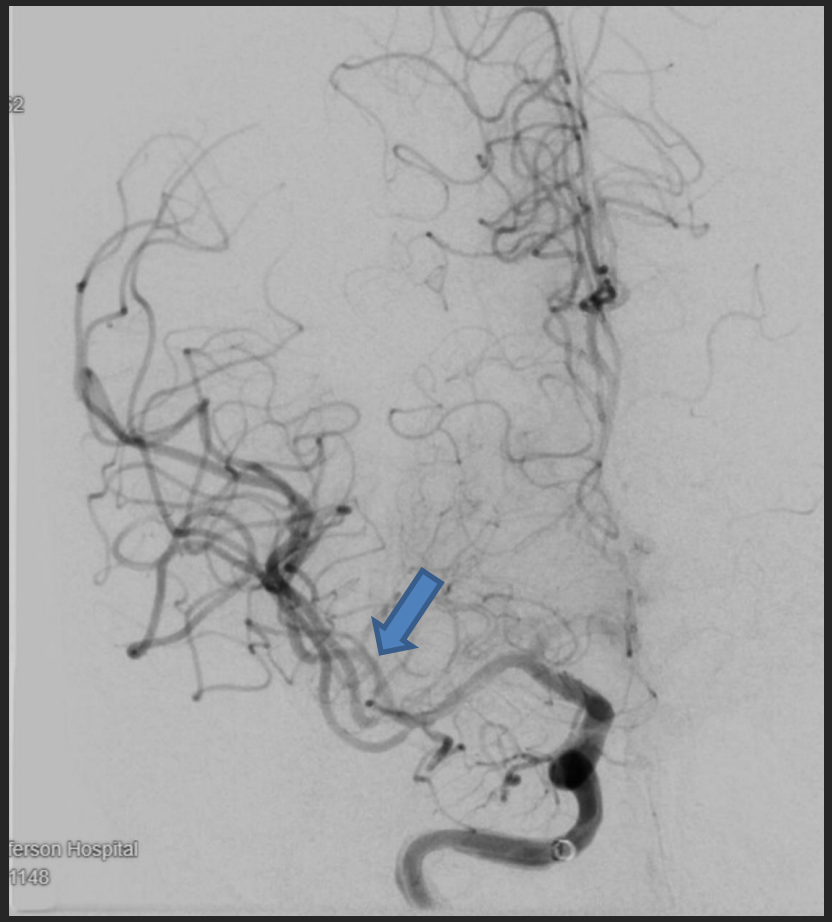
History of Present Illness: 66 y.o. male with known past medical history of atrial fibrillation and hypertension who presents with abrupt onset of left-sided weakness, facial droop, and neglect. The patient has a reported medication list that includes antiplatelet monotherapy with Plavix 75 mg daily. There is no documentation of oral anticoagulation use. Last known well at 2:45 AM. CT and CTA imaging demonstrates a large core right MCA infarct with a right M1 occlusion. The patient received intravenous thrombolysis with emergent transfer via air ambulance to SMJH for endovascular treatment.

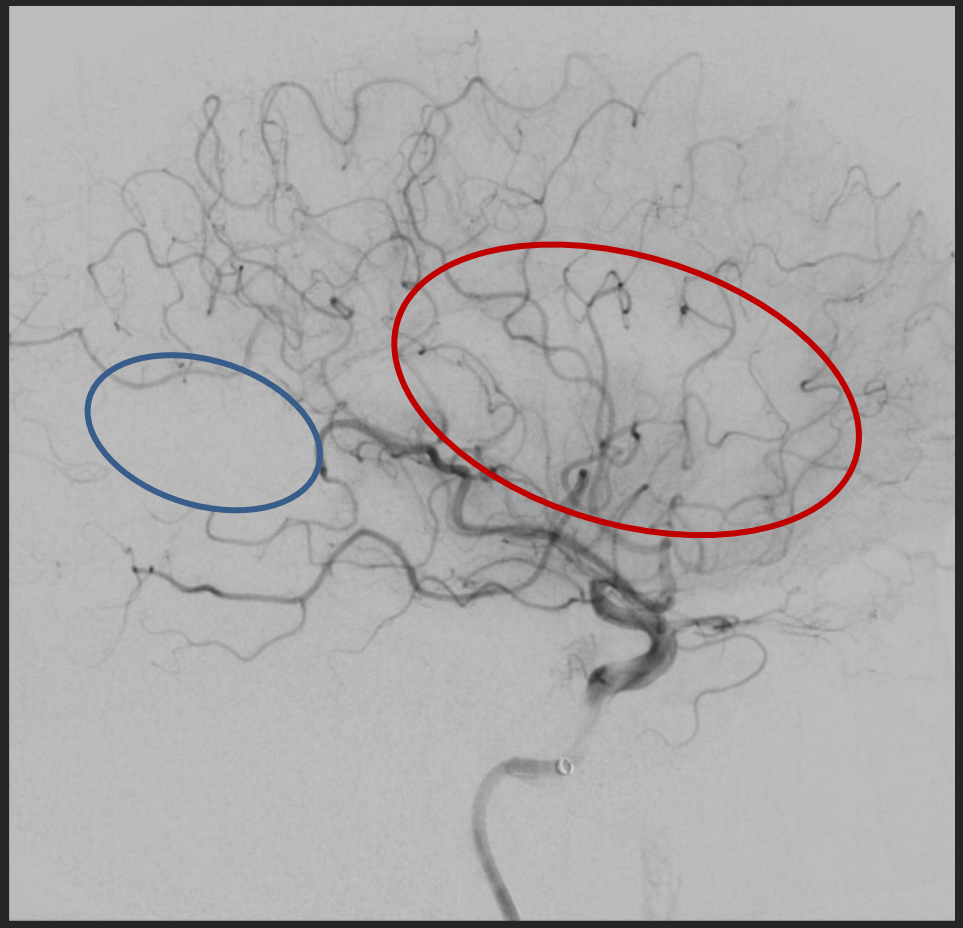
Pre-Thrombectomy RMCA Superior Division (M2)



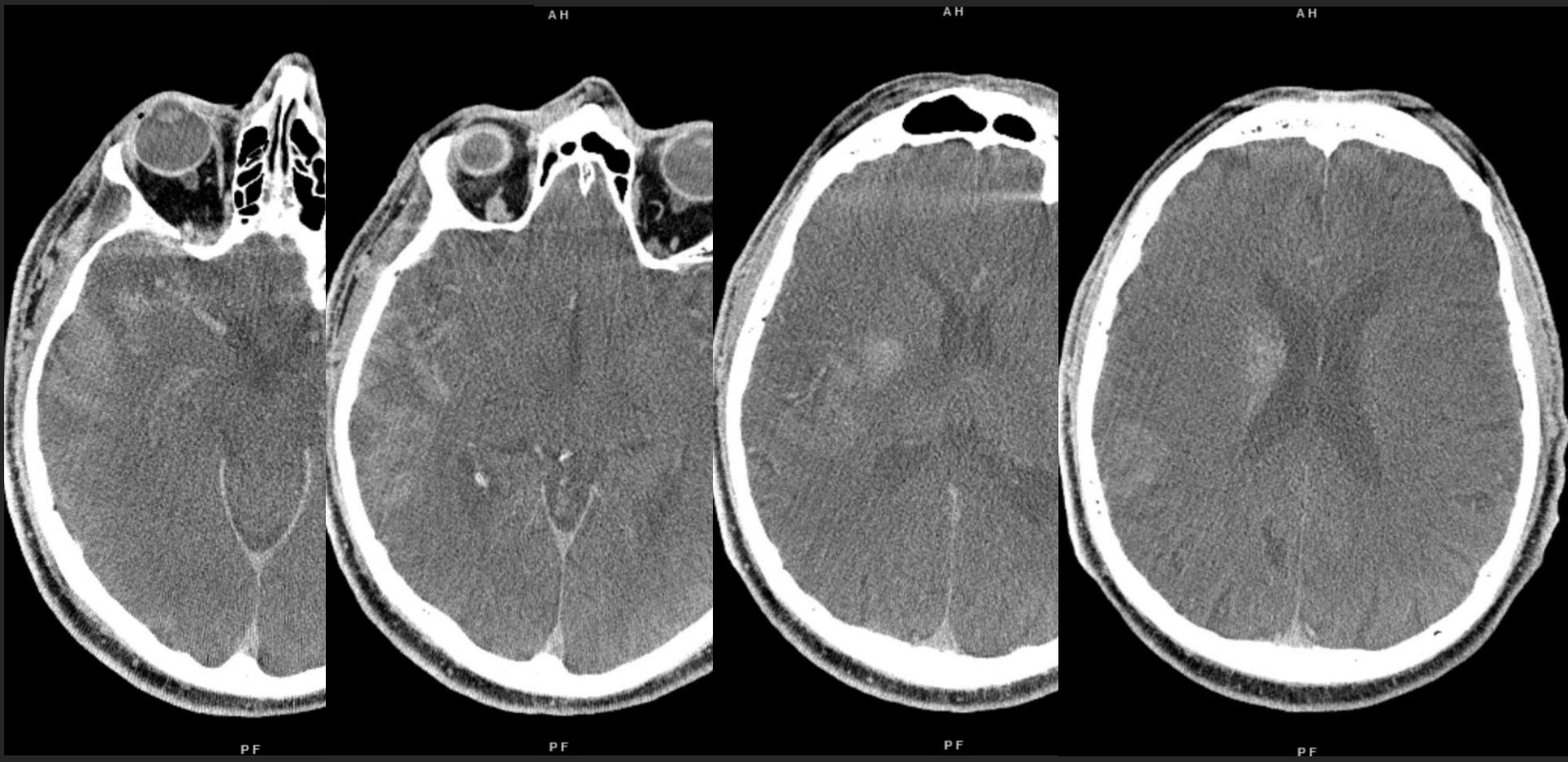


Post-Thrombectomy RMCA Superior Division





Post Thrombectomy Dyna-CT



Neurology Consult Post-Thrombectomy

Neurological Examination:

Mental Status:
Attention: Awake and alert. Attentive to examiner.
Appropriately oriented.
Language: Fluent, coherent speech. Follows commands. Able to repeat.
Neglect: Left visual neglect and tactile extinction noted.
Mood: Euthymic.

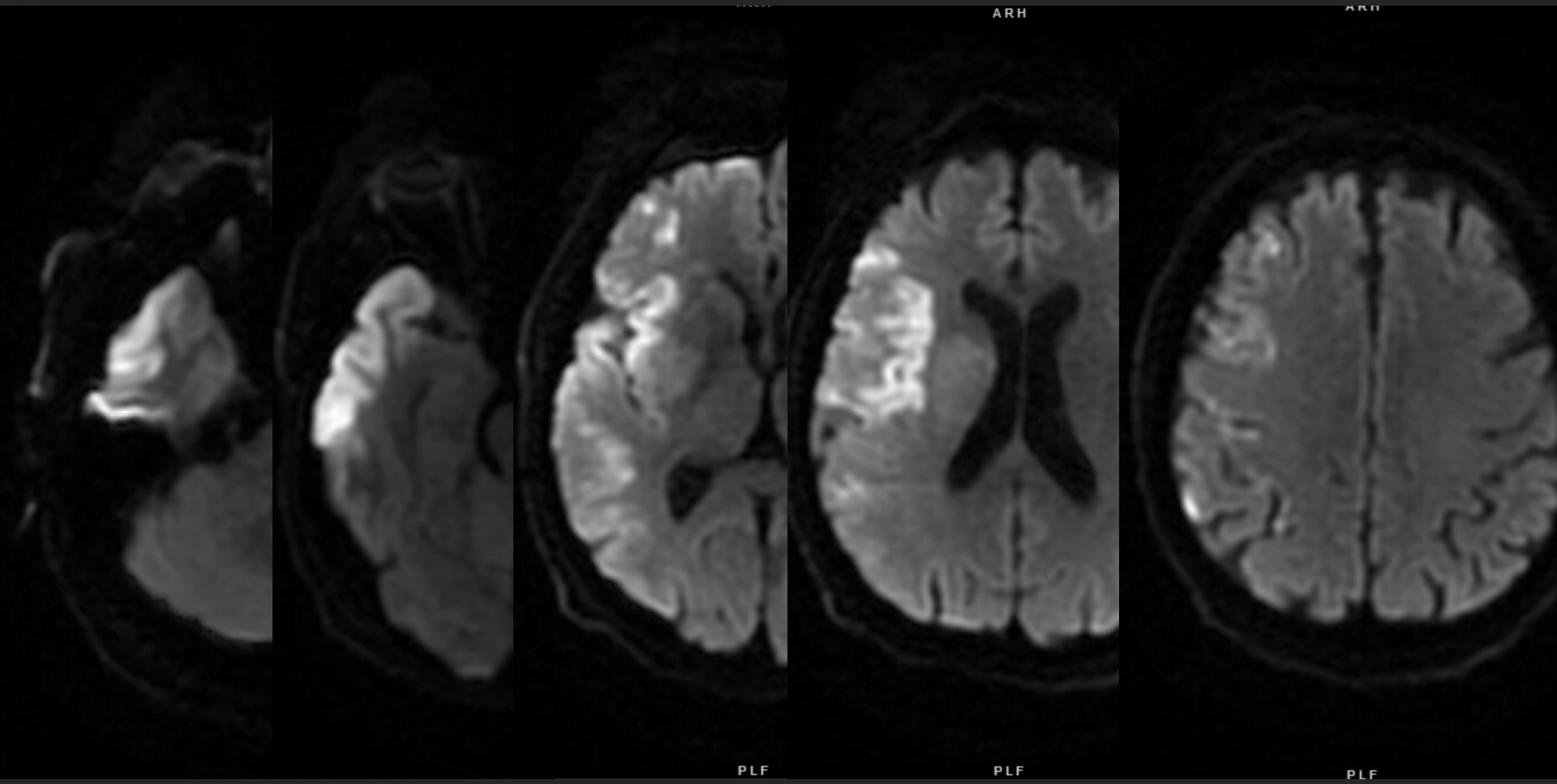
Cranial Nerves:
II: Visual fields full to confrontation. PERRL.
III, IV, VI: Conjugate primary gaze.
Right gaze preference. Able to overcome. Otherwise EOMI.
No spontaneous nystagmus noted.
V: Facial sensation symmetric.
VII: Decreased left facial activation.
VIII: Hearing at baseline bilaterally.
IX, X: Mild dysarthria.
XI: Shoulder shrug weak on left.
XII: Tongue midline.

Motor: Strength 5/5 in right arm and leg.
Strength 4-/5 in left arm and leg.
Left arm and left drifts to bed. Decreased left fine manual dexterity.
No tremor or adventitious movements.
Sensory: Decreased sensation to pinprick on left arm and leg.
Coordination: No dysmetria on FNF. Slowed left rapid alternating movements.
Gait: Deferred.

NIH Stroke Scale:

1) Level of Consciousness:	**0 - Alert and keenly responsive.**
2) Month and age:	**0 - Answers both questions correctly.**
3) Commands:	**0 - Performs both task correctly.**
4) Gaze:	**1 - Partial gaze palsy in one or both eyes. No forced deviation or total paresis.**
5) Visual fields:	**0 - No visual loss.**
6) Facial paresis:	**2 - Partial/lower unilateral facial paralysis.**
7) RUE Strength:	**0 - No arm drift over 10 seconds.**
8) LUE Strength:	**2 - Some effort against gravity. Arm drifts to bed.**
9) RLE Strength:	**0 - No leg drift over 5 seconds.**
10) LLE Strength:	**2 - Some effort against gravity. Leg drifts to bed.**
11) Ataxia:	**0 - No ataxia.**
12) Pin Sensation:	**1 - Mild/moderate sensory loss. Can sense sharp touch.**
13) Language:	**0 - No aphasia.**
14) Dysarthria:	**1 - Mild/moderate dysarthria. Slurred but intelligible.**
15) Neglect:	**2 - Severe neglect or extinction to >1 modality.**
Total NIHSS:	**11**

DWI MRI Day 1 Post-Thrombectomy



Neurology Follow-up Day 2 Post Thrombectomy

Mental Status:
Attention: Awake and alert. Attentive to examiner.
Appropriately oriented.
Language: Fluent, coherent speech. Follows commands. Able to repeat.
Neglect: No visual or tactile neglect noted.
Mood: Euthymic.

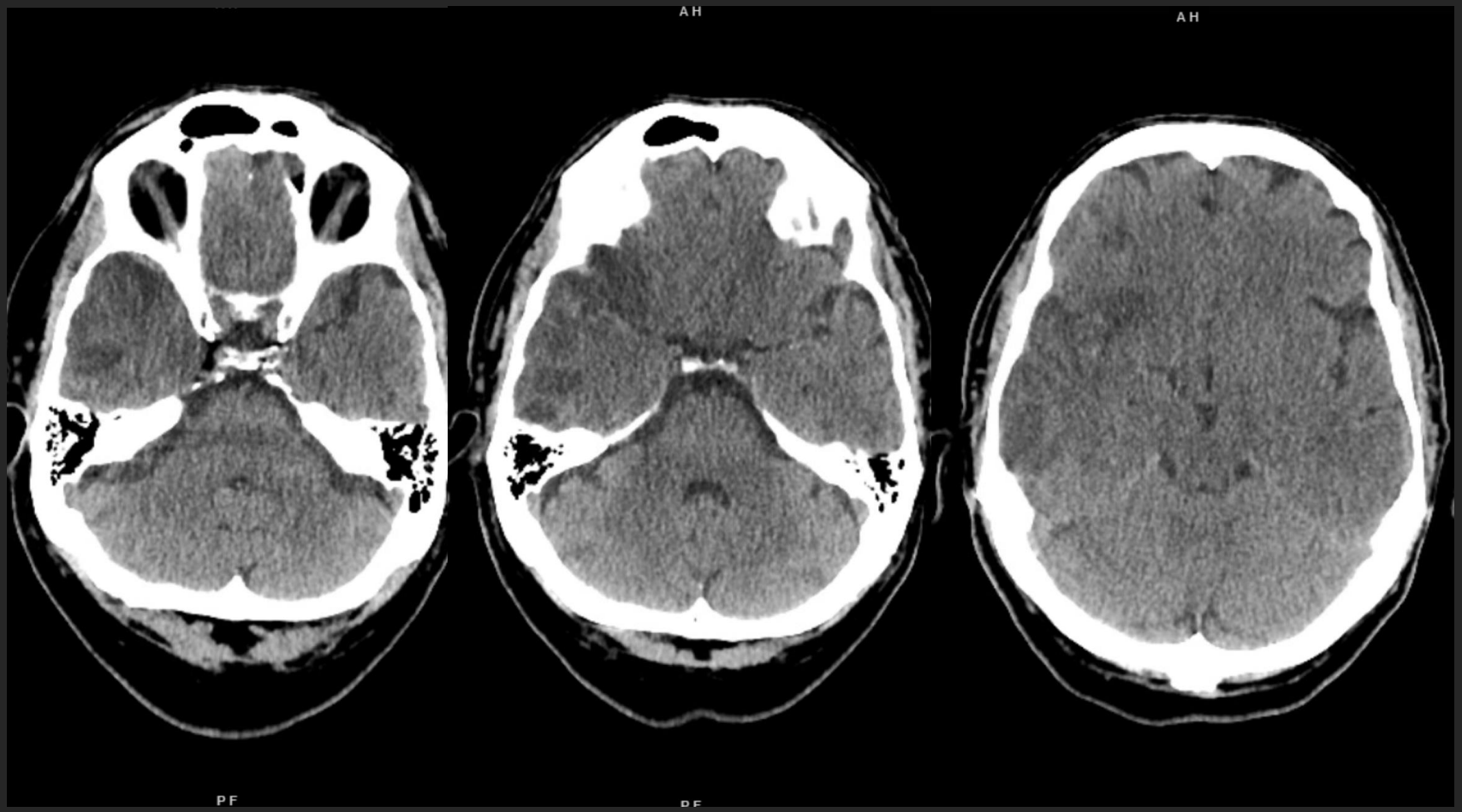
Cranial Nerves:
II: Visual fields full to confrontation. PERRL.
III, IV, VI: Conjugate primary gaze.
Slight right gaze preference. Able to overcome. Otherwise EOMI.
No spontaneous nystagmus noted.
V: Facial sensation symmetric.
VII: Decreased left facial activation.
VIII: Hearing at baseline bilaterally.
IX, X: Mild dysarthria.
XI: Shoulder shrug weak on left.
XII: Tongue midline.

Motor: Strength 5/5 in right arm and leg.
Strength 4-/5 in left arm. 5/5 in left leg.
Left arm drifts but not to bed. No drift in left leg. Decreased left fine manual dexterity.
No tremor or adventitious movements.
Sensory: Decreased sensation to pinprick on left arm and leg.
Coordination: No dysmetria on FNF. Slowed left rapid alternating movements.
Gait: Deferred.

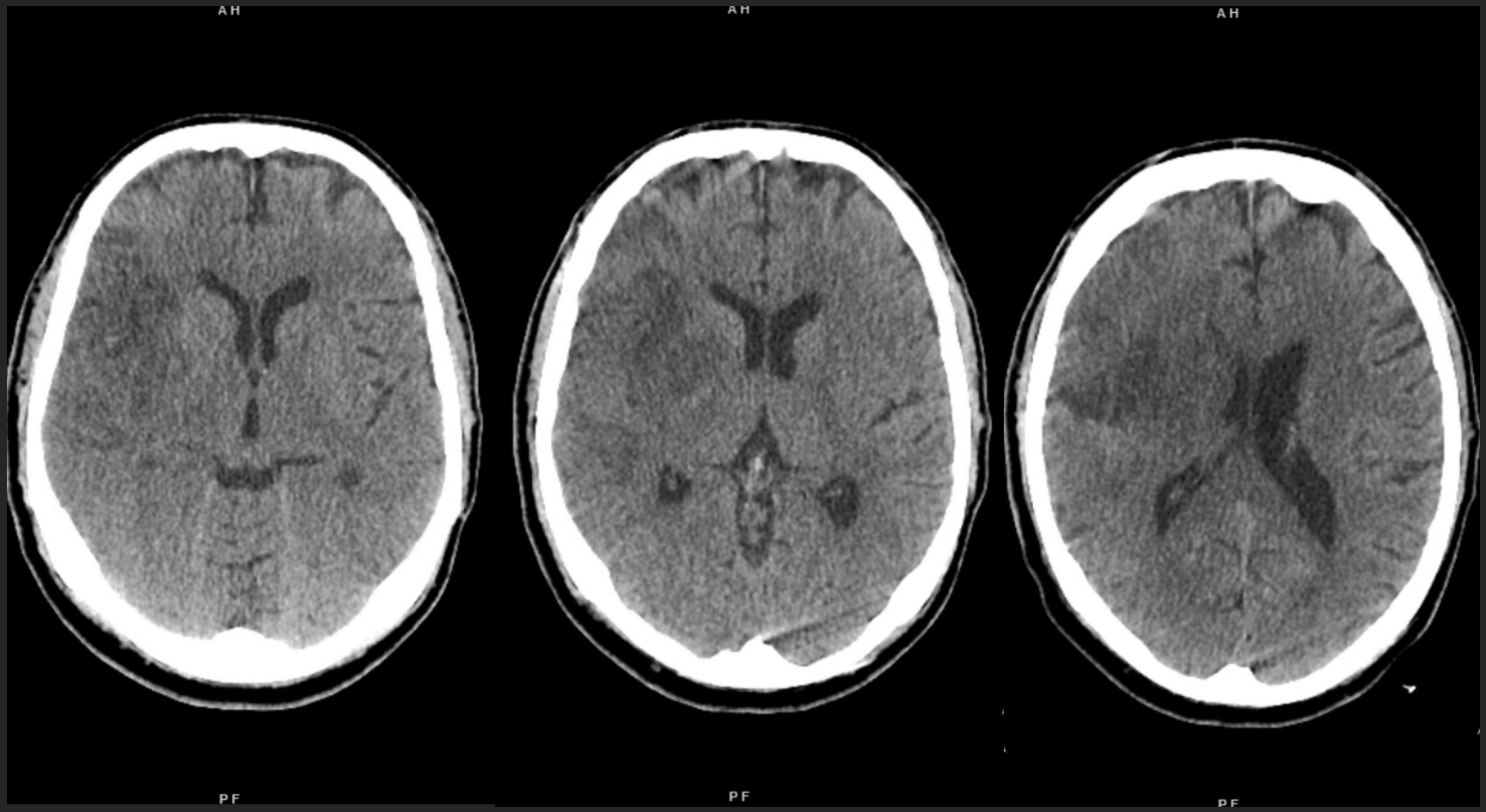
NIH Stroke Scale:

1) Level of Consciousness:	**0 - Alert and keenly responsive.**
2) Month and age:	**0 - Answers both questions correctly.**
3) Commands:	**0 - Performs both task correctly.**
4) Gaze:	**1 - Partial gaze palsy in one or both eyes. No forced deviation or total paresis.**
5) Visual fields:	**0 - No visual loss.**
6) Facial paresis:	**2 - Partial/lower unilateral facial paralysis.**
7) RUE Strength:	**0 - No arm drift over 10 seconds.**
8) LUE Strength:	**1 - Arm drifts but not to bed over 10 seconds.**
9) RLE Strength:	**0 - No leg drift over 5 seconds.**
10) LLE Strength:	**0 - No leg drift over 5 seconds.**
11) Ataxia:	**0 - No ataxia.**
12) Pin Sensation:	**1 - Mild/moderate sensory loss. Can sense sharp touch.**
13) Language:	**0 - No aphasia.**
14) Dysarthria:	**1 - Mild/moderate dysarthria. Slurred but intelligible.**
15) Neglect:	**0 - No neglect or extinction.**
Total NIHSS:	**6**

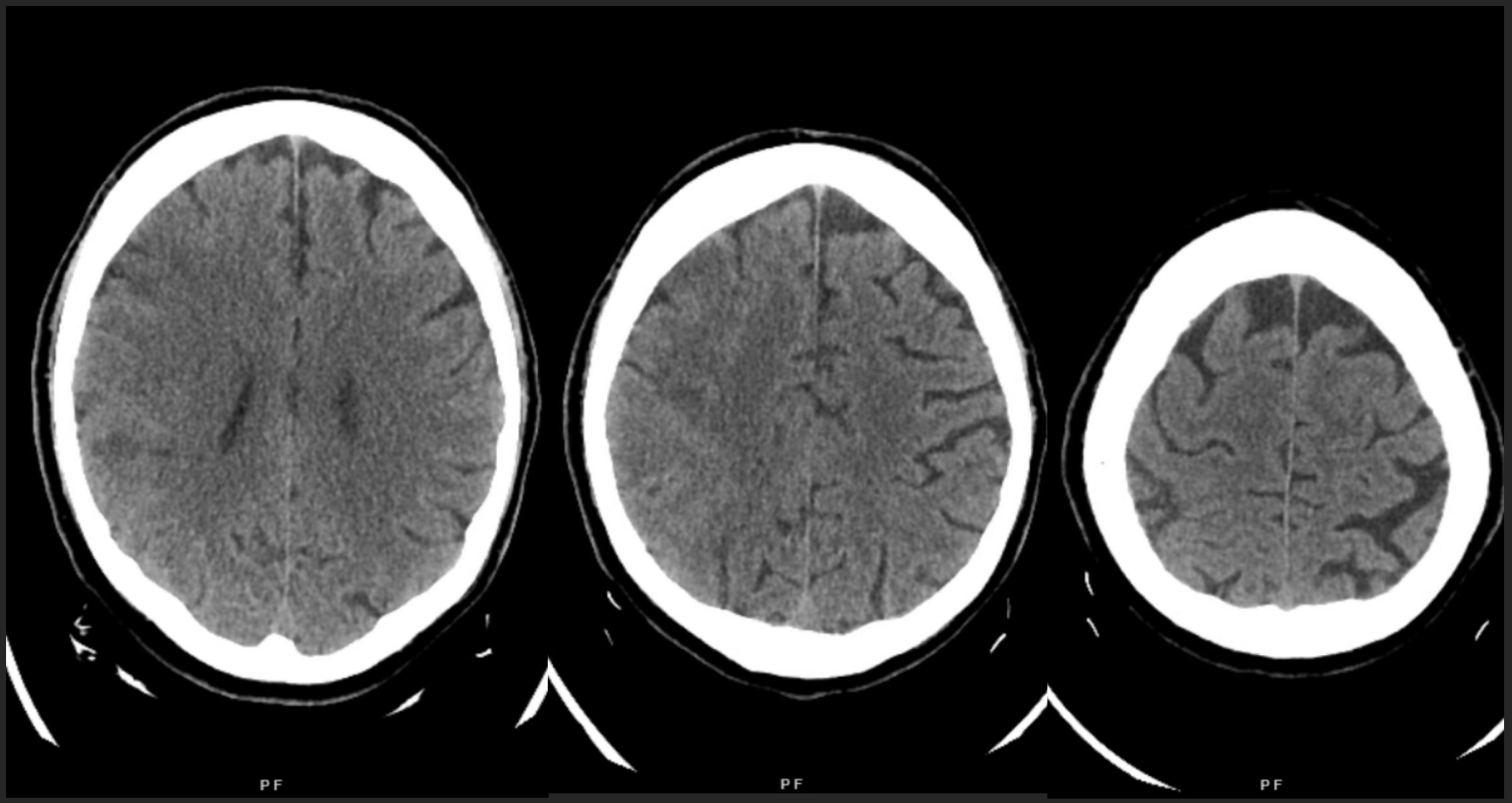
Head CT Day 3 Post-Thrombectomy



Head CT Day 3 Post-Thrombectomy



Head CT Day 3 Post-Thrombectomy



Conclusions

- Faster reperfusion leads to better outcome
- Appropriate patient selection leads to increased good outcomes and decreased bad outcomes/complications
    - LVO
    - ~~Salvageable tissue~~
    - ~~Early treatment~~
- Mechanical thrombectomy is the standard of care for this subset of stroke patients (up to 24 h)
- LVO scales help improve speed of diagnosis and treatment

Questions?


A STROKE IS
BRAIN ATTAC
LL 911
STROKE IS
RAIN ATTACK
CALL 911
OKE IS A
N ATTACK
L 911