

Inpatient Stroke Care

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Disclosures

None

Educational need/practice gap

- Practice gap: lack of standardized approach to stroke care
- Educational need: lack of familiarity with evidence-based stroke evaluation and management concepts

Upon completion of this educational activity, you will be able to



Describe (briefly) the epidemiology of stroke and mechanisms of ischemic stroke



Discuss best practices in stroke management



Review secondary stroke prevention measures

Expected outcome

- Provide high-quality care to patients with cerebrovascular pathologies

General approach to stroke

- Is it a stroke?
- What—if anything—can we do acutely
- Why did it happen?
- How can we reduce future morbidity and mortality?

What is a stroke?

- Stroke can be ischemic or hemorrhagic
 - Majority are ischemic (in adults)
 - Obstruction of blood flow (e.g., stenosis, thrombosis, or embolism) through a cerebral, retinal, or spinal artery, resulting in permanent tissue injury
 - Hemorrhagic strokes occur due to leakage of blood into tissue/parenchyma (intraparenchymal, IPH), ventricles (intraventricular, IVH), or the subarachnoid space (SAH)
 - Can be due to primary rupture of small arteries (e.g., from hypertension), rupture of vascular malformations (e.g., aneurysms), or conversion of ischemic stroke, among other things

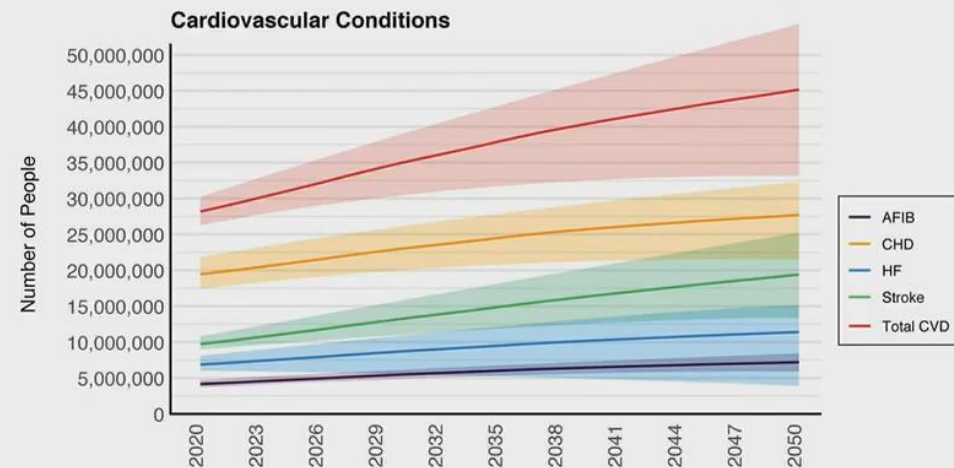
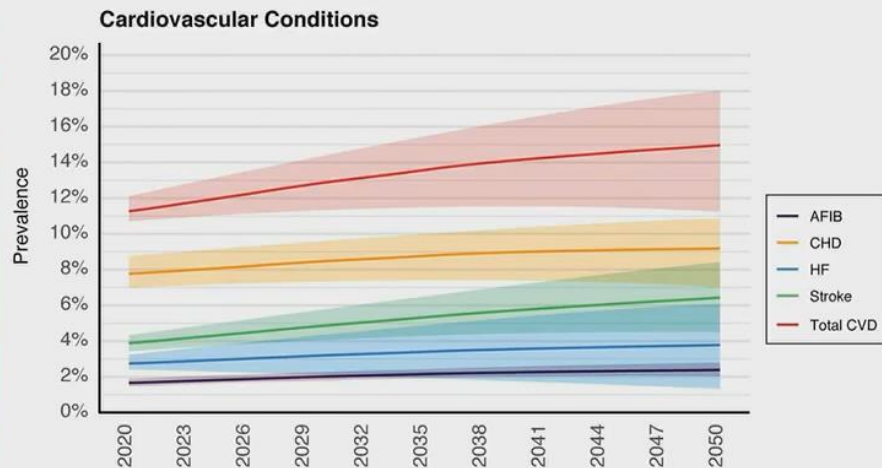
What is a stroke?

- Central retinal artery occlusion
 - Interruption of blood flow through the central retinal artery by thromboembolism or vasospasm with or without retinal ischemia
- Cerebral venous sinus thrombosis
 - Infarction or hemorrhage in the brain, spinal cord, or retina because of thrombosis of a cerebral venous structure
- TIA (transient ischemic attack)
 - Transient episode of neurological dysfunction caused by focal brain, spinal cord, or retinal ischemia without acute stroke

A booming business

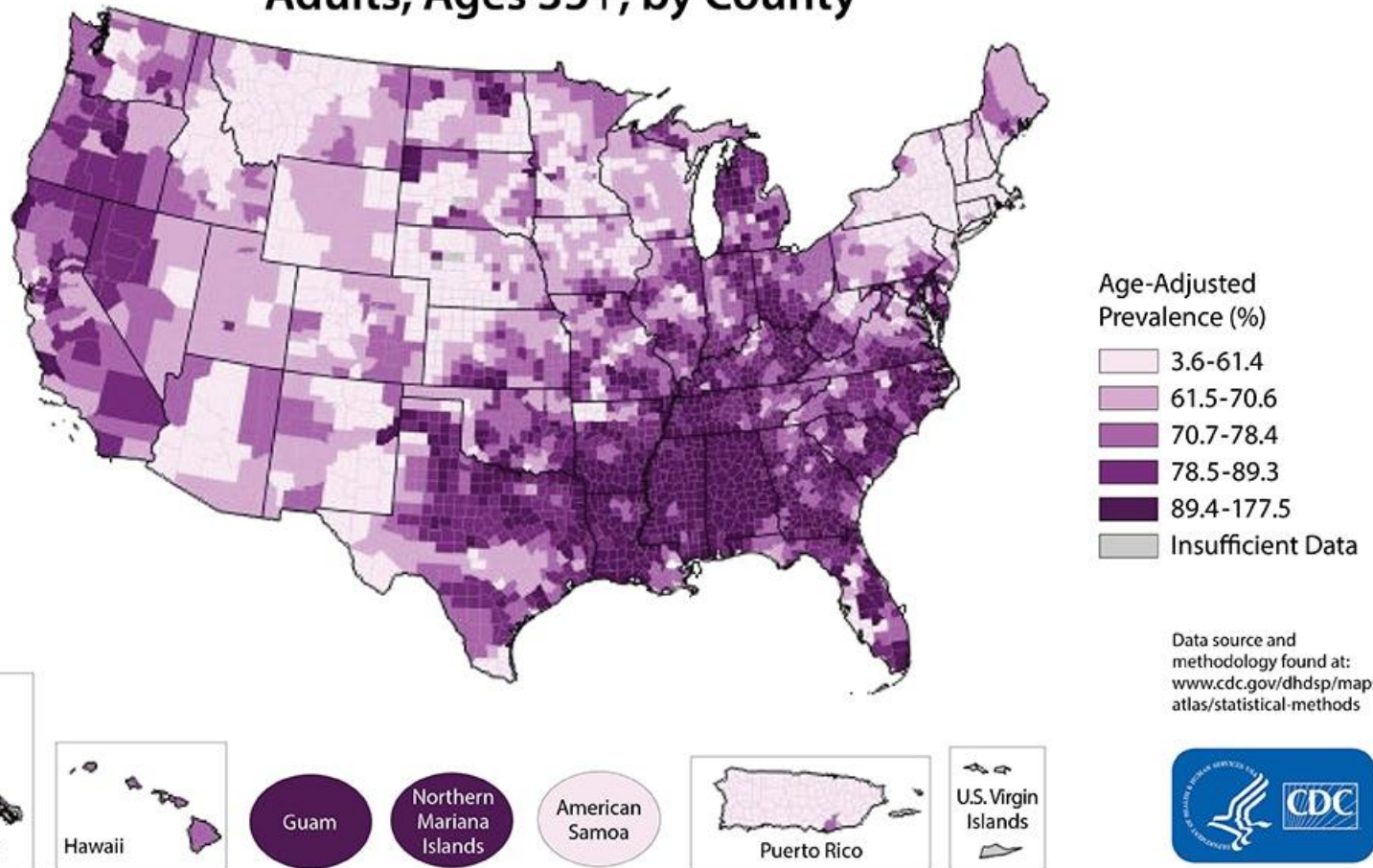


FORECAST FOR PREVALENCE AND NUMBER OF ADULTS WITH STROKE: 2020→2050, U.S.



This is fine. Everything's fine.

Stroke Death Rates, 2018-2020 Adults, Ages 35+, by County



Rural patients

- Higher mortality rates relative to urban patients
- Reduced access to treatment
- Worse functional outcomes after acute therapies (chemical fibrinolysis, thrombectomy)
- More socially vulnerable at baseline
 - Higher enrollments in Medicaid
 - Higher levels of disability
 - Risk factors are more prevalent
 - Risk factors are less controlled
- Disparities are more pronounced for Black patients in rural areas

Cerebrovascular disease risk factors

- Sleep apnea
- Hypertension
- Low physical activity
- Poor diet quality
- Inadequate sleep duration
- Hypertension
- Dyslipidemia
- Diabetes
- Atrial fibrillation
- Cigarette smoking
- High body weight
- Etcetera

General approach to stroke

- ~~Is it a stroke?~~
 - ~~Yes~~
- ~~What—if anything—can we do acutely~~
 - ~~No longer relevant~~
- Why did it happen?
 - We'll focus on ischemic stroke, since it's the majority of stroke in adults
- How can we reduce future morbidity and mortality?

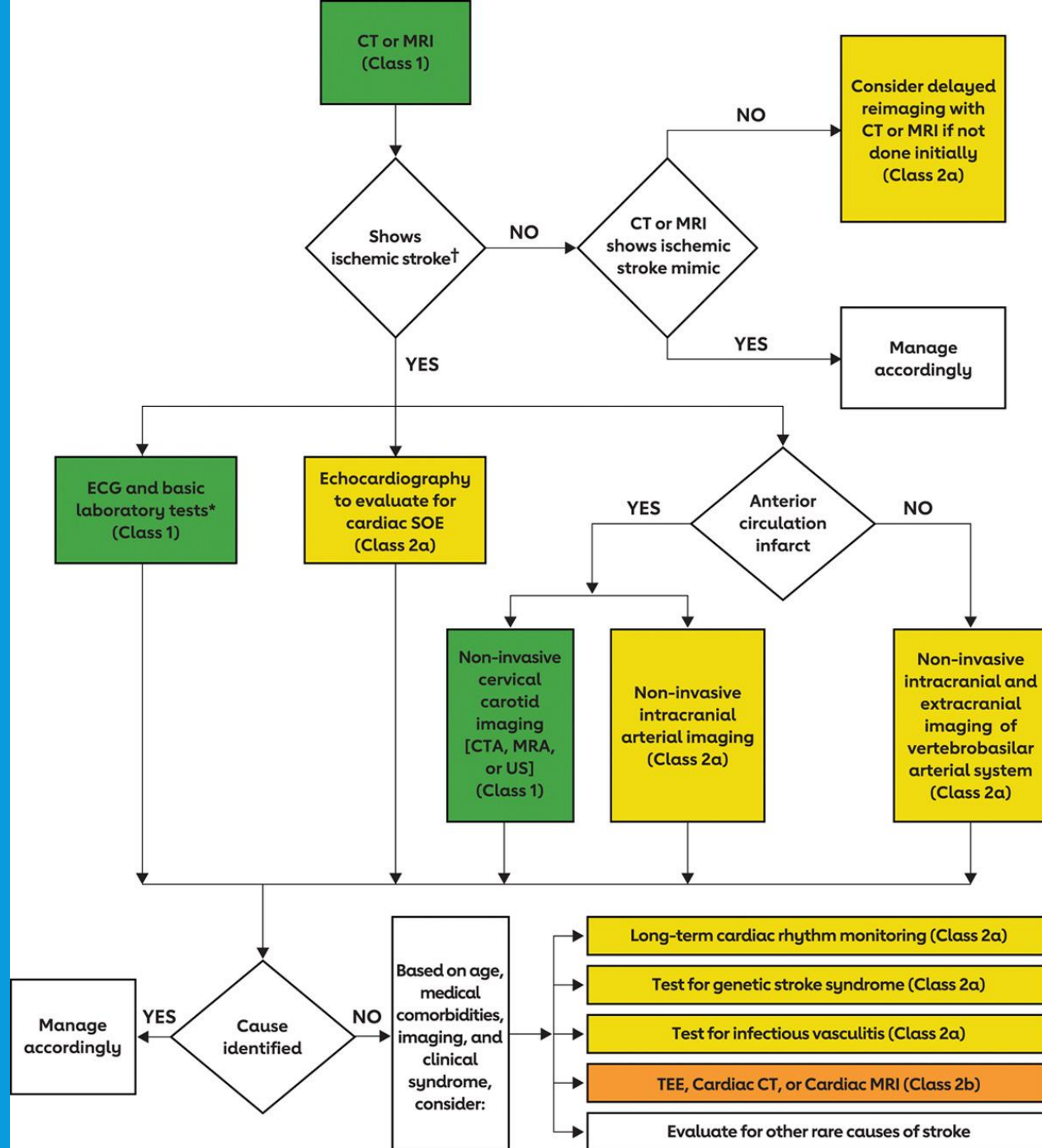
Case

- Bob is an elderly person who hasn't been to the doctor since soda was a nickel
- He couldn't use his left arm or leg yesterday and thought he'd sleep it off
- Shockingly, his symptoms didn't get better, so his family forced him to come in to the ED
- He gets admitted for a suspected stroke

Case



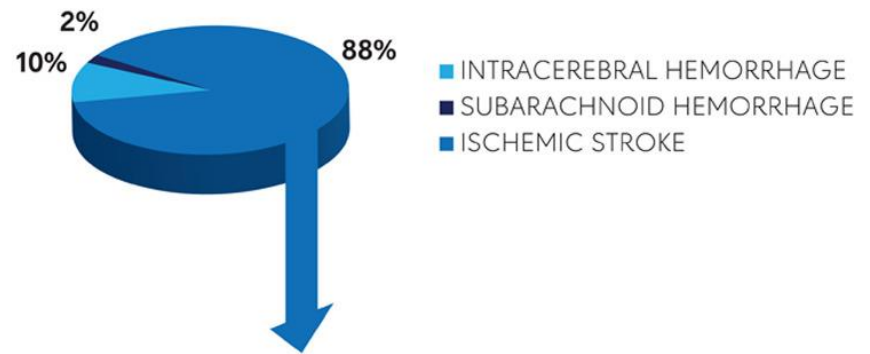
Just follow the algorithm and we're done.



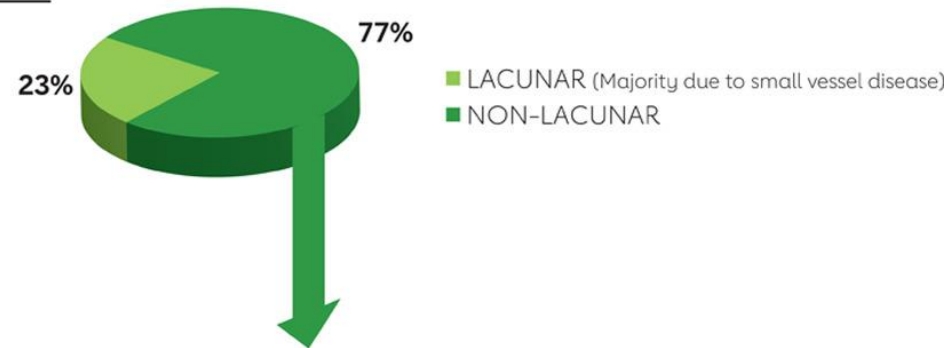
Why did the stroke happen?

- Vessel imaging
 - Arteries, veins
- Cardiac studies (EKG, echocardiogram, rhythm monitoring)
- Lab work: TSH, A1c, lipid panel
 - Hypercoagulable studies (maybe)
- May or may not need MRI

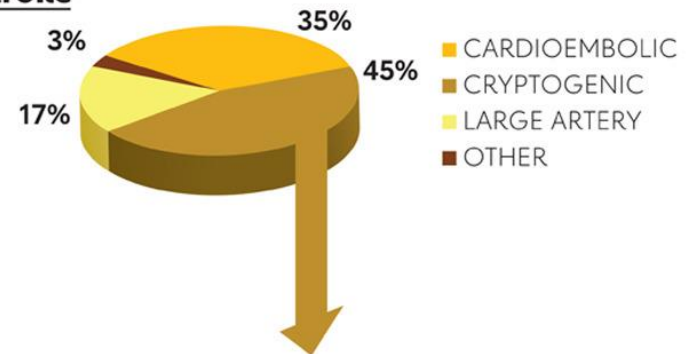
Stroke



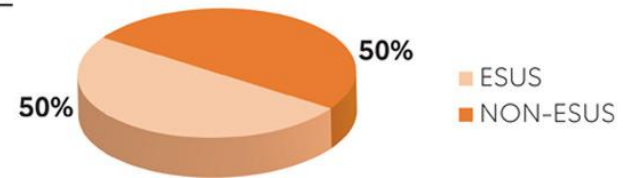
Ischemic Stroke

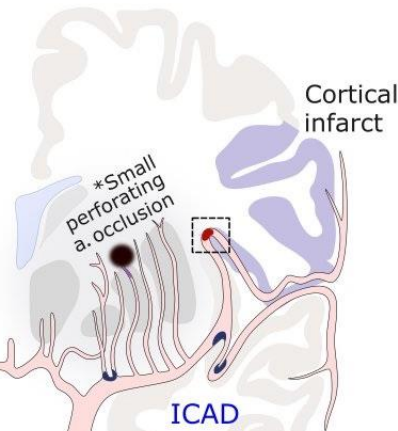
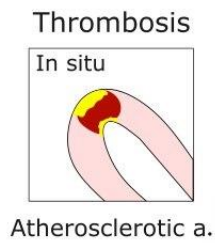
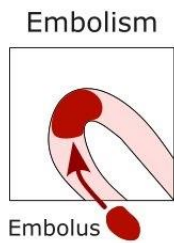


Non-lacunar Stroke

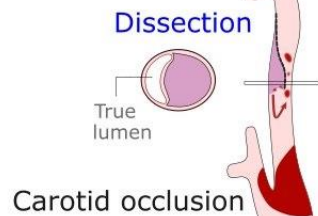
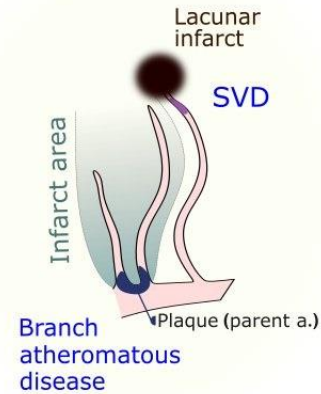


Cryptogenic Stroke





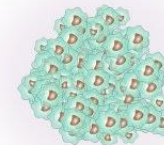
*Small subcortical infarcts



Artery-to-artery thromboembolism

Carotid a. disease (Plaque w thrombus)

Cancer-related stroke



Cardioembolism

Aortic arch atherosclerosis

AFib



LAA & thrombus

Valvular disease
Endocarditis

LV thrombus

Paradoxical embolism

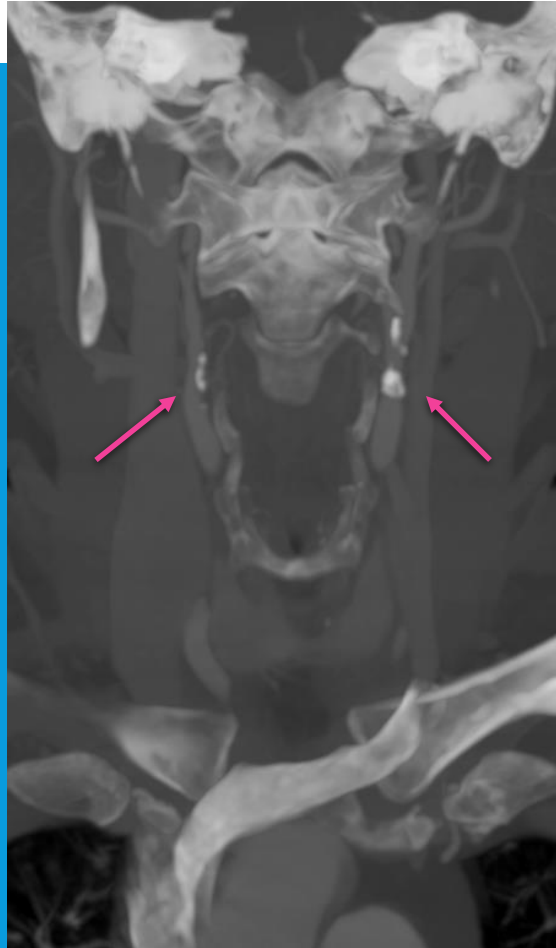
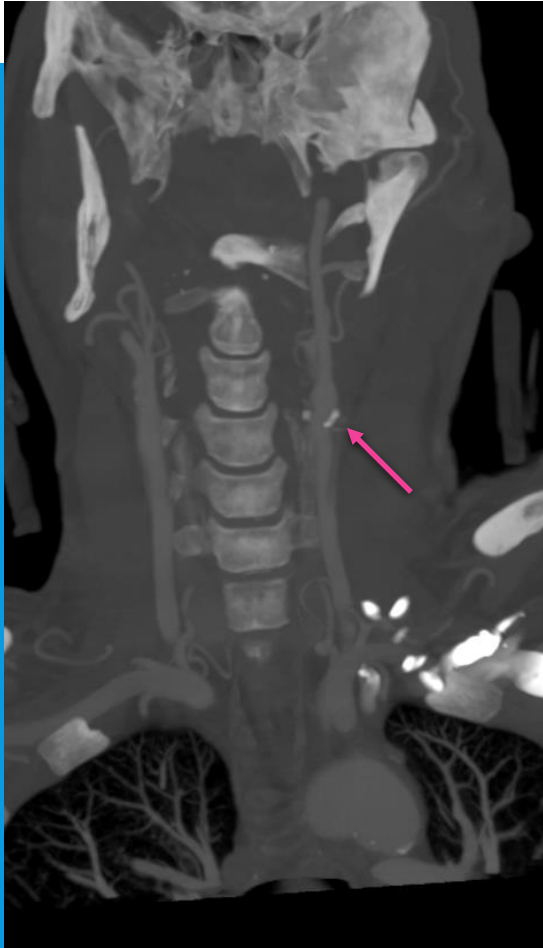


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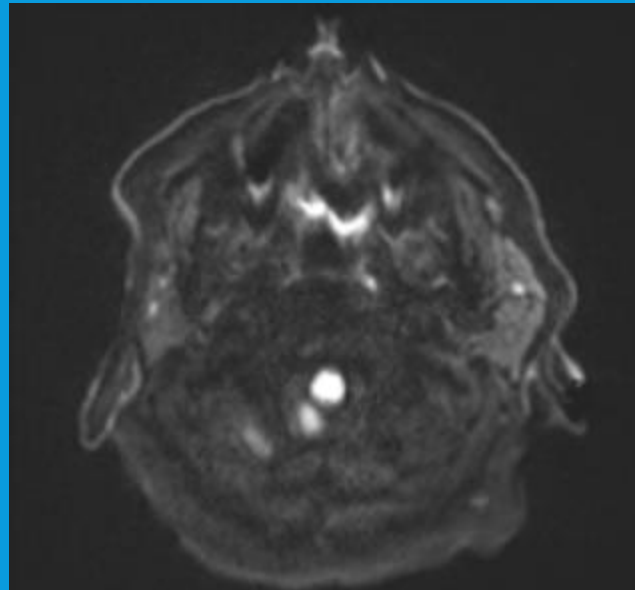
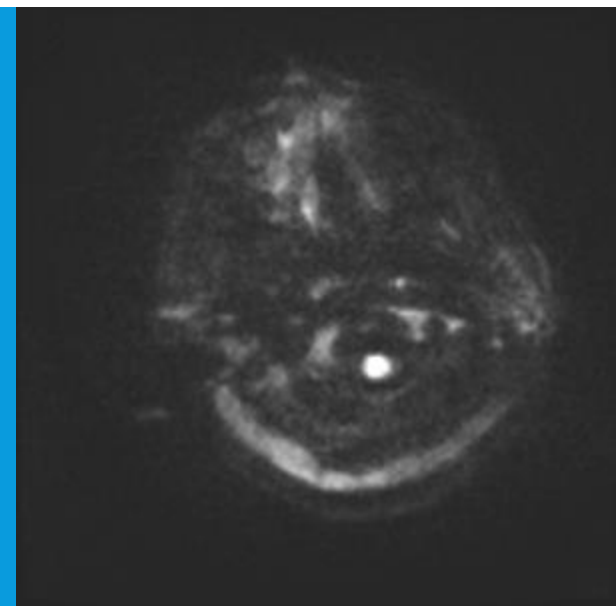
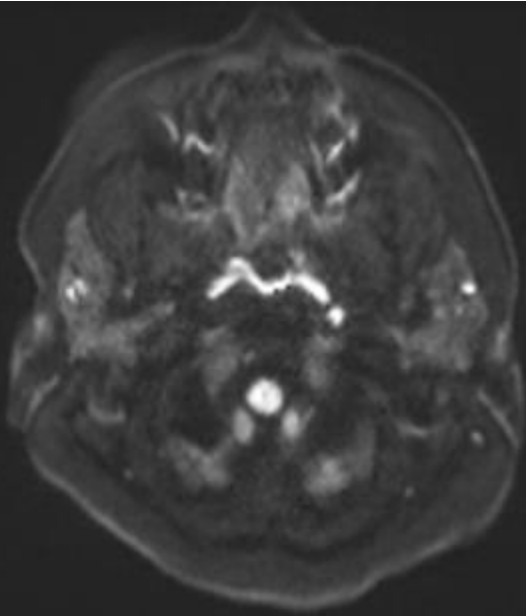
Is there a culprit vessel?

- CTA head/neck: quick, easy, cost-effective; good view of lumen
 - Uses radiation, iodinated contrast; not great at vessel wall; no idea of flow dynamics
- MRA head/neck: good view of vessel wall if protocols are available; can overestimate stenosis unless contrast is used; no radiation
 - Takes more time, patience; higher cost; gadolinium may be an issue; no flow dynamics
- Ultrasound: can be quick, cost-effective, good for flow dynamics
 - Operator dependent; limited intracranial views

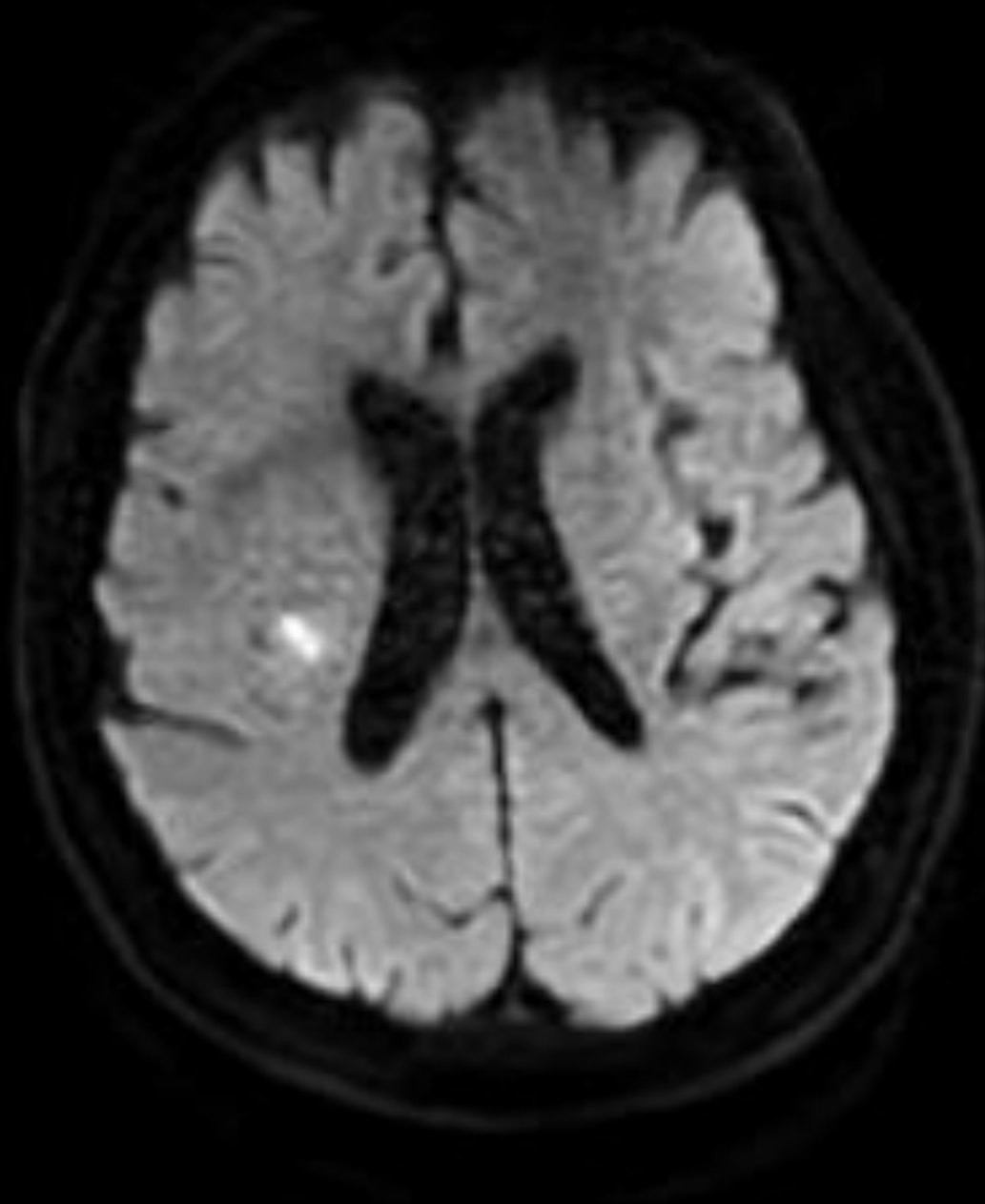
CTA neck, coronal



Stroke patterns



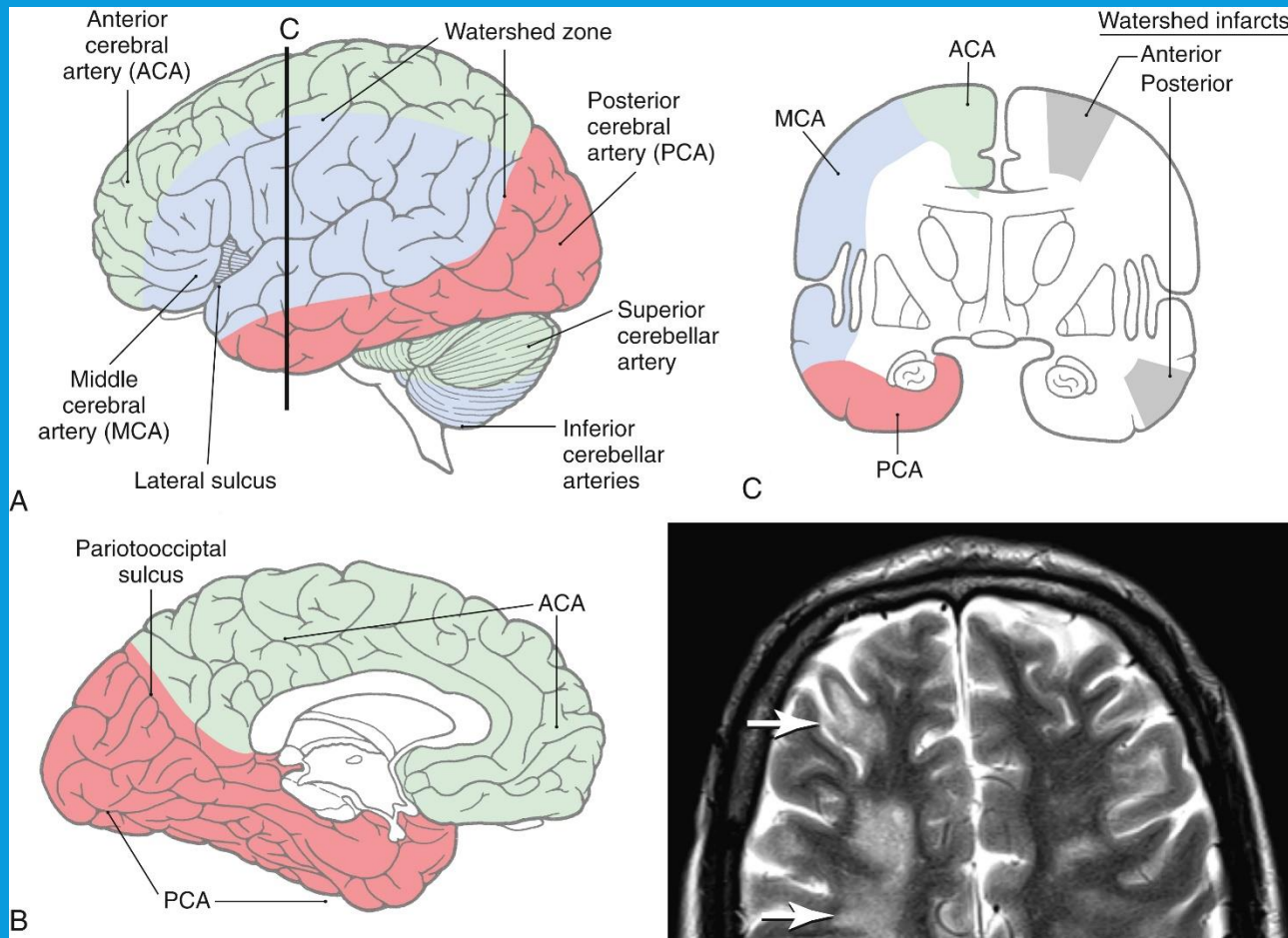
Case



Watershed infarcts (hypotensive stroke)

- Occur in the setting of a stenotic-occluded vessel
 - Collateral blood supply can only go so far
- Strokes occur in border zones between arterial territories
- Blood pressure targets are individualized
 - May be based on systolic or mean arterial pressure to avoid symptoms (hypotension)
- Avoid large drops in blood pressure in the acute setting
 - As with all acute ischemic strokes, permissive hypertension up to 220 mm Hg initially, with gradual normalization
- Maximal medical therapy and/or procedural intervention for long-term management

Watershed infarcts (hypotensive stroke)



Lab work

- TSH
- Lipid panel
- Hemoglobin A1c

Case

- Bob's hemoglobin A1c was 7.5
- His LDL was 150
- His TSH was unremarkable

Let's get to the heart of the matter

- We investigate the heart when we suspect an embolic process, or specifically a cardioembolic process
- We're looking for arrhythmias and/or structural pathology
- EKG
- TTE
- TEE
- Cardiac CT
- Cardiac MRI

Echocardiography

- Patent foramen ovale
- Atrial myxoma
- Papillary fibroelastoma
- Valvular vegetations

PFO

- RoPE Score
- PASCAL

Patient

Risk o

Identifies str

Evaluation

INSTRUCT

Use in pati
for stroke.

When

History of hy

History of dia

Treat under

History of str

Smoker

Cortical infar

Age

High R

PFO closure i

Factors reducing
of clc

- Low RoPE score, age and multi
- Need for antico

(Class 2a)

Proposed flexible clinical practice approach to classifying patent foramen ovale causal association in patients with embolic infarct topography and without other major stroke sources*

Risk source	Features	RoPE score	
		Low [¶]	High [¶]
Very high	A PFO and a straddling thrombus	Definite	Definite
High	(1) Concomitant pulmonary embolism or deep venous thrombosis preceding an index infarct combined with either (2a) a PFO and an atrial septal aneurysm or (2b) a large-shunt PFO	Probable	Highly probable
Medium	Either (1) a PFO and an atrial septal aneurysm or (2) a large-shunt PFO	Possible	Probable
Low	A small-shunt PFO without an atrial septal aneurysm	Unlikely	Possible

RoPE: Risk of Paradoxical Embolism; PFO: patent foramen ovale.

* The algorithm in this table is proposed for use in flexible clinical practice when application of an entire formal classification system is not being conducted.

¶ The RoPE score includes points for 5 age categories, cortical infarct, absence of hypertension, diabetes, prior stroke or transient ischemic attack, and smoking. A higher RoPE score (≥ 7 points) increases probability of causal association.

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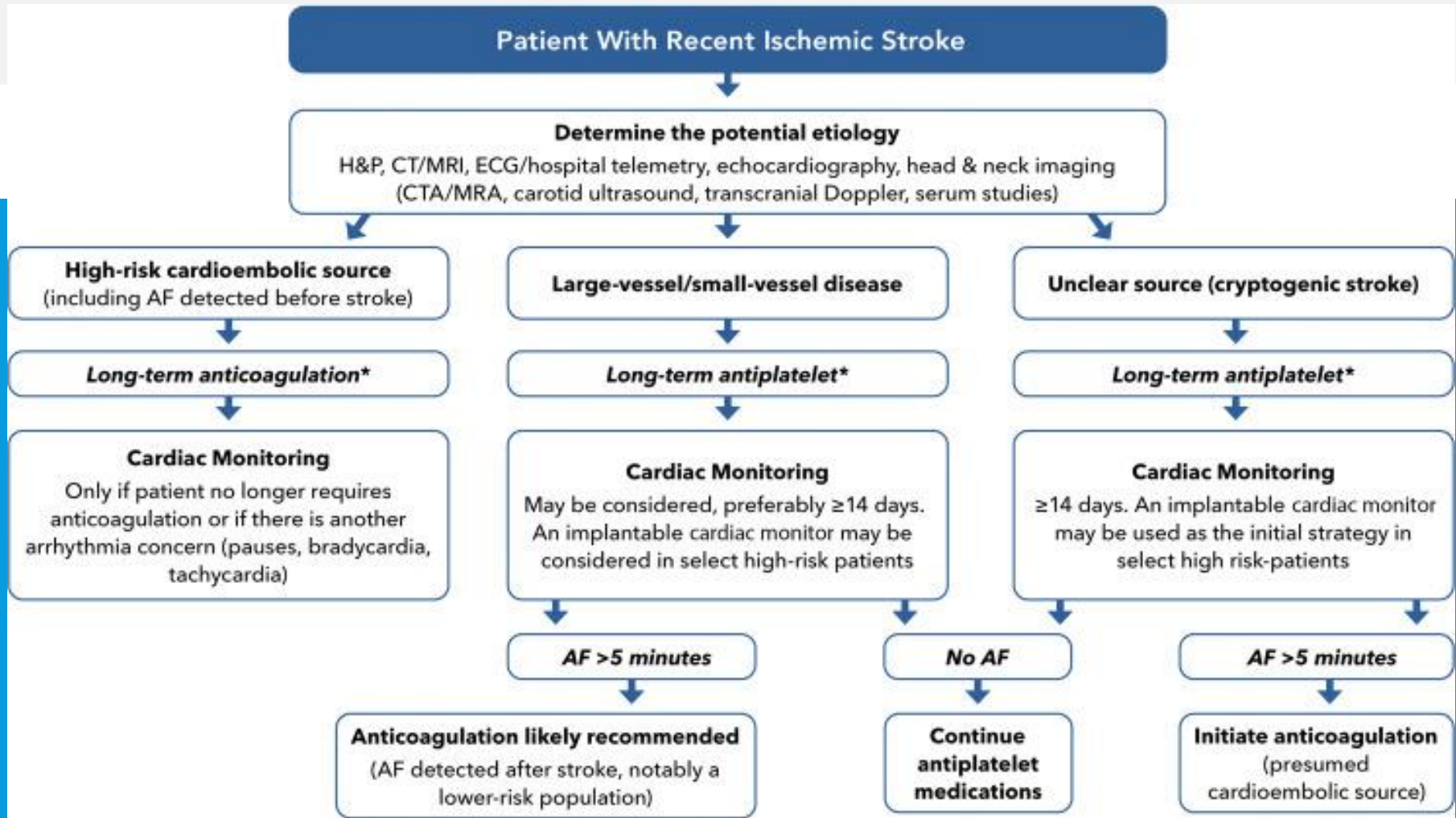
• Failure of antiplatelet treatment

(Class 2b)

Heart monitoring

- “As recommended in current guidelines from a variety of professional societies, prolonged cardiac monitoring should be offered to patients with recent [embolic stroke of undetermined source] if they are felt to be a candidate for long-term anticoagulation should [atrial fibrillation] be identified.”

2024 ACC Expert Consensus Decision Pathway on Practical Approaches for Arrhythmia Monitoring After Stroke



All stroke patients require optimized medical management, including:

- High-intensity statin (if stroke related to atherosclerosis)
- Long-term BP control
- Long-term glucose control
- Lifestyle interventions, including increased physical activity, weight loss if overweight, alcohol moderation, smoking cessation

How much is enough?

- “Uncertainty remains around the optimal duration of monitoring and the minimum burden of atrial fibrillation detection necessary to justify long-term oral anticoagulation.”

European stroke organization guidance

- Some cost-effectiveness models/analyses have shown that implanted devices are more economical (albeit with higher upfront costs) compared to external-to-internal strategies.

Evidence-based recommendation

In adult patients with ischaemic stroke or TIA of undetermined origin, we suggest the use of implantable devices for cardiac monitoring instead of non-implantable devices to increase the detection of subclinical AF.

Quality of evidence: **Low** ⊕⊕

Strength of recommendation: **Strong for intervention** ↑↑

Thrombophilia or hypercoagulability

Thrombophilia	Location	Inheritance	Acute phase reactant	Affected by anticoagulation
Protein C	Venous thromboembolism (VTE)	Inherited or de novo	Yes	Yes
Protein S	VTE	Inherited or de novo	Yes	Yes
Antithrombin III	VTE	Inherited or de novo	Yes	Yes
Factor VIII	VTE	Inherited or de novo	Yes	Yes
Prothrombin mutation	VTE	Inherited or de novo	No	No
Factor V Leiden	VTE	Inherited or de novo	No	No
Lupus anticoagulant	VTE or arterial	Acquired	Maybe	Yes
Anticardiolipin	VTE or arterial	Acquired	Maybe	No
Antibeta2 glycoprotein	VTE or arterial	Acquired	Maybe	No

Thrombophilia testing

- Due to possibility of abnormal tests in the acute setting, thrombophilia testing recommended as an outpatient
- Because certain anticoagulants can affect certain thrombophilia tests, testing should be done 2-4 weeks after last dose

MRI

- Stroke is a clinical diagnosis
 - If the story, exam, CT head imaging all fit together, MRI can be deferred
- If something doesn't add up, MRI may help clarify

General approach to stroke

- ~~Is it a stroke?~~
 - ~~Yes~~
- ~~What—if anything—can we do acutely~~
 - ~~No longer relevant~~
- Why did it happen?
- How can we reduce future morbidity and mortality?

Complications of stroke

- Neurologic deficits
- Headache
- Aspiration pneumonia
- Seizures (not common)
- Cerebral edema
- Increased intracranial pressure and possible herniation
- Hemorrhagic transformation
 - Petechial hemorrhage more common than frank hemorrhage
 - Post-thrombolytic bleeding not common

Stroke units

- Organized inpatient interdisciplinary care team comprising nursing, pharmacy, rehabilitation, neurology, hospitalist, and case management staff, among others
- Incorporation of standardized order sets and protocols to reduce odds of poor outcomes and death

CO R	RECOMMENDATIONS
1	In patients with AIS of all ages, treatment within an organized inpatient stroke care unit supported by a specialty trained, interdisciplinary care team (ie, acute stroke units, rehabilitation stroke units, comprehensive stroke units, and mixed rehabilitation units) that incorporates standardized stroke care order sets and protocols is recommended to reduce the odds of poor outcomes and death.

Characteristics of an inpatient stroke care unit



Clinical Management (first 5 days)

- Standardized acute stroke care order sets utilization
- Physical and medical complications management guided by clinical practice guidelines/protocols
- Early rehabilitation assessment and mobilization by the stroke team
- Multidisciplinary team care to include nursing and caregivers with weekly meetings



Rehabilitation

- Early goal setting and onset of rehabilitation by physical, occupational, and speech therapy
- Integration with specialized rehabilitation nursing care and caregivers
- Collaborative planning with interdisciplinary clinical team



Discharge Planning

- Early assessment of discharge needs
- Integration of patient and care givers with a focus on continued education support
- Coordination of follow-up care

Inpatient stroke measures	Ischemic stroke	Hemorrhagic stroke
Venous thromboembolism (VTE prophylaxis)	✓	✓
Assessed for rehabilitation	✓	✓
Discharged on antithrombotic therapy	✓	
Anticoagulation therapy for atrial fibrillation/flutter	✓	
Thrombolytic therapy	✓	
Antithrombotic therapy by end of hospital day two	✓	
Discharged on statin medication	✓	
Stroke education	✓	✓
Dysphagia screen	✓	✓
Smoking cessation	✓	✓
LDL documented	✓	

General BP considerations in ischemic stroke (absent fibrinolysis)

Acute elevations of BP are common in stroke

- Seen in majority of patients
- Often declines spontaneously in first 24-48 hours

Cerebral autoregulation is defective in most stroke patients

- Typically, we allow permissive hypertension (SBP <220 mm Hg) for the first 24 hours (or so)

Acutely lowering BP can expand area of ischemia

- Supported by PET studies
- Supported by clinical experience
- Supported by AHA/ASA guidelines

Safety measures

- Deep vein thrombosis (DVT) prophylaxis
- NPO including medications until dysphagia screen passed
- Assess for fall, aspiration, and (if clinically indicated) seizure risk
 - Empiric antiseizure medication is not recommended
 - Antiseizure medication should be considered on the basis of ongoing seizure risk
- Appropriate precautions in place

Seizure prophylaxis

- Empiric antiseizure medication is not recommended
- Antiseizure medication should be considered on the basis of ongoing seizure risk
 - Seizure at stroke onset may be a provoked seizure and not indicative of the development of poststroke epilepsy
 - Optimal secondary prophylactic agent(s) unknown
 - Newer agents with fewer adverse effects and drug-drug interactions may be ideal compared to older agents
- Appropriate seizure precautions in place (padding around bed)

Post-stroke headache (PSH)

- Acute headache occurs in 6-44% of the ischemic stroke population with stroke onset
 - Usually tension-type
- Posterior circulation stroke and the female sex were associated with greater odds of having headache after ischemic stroke
- Also seen more often in lobar (hemorrhagic) and cortical (ischemic) strokes compared to subcortical

PSH features

- Tension-type (bilateral, squeezing or pressure like in quality, with no nausea/vomiting, only one of either photophobia or phonophobia, and overall shorter in duration)
- Migraine features occurred in 8-30% across studies, and photophobia was the most common, which is also a tension type feature
- Pain was described as moderate or severe in intensity

Treating PSH

- No clinical trials or large studies on an appropriate treatment
- Generally, pain is treated based on the primary headache disorder it most closely resembles (e.g., tension type or migraine)
 - Gabapentin can be a reasonable option (anecdotal)
 - Non-steroidal anti-inflammatory agents should probably be avoided early after stroke
 - Agents containing butalbital should be avoided to prevent long-term reliance
 - Don't use triptans or CGRP agents (theoretical-ish increased risk of vasoreactivity and stroke)

Post-stroke dysphagia

- Perform a bedside swallow screening prior to initiation of liquid or food intake to screen for patients at increased risk for aspiration
- It is reasonable for dysphagia screening to be performed by speech pathologists or other trained health care professionals
- Dobbhoff or other nasogastric tube as needed
- Modified barium swallow or other testing
- Frequent repositioning, physical therapy

Aspiration pneumonia

- Affects up to 55% of stroke patients due to dysphagia
- Contributes to 15–25% of stroke-related deaths
- High-risk indicators:
 - Altered consciousness
 - Impaired gag reflex or swallowing
 - Found unconscious or after prolonged immobility
- Management
 - Assume aspiration if clinical suspicion is high
 - Broad-spectrum antibiotics

Deep vein thrombosis prophylaxis

- Stroke patients with impaired mobility who do not have contraindications to intermittent pneumatic compression (IPC) should receive IPC in addition to routine care
 - Recommended over routine care alone to reduce the risk of deep vein thrombosis (DVT)
- For stroke patients with impaired mobility, either prophylactic-dose subcutaneous heparin or enoxaparin are reasonable to reduce the risk of VTE
- Early mobilization when appropriate

The sugars

- Maintenance of good glycemic control (140-180mg/dl) in hospital
- Intensive glucose control to the range of 80 to 130 mg/dL is not recommended to improve clinical outcome and increases the risk of severe hypoglycemia

Rehabilitation reduces disability

- Physical therapy
- Occupational therapy
- Speech therapy
- May require acute rehabilitation, subacute rehabilitation, outpatient services

COR	RECOMMENDATIONS
1	In-hospital, formal, interdisciplinary assessment and provision of rehabilitation at a level appropriate for the individual patient is recommended to improve functional recovery.

Secondary stroke prevention

- Risk factor management (easier to do if you know the mechanism)
- Stroke-specific medication list is pretty short
 - Antithrombotics
 - Statins

Ischemic stroke secondary prevention

- Antithrombotic treatment, unless contraindicated
 - Anticoagulation: atrial fibrillation, left ventricular thrombus, antiphospholipid antibody syndrome
 - Warfarin, apixaban, rivaroxaban, dabigatran
 - Started days-weeks after ischemic stroke (size/location dependent)
 - Antiplatelet: monotherapy or dual therapy
 - Aspirin, clopidogrel, ticagrelor
 - Prasugrel: box warning says not to use in patients with history of TIA or stroke
 - Started within 1-2 days after ischemic stroke
- “With very few exceptions, the combination of antiplatelets and anticoagulation is typically not indicated for secondary stroke prevention.”
 - Carotid or intracranial stenting
 - Ulcerated atherosclerotic plaque

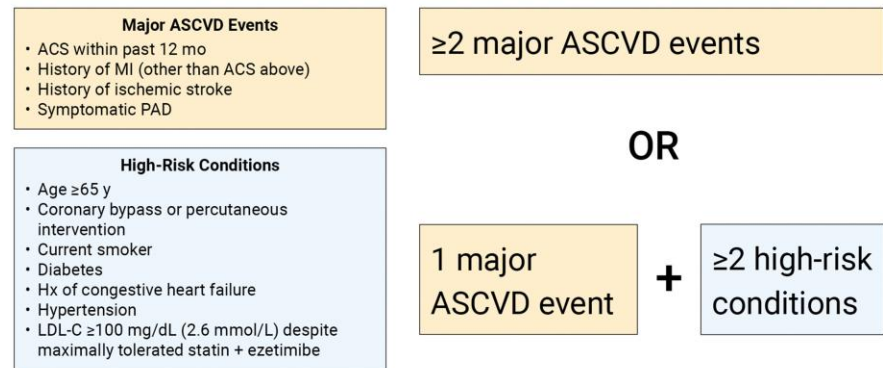
Short-course dual antiplatelet therapy

- 21 days: following minor stroke (NIHSS score ≤ 3) or high-risk transient ischemic attack (ABCD² score ≥ 4)
 - Non-cardioembolic
- 90 days: ischemic stroke secondary to symptomatic intracranial stenosis
- Perioperative for a carotid intervention (carotid endarterectomy, stenting)
 - Pre- and post-op duration determined by proceduralist

Atherosclerotic cardiovascular disease (ASCVD)

- Initiation of high-intensity statin therapy for goal LDL <70 mg/dL for ischemic stroke unless they are at very high-risk, then <55 mg/dL
 - Atorvastatin (40/80) or rosuvastatin (20/40)
 - Consider addition of ezetimibe, PCSK9 inhibitors (alirocumab, evolocumab)

Clinical ASCVD: Criteria for Defining “At Very High Risk” in Adults



Interventions for hemorrhagic stroke

- Reversal of anticoagulation, if possible
 - Warfarin: prothrombin complex concentrate (4-factor PCC), vitamin K
 - Factor Xa inhibitors: andexanet alfa
 - Dabigatran: idarucizumab
- Careful lowering of blood pressure to a systolic <150 mm Hg
 - “treatment regimens that limit blood pressure variability and achieve smooth, sustained blood pressure control appear to reduce hematoma expansion and yield better functional outcome”
- Increasing serum sodium with supplemental fluids and/or salt tablets as a bridge to neurosurgical intervention, if indicated

Management of cerebral venous thrombosis

- Initiation of anticoagulation to prevent thrombus propagation and additional injury
 - Presence of hemorrhage is not a contraindication to anticoagulation
- Investigations into why

Conclusions



Stroke is a common pathology in Kentucky and will likely become more common due to our demographics, with greater impact on rural populations



Most stroke in adults is ischemic with smaller proportions of hemorrhagic stroke and cerebral venous thrombosis



Various investigations can help us determine the mechanism of stroke so we can tailor prevention strategies



General strategies to reduce morbidity and mortality include VTE prophylaxis, dysphagia screening, and use of rehabilitation services



Secondary stroke risk reduction relies on antithrombotic and lipid-lowering agents



Context matters when it comes to stroke care and management; it's not all algorithms

Questions?