Cerebrovascular diseases

Angelo Antonini

Stroke Objectives

- Review etiology of strokes
- Identify likely location/type of stroke based of physical exam
- Acute management of ischemic stroke
- Acute management of hemorrhagic stroke

Stroke Fast Facts

- Affects ~ 800, 000 people per year
- Leading cause of disability, cognitive impairment, and death in the United States
- Accounts for 1.7% of national health expenditures.
- Estimated U.S. cost for 2012 = $71.5 billion
  - Mostly hospital (esp. LOS) & post stroke costs
  - Appropriate use of IV t-PA ↓s long-term cost
  - Appropriate billing for AIS w/ thrombolysis (↑ hospital reimbursement from $5k to $11.5k)

Stroke. 2013;44:2361-2375

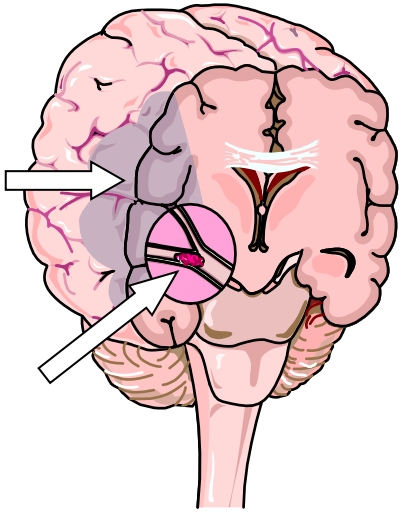
Where We're Headed

- By 2030 ~ 4% of the US population over the age of 18 is projected to have had a stroke
- Between 2012 and 2030, total direct stroke-related medical costs are expected to increase from $71.55 billion to $183.13 billion
- Total annual costs of stroke are projected to increase to $240.67 billion by 2030, an increase of 129%

Stroke. 2013;44:2361-2375

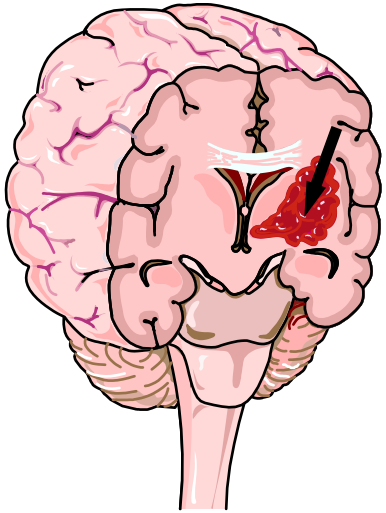
Three Stroke Types

Ischemic Stroke



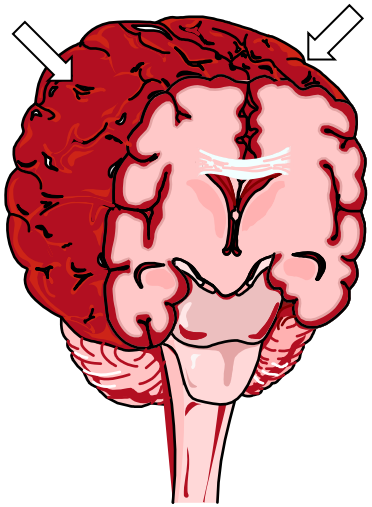
Clot occluding artery
85%

Intracerebral Hemorrhage



Bleeding into brain
10%

Subarachnoid Hemorrhage



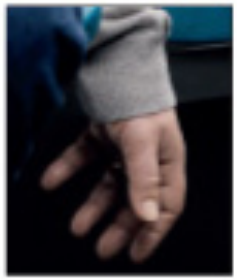
Bleeding around brain
5%

When Stroke Strikes,
Act F.A.S.T.

FACE

Smile.

Does one side of the face droop?



ARMS

Raise both arms.

Does one arm drift downward?

SPEECH

Repeat a sentence.

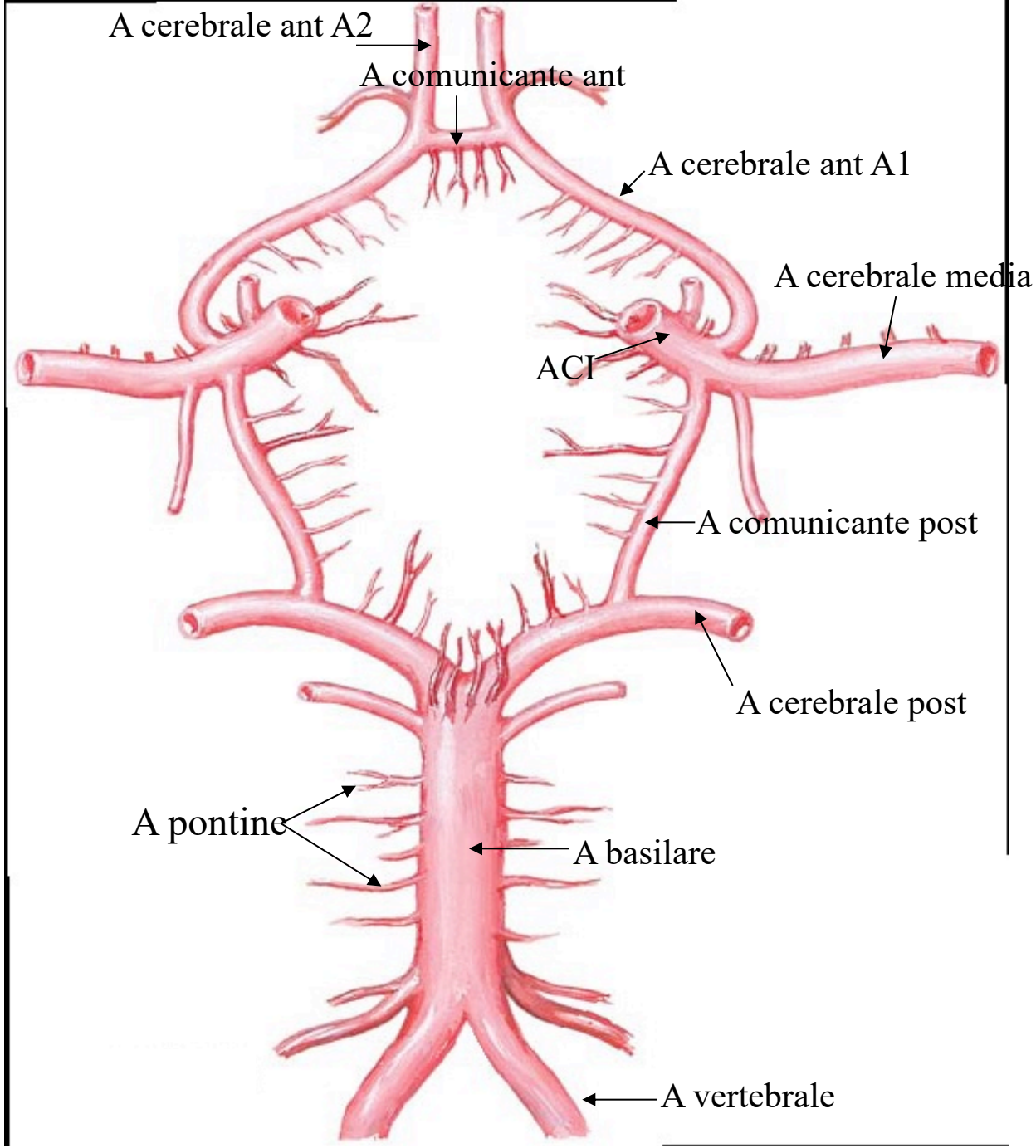
Are they able to speak clearly? Can they repeat the sentence?

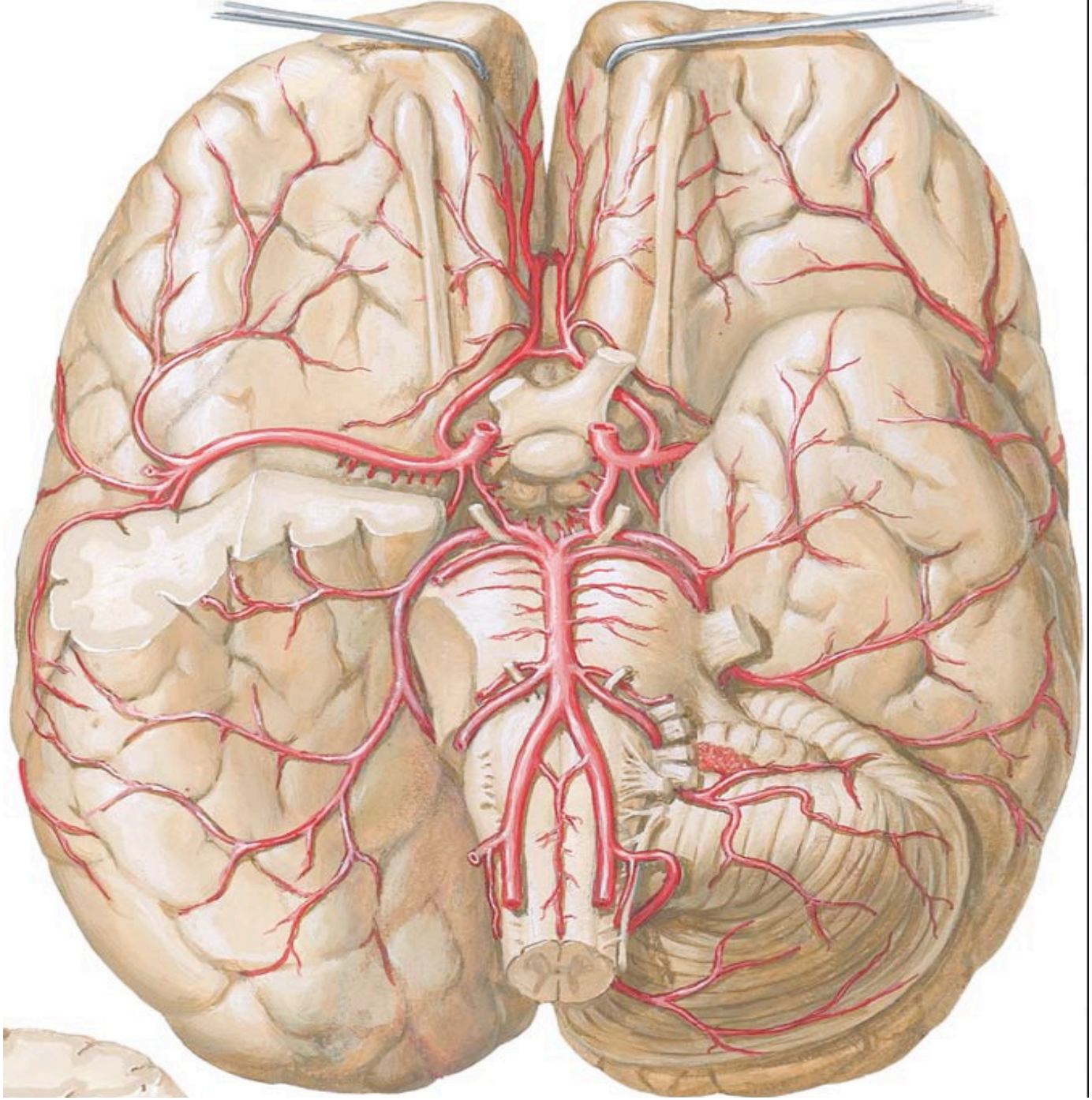
TIME

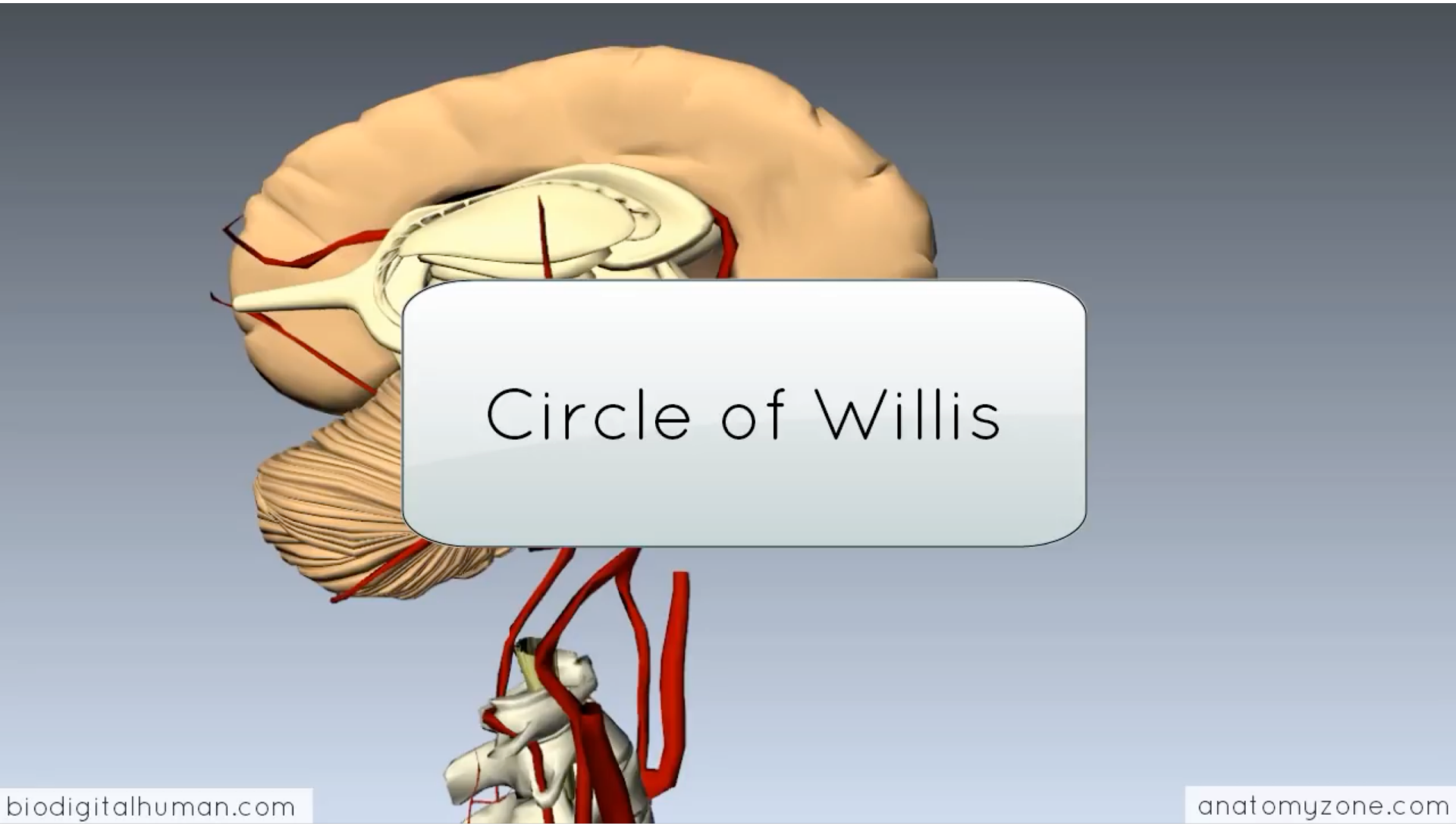
Time is critical.

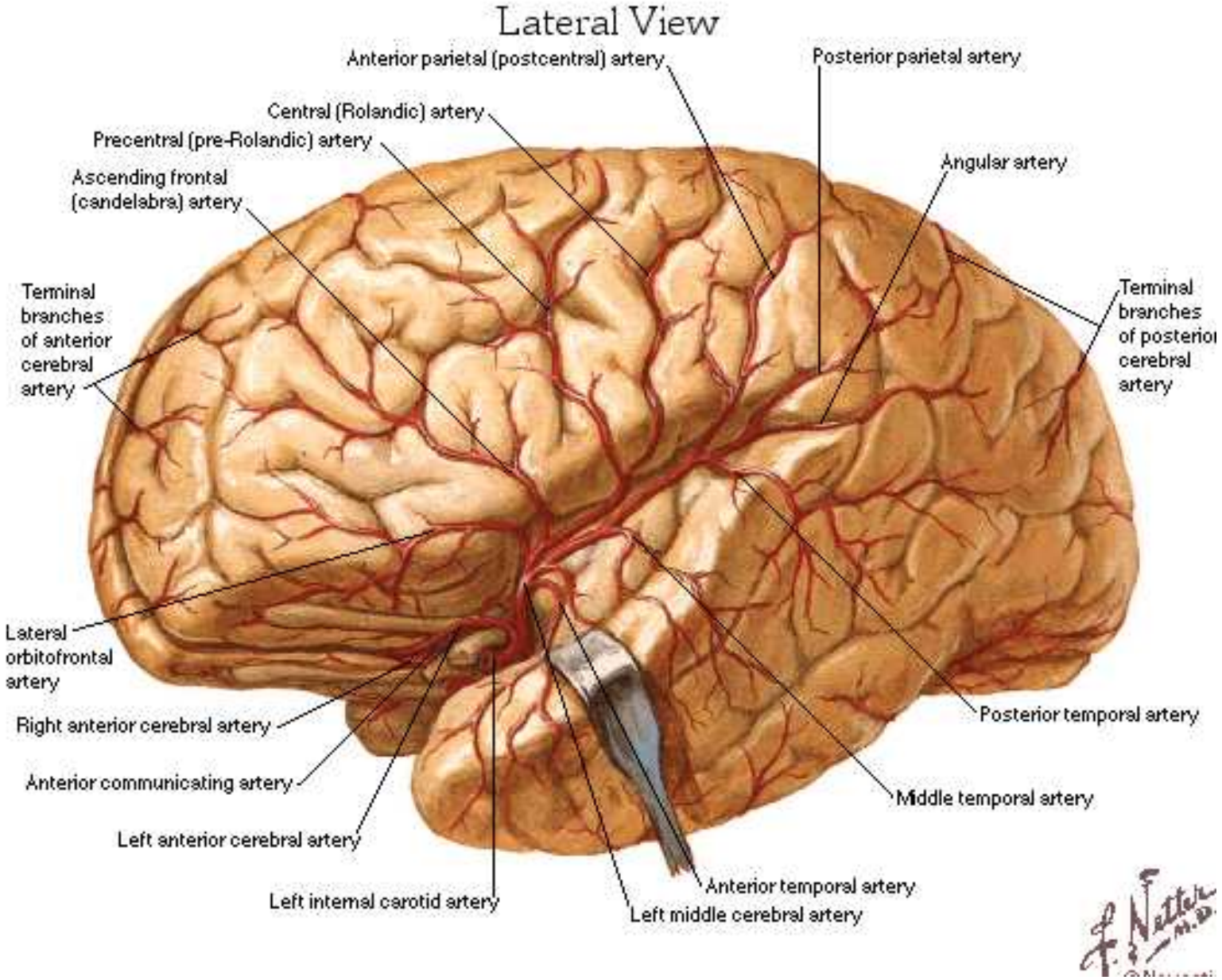
Call 911. Get to the hospital immediately. Brain cells are dying. Every Minute Counts!

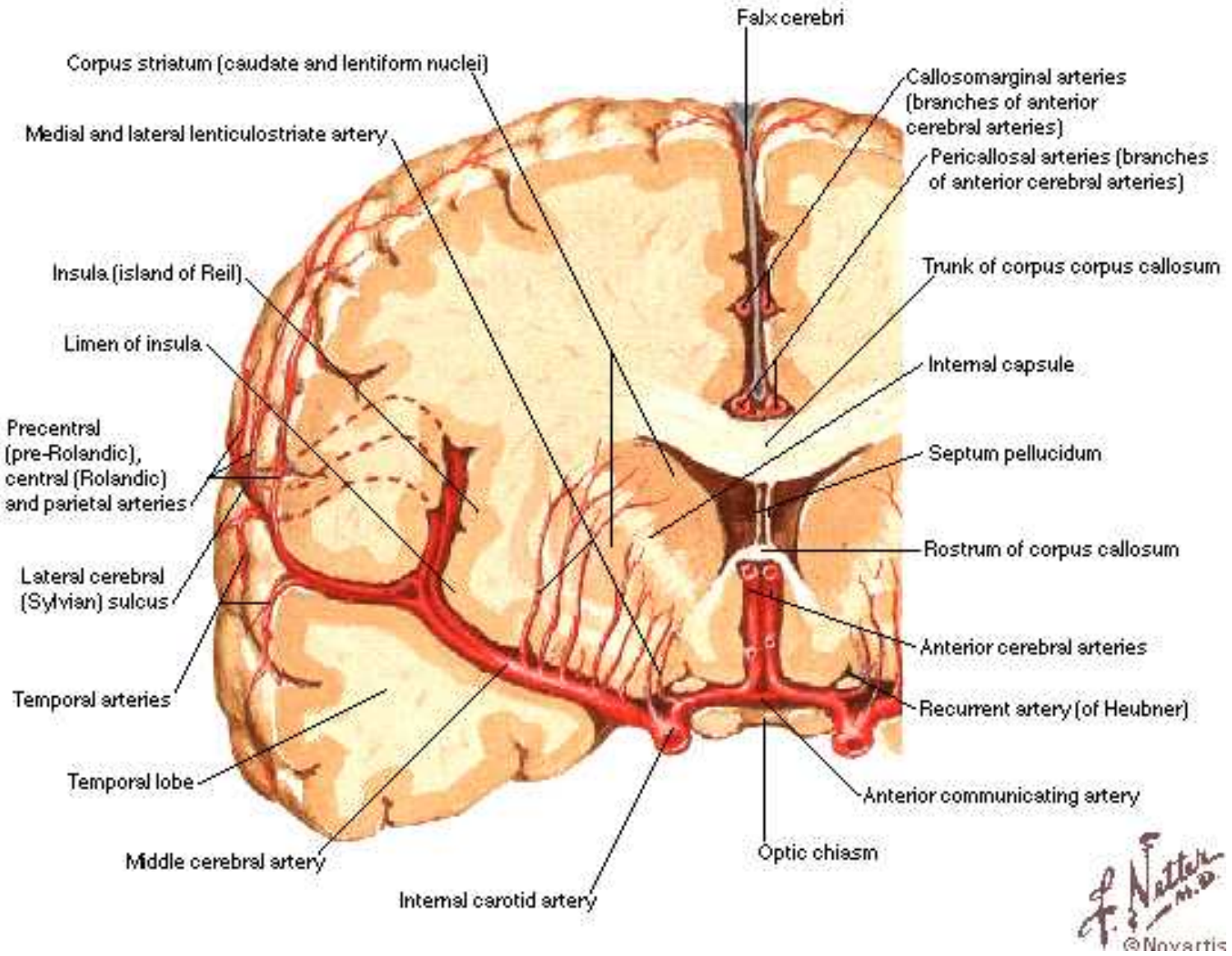
http://www.phillystroke.org/content/learn_about_stroke/act_fast.asp


A cerebrale ant A2
A comunicante ant
A cerebrale ant A1
A cerebrale media
ACI
A comunicante post
A cerebrale post
A pontine
A basilare
A vertebrale



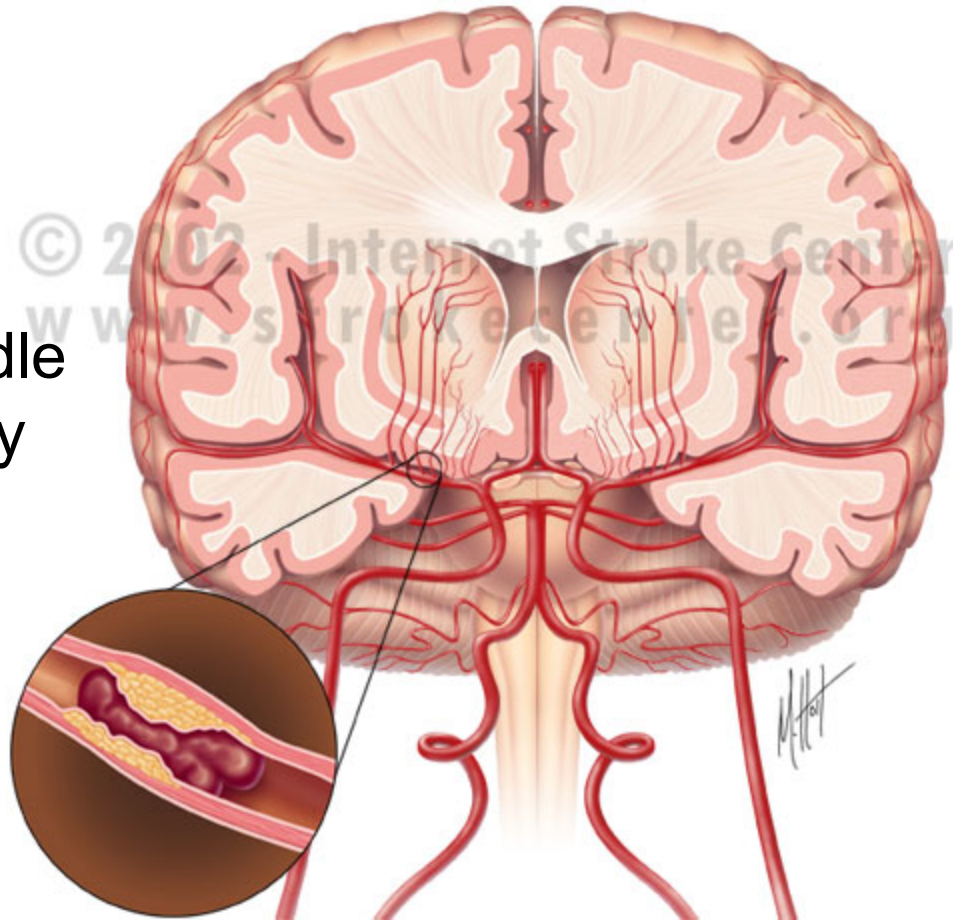

Circle of Willis
biodigitalhuman.com
anatomyzone.com


Lateral View
Anterior parietal (postcentral) artery
Posterior parietal artery
Central (Rolandic) artery
Precentral (pre-Rolandic) artery
Angular artery
Ascending frontal (candelabra) artery
Terminal branches of anterior cerebral artery
Terminal branches of posterior cerebral artery
Lateral orbitofrontal artery
Right anterior cerebral artery
Posterior temporal artery
Anterior communicating artery
Middle temporal artery
Left anterior cerebral artery
Anterior temporal artery
Left internal carotid artery
Left middle cerebral artery


Falx cerebri
Corpus striatum (caudate and lentiform nuclei)
Callosomarginal arteries (branches of anterior cerebral arteries)
Medial and lateral lenticulostriate artery
Pericallosal arteries (branches of anterior cerebral arteries)
Insula (island of Reil)
Trunk of corpus corpus callosum
Limen of insula
Internal capsule
Precentral (pre-Rolandic), central (Rolandic) and parietal arteries
Septum pellucidum
Rostrum of corpus callosum
Lateral cerebral (Sylvian) sulcus
Anterior cerebral arteries
Temporal arteries
Recurrent artery (of Heubner)
Temporal lobe
Anterior communicating artery
Optic chiasm
Middle cerebral artery
Internal carotid artery
F. Netter M.D.
©Novartis

A collaboration between the American Association of Colleges of Nursing and Khan Academy

Clot in the middle cerebral artery



NIHSS

- NIHSS (National Institute of Health Stroke Scale)
  - Standardized method used by health care professionals to measure the level of impairment caused by a stroke
  - Purpose
    - Main use is as a clinical assessment tool to determine whether the degree of disability is severe enough to warrant the use of tPA
    - Another important use of the NIHSS is in research, where it allows for the objective comparison of efficacy across different stroke treatments and rehabilitation interventions
  - Scores are totaled to determine level of severity
  - Can also serve as a tool to determine if a change in exam has occurred

Breaking Down the Scale

- 13 item scoring system, 7 minute exam
- Integrates neurologic exam components
- CN (visual), motor, sensory, cerebellar, inattention, language, LOC
- Maximum score is 42, signifying severe stroke
- Minimum score is 0, a normal exam
- Scores greater than 15-20 are more severe

NIHSS cont.

- NIHSS Interpretation

Stroke Scale	Stroke Severity
0	No Stroke
1-4	Minor Stroke
5-15	Moderate Stroke
15-20	Moderate/Severe Stroke
21-42	Severe Stroke

NIHSS and Outcome Prediction

- NIHSS below 12-14 will have an 80% good or excellent outcome
- NIHSS above 20-26 will have less than a 20% good or excellent outcome
- Lacunar infarct patients had the best outcomes

Adams HP Neurology 1999;53:126-131
Baseline NIH Stroke Scale score strongly predicts outcome after stroke (TOAST)

Etiology of Ischemic Strokes

LARGE VESSEL **THROMBOTIC**:

Virchow's Triad….

- **Blood vessel injury**
  - HTN, Atherosclerosis, Vasculitis
- **Stasis/turbulent blood flow**
  - Atherosclerosis, A. fib., Valve disorders
- **Hypercoagulable state**
  - Increased number of platelets
  - Deficiency of anti-coagulation factors
  - Presence of pro-coagulation factors
  - Cancer

Etiology Of Ischemic Stroke:

LARGE VESSEL **EMBOLIC**:

- **The Heart**
  - Valve diseases, A. Fib, Dilated cardiomyopathy, Myxoma
- **Arterial Circulation (artery to artery emboli)**
  - Atherosclerosis of carotid, Arterial dissection, Vasculitis
- **The Venous Circulation**
  - PFO w/R to L shunt, Emboli

What is a TIA?

Transient ischemic attack (TIA) is defined as a transient episode of neurologic dysfunction caused by focal brain, spinal cord, or retinal ischemia, without acute infarction

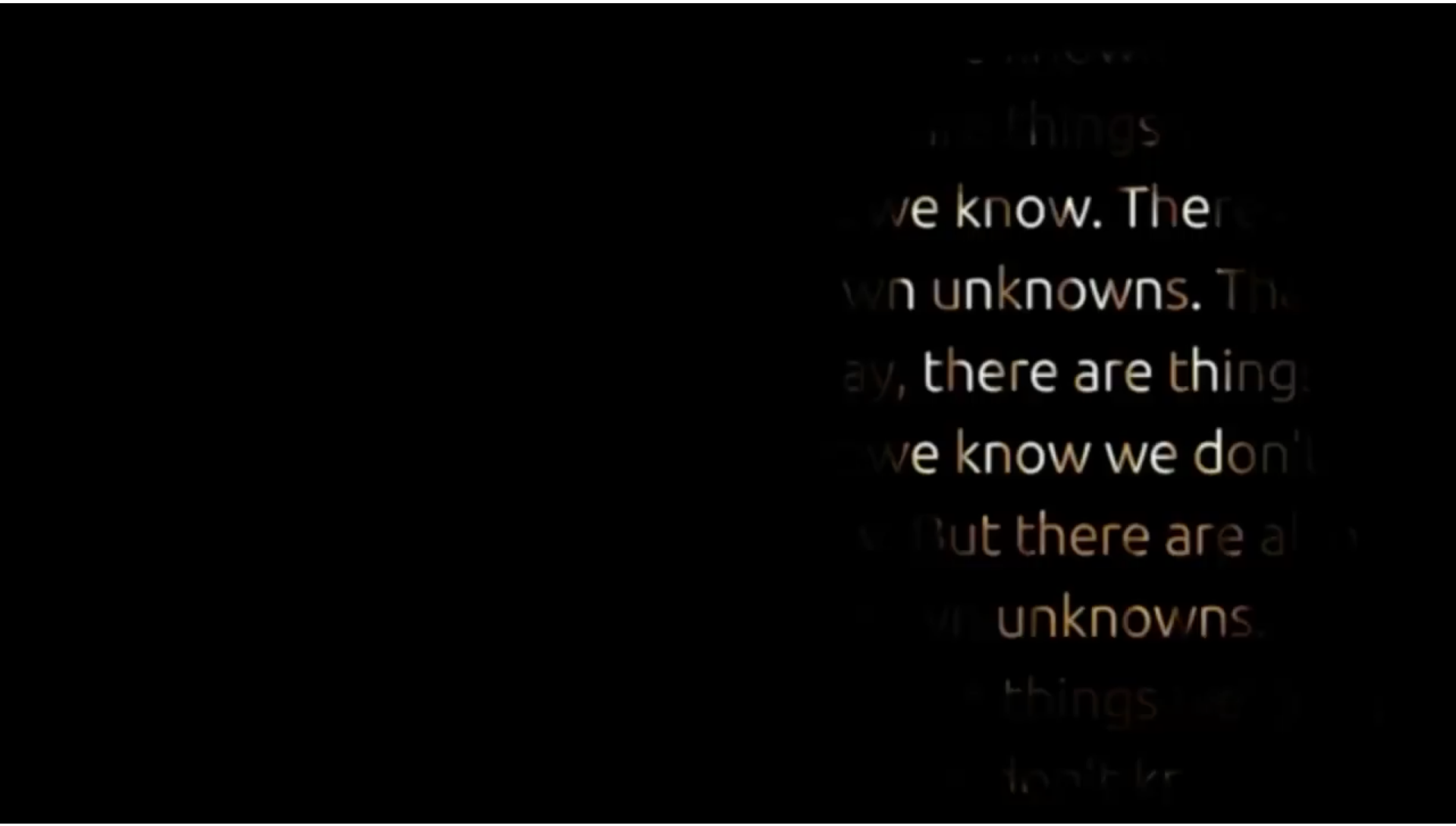
Determining the Location

- Large Vessel:
  - Look for cortical signs
- Small Vessel:
  - No cortical signs on exam
- Posterior Circulation:
  - Crossed signs
  - Cranial nerve findings
- Watershed:
  - Look at watershed and borderzone areas
  - Hypo-perfusion

Cortical Signs

RIGHT BRAIN:	**LEFT BRAIN:**
- Right gaze preference	- Left gaze preference
- Neglect	- Aphasia

- If present, think LARGE VESSEL stroke

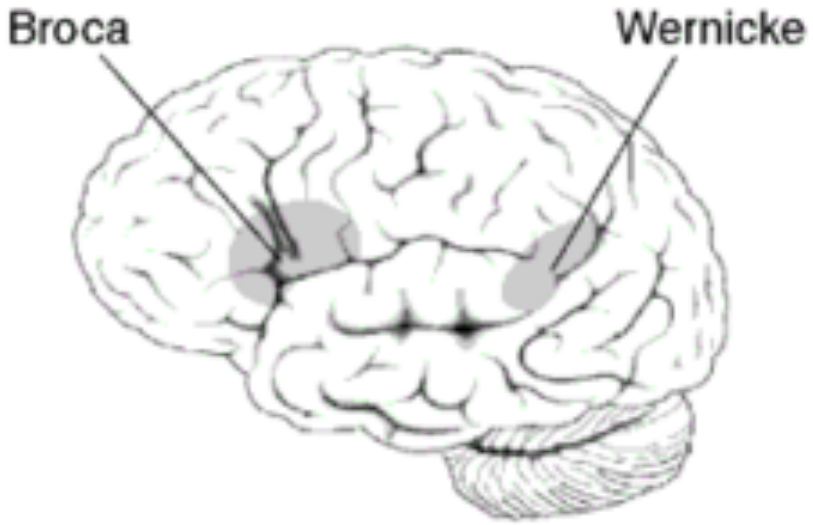

ve know. Ther
n unknowns. Th
ay, there are thing
we know we don'
But there are al
unknowns
things
don't kn

Large Vessel Stroke Syndromes

- MCA:
  - Arm>leg weakness
  - LMCA cognitive: Aphasia
  - RMCA cognitive: Neglect,, topographical difficulty, apraxia, constructional impairment
- ACA:
  - Leg>arm weakness, grasp
  - Cognitive: muteness, perseveration, abulia, disinhibition
- PCA:
  - Hemianopia
  - Cognitive: memory loss/confusion, alexia
- Cerebellum:
  - Ipsilateral ataxia

Aphasia

- Broca's
  - Expressive aphasia
  - Left posterior inferior frontal gyrus



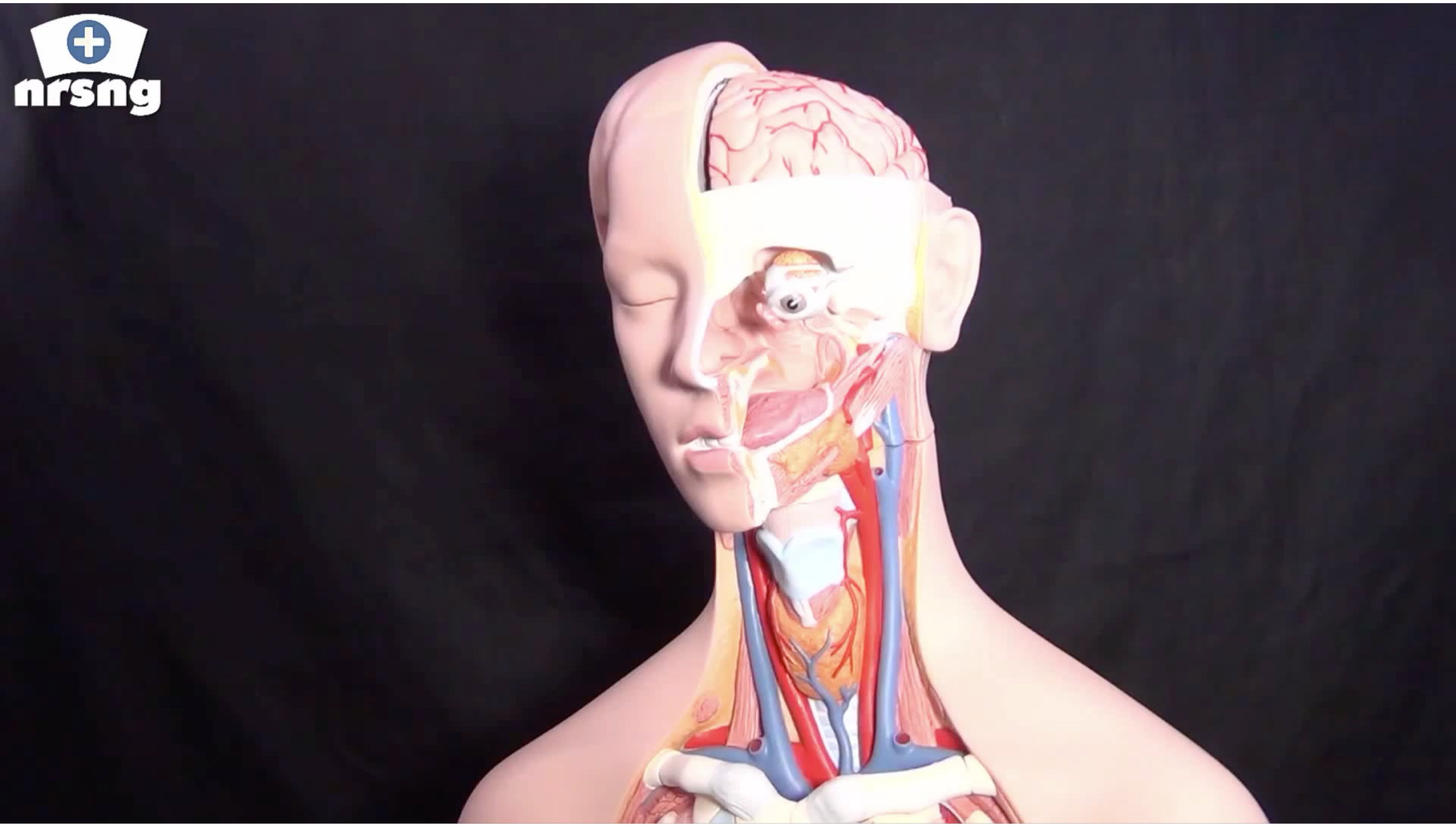
- Wernicke's
  - Receptive aphasia
  - Posterior part of the superior temporal gyrus
  - Located on the dominant side (left) of the brain

Cerebral Blood Flow (CBF)

- CBF = CBV/t
- 750 mL/minute, which is 15% of the cardiac output
- The normal cerebral blood flow is 45-50ml/100g/min, ranging from 20ml 100g-1 min-1 in white matter to 70ml 100g-1 min-1 in grey matter. Highest in neurohypophysis

CBF

- When CBF falls to less than 10-23ml/100g/min, physiological electrical function of the cell begins to fail- “ischemic penumbra”.
- Below 8 ml/100g/min irreversible cell death- ionic membrane transport failure


nrsng

Cerebral Perfusion Pressure (CPP)

- Cerebral Perfusion Pressure (CPP)

  MAP-ICP=CPP

normal CPP is between 50-150 mmHg

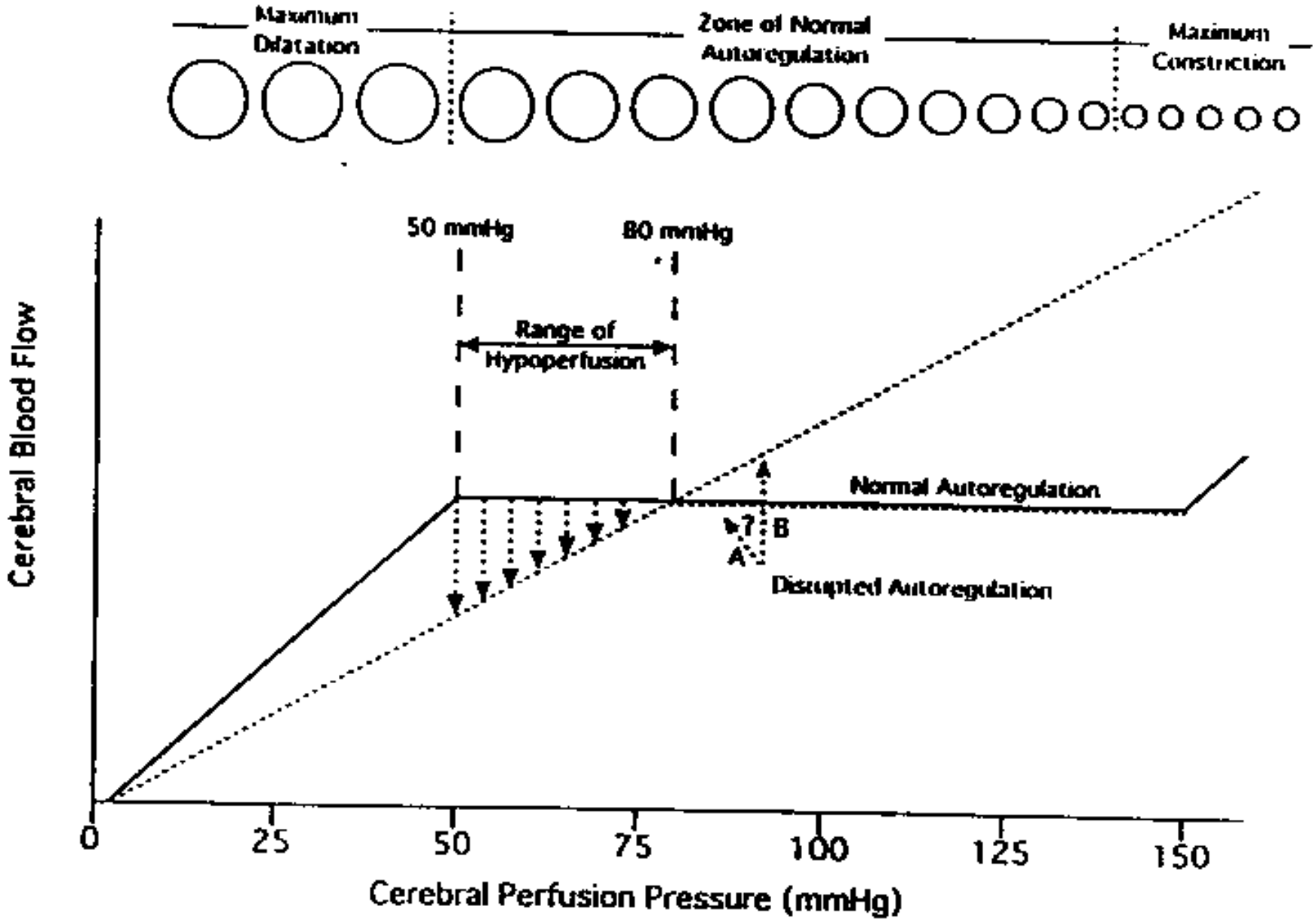
- <50 mmHg --> ischemia
- >150 mmHg --> hyperemia

Autoregulation

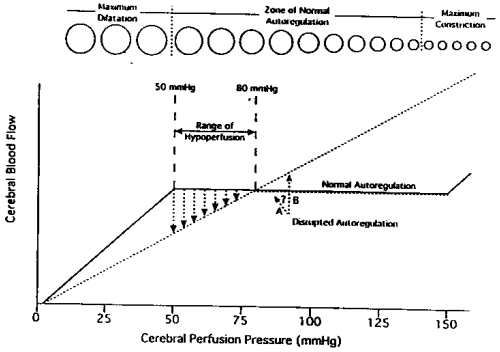
- CBF is maintained at a constant level in normal brain in the face of the usual fluctuations in blood pressure by the process of autoregulation. It is a poorly understood local vascular mechanism. Normally autoregulation maintains a constant blood flow between CPP 50 mmHg and 150 mmHg.

- Poiseuille's law- flow through a rigid vessel:

$$Q = \Delta P \pi r^4 / 8 L \eta$$


Maximum Dilatation
Zone of Normal Autoregulation
Maximum Constriction
50 mmHg
80 mmHg
Range of Hypoperfusion
Normal Autoregulation
A
B
Disrupted Autoregulation
Cerebral Blood Flow
0
25
50
75
100
125
150
Cerebral Perfusion Pressure (mmHg)

Autoregulation



- Dysregulation can occur in pathologic states
- In traumatised or ischaemic brain, or following vasodilator agents (volatile agents and sodium nitroprusside) CBF may become blood pressure dependent. Thus as arterial pressure rises so CBF will rise causing an increase in cerebral volume. Similarly as pressure falls so CBF will also fall, reducing ICP, but also inducing an uncontrolled reduction in CBF.

Autoregulation

- pressure/myogenic autoregulation

  arterioles dilate or constrict in response to changes in BP and ICP in order to maintain a constant CBF
- “myogenic theory”- vascular smooth muscle within cerebral arterioles intrinsically contract to stretch thereby regulating pressure
- NO- limited role overall, but if completely abolish NO production then loss of autoregulation; with CBF being completely BP-dependent

Metabolic Autoregulation

- arterioles dilate in response to potent chemicals that are by-products of metabolism such as lactic acid, carbon dioxide and pyruvic acid

  CO_2 is a potent vasodilator

  increased CO_2/decreased BP --> vasodilation

  decreased CO_2/increased BP ->vasoconstriction

Neurogenic Autoregulation

- Autonomic- sympathetic adrenergic receptors seen in cortical layers IV and V.
- B_1, β_2, and α_2 (“dilators”), and α_1 (“constrictor”) receptors
- Overall sympathetic system plays minor role unlike in non-cerebral vascular beds.

Neurogenic Autoregulation- cont

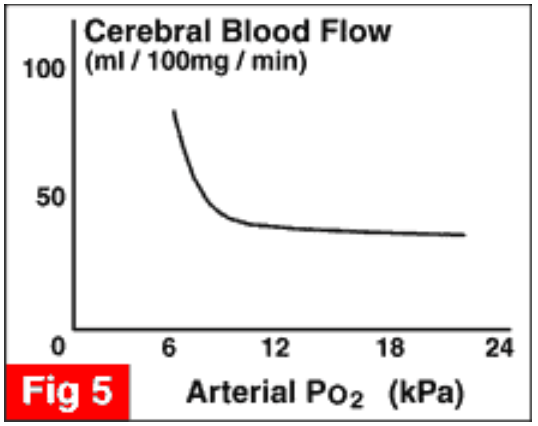
- 5-HT- potent “constrictor,” antagonized by NO
- Neuropeptide Y- “vasoconstriction”, in assoc with NO and sympathetic system
- Vasoactive intestinal polypeptide (VIP) and peptide histidine isoleucine (PHI)- “vasodilators”
- Substance P, neurokinin A, calcitonin gene-related peptide histamine H_2 -”vasodilatory” esp. substance P
- CCK, neurotensin, somatostatin, vasopressin, endorphin

Neurogenic Autoregulation-cont

- Autonomic system and neurochemical control of CBF in general is a minor control
- Overall, pressure and metabolic autoregulation most important

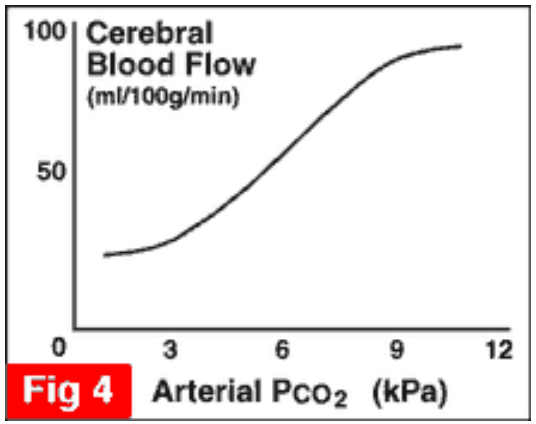
Increasing CBF-Hyperemia

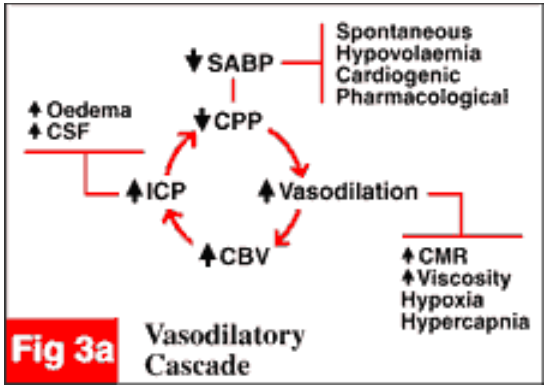
- Low arterial oxygen tension has profound effects on cerebral blood flow. When it falls below 50 mmHg (6.7 kPa), there is a rapid increase in CBF and arterial blood volume



CBF and CO_2

- Carbon dioxide causes cerebral vasodilation. As the arterial tension of CO2 rises, CBV and CBF increases and when it is reduced vasoconstriction is induced.





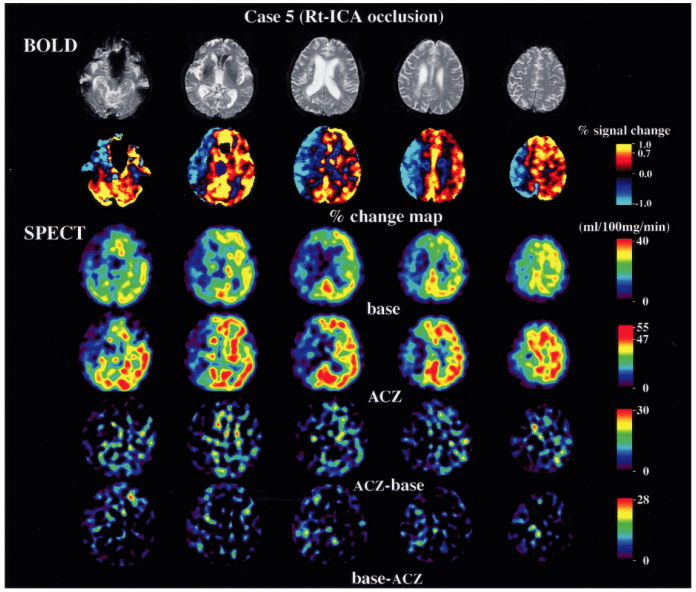
“Cerebrovascular Reserve”

- In functionally activated areas, CBF augmentation exceeds the small increases in oxygen utilization and the concentration of deoxyhemoglobin is relatively low. Thus, this excess supply of oxygen in response to a demand stimulus reflects the *cerebral perfusion reserve capacity*

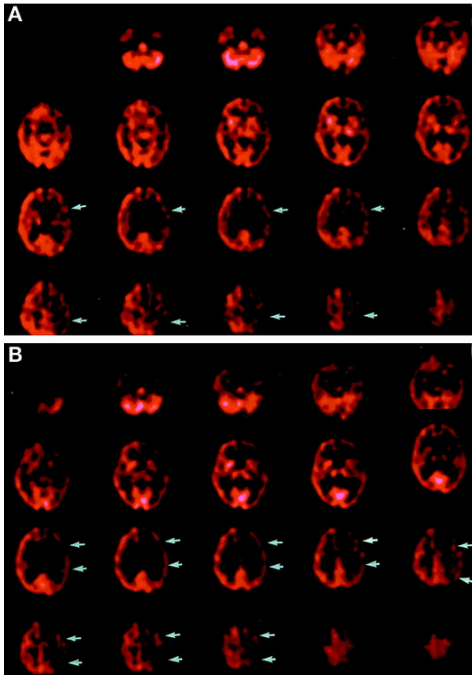
- Cerebrovascular reserve capacity is impaired by risk factors such as hypertension and diabetes, carotid/cerebral vasc. stenosis, and can be an etiologic factor in ischemic stroke

Cerebrovascular Reserve

- PET, SPECT, Xe-CT, CT-perfusion to assess. Pre/post diamox challenge.
- acetazolamide challenge and the CO2-loading (breath-holding) test raise global CBF
- (MRI) of T2-weighted or Blood oxygenation level–dependent (BOLD)-weighted images correlate well with changes in the total amount of oxygenated hemoglobin

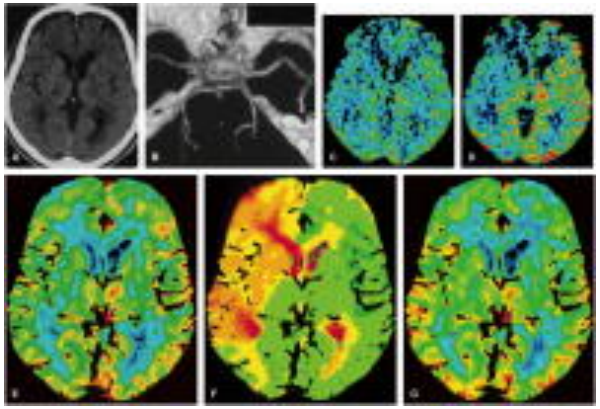


BOLD-MRI and single-photon emission computed tomography (SPECT)

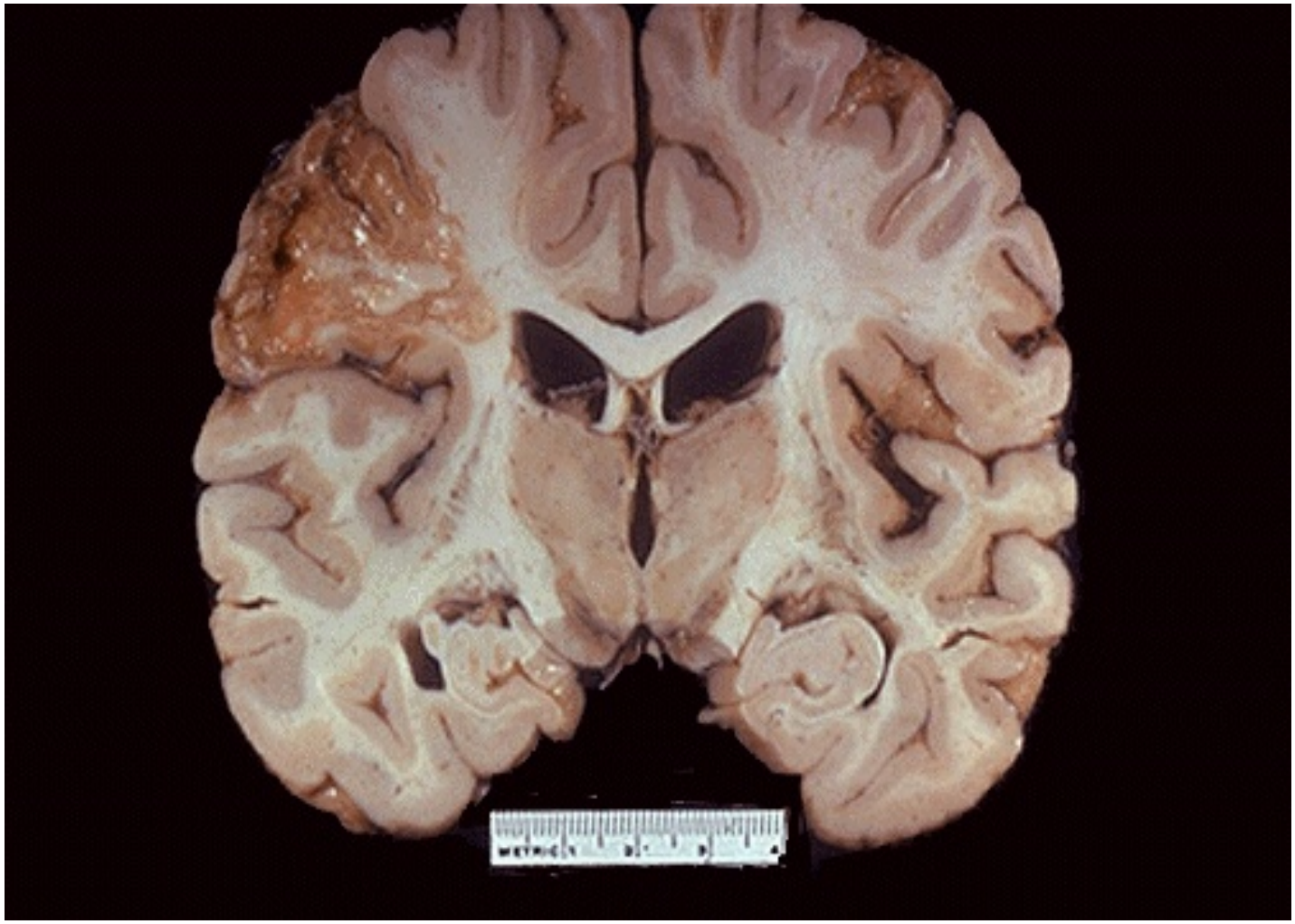


(SPECT)

Xenon CT



perfusion CT



Who's at Risk?

Every year, nearly 800,000 Americans have a stroke. Here's what increases risk:

- Family history of stroke
- A history of TIAs (Transient Ischemic Attacks)
- Medical conditions such as Afib or fibromuscular dysplasia
- Age – After age 55, stroke risk doubles every decade
- Race – African Americans, Hispanics, and Asian/Pacific Islands have a greater risk
- Gender

Stroke and Women

Annually, nearly 55,000 more women than men have strokes.

Characteristics that are specific to women, such as taking birth control pills or hormone replacement therapy, can increase stroke risk.

Women who have high blood pressure before or during pregnancy have a greater risk of stroke.

Ask About the Four H's!

- Heredity
- High Blood Pressure
- Heart Disease
- High Cholesterol

Heredity

Alert your doctor if someone in your family has had a stroke, high blood pressure, or heart disease.

If you don't know your history, ask around. A sibling or other relative may have more information.

What can you do?

If you have a family history of stroke, take extra precaution to manage the risk factors you can control.

High Blood Pressure

Ask your doctor whether you have high blood pressure – the No. 1 cause of stroke.

What can you do?
Start a plan to eat healthier and exercise.

Ask about medications that can be effective in lowering your blood pressure and keeping it down.

Heart Disease

Determine your overall heart health. Conditions like atherosclerosis, coronary artery disease, Afib, valve defects, and enlarged heart chambers can block vessels in or leading to the brain.

What can you do?

Ask you doctor about treatment, such as surgical procedures or taking aspirin or blood-thinning therapy to prevent clots.

High Cholesterol

Cholesterol is a fatty substance in blood. If there's too much cholesterol in your blood, it can clog arteries and cause a stroke.

What you want:
Total Cholesterol: < 200 mg
LDL "Bad" Cholesterol: < 100 mg
HDL "Good" Cholesterol: > 40 for men, > 50 for women

What can you do?
Take steps to eat healthier and start exercising.

Ask about medications. They can be effective in reducing your cholesterol and keeping it down.

More Conditions to Ask About

- Sleep Apnea – Untreated, this can cause high blood pressure, heart failure, irregular heartbeat, heart attacks, and stroke
- Diabetes – People with diabetes are two to four times more likely to have a stroke
- Circulation Problems – Strokes can be caused by complications with any component of your circulation, including your heart, arteries, veins, and blood.

- Hormones – Hormone levels, especially estrogen in women, can play a role in stroke risk.

- Fibromuscular dysphasia – With this condition, some of the arteries that carry blood throughout the body are not fully developed.

- Patent foramen ovale – This is an opening between the two chambers of the heart where blood can clot.

What can YOU do?

Be aware of these conditions, and talk to your doctor if you're experiencing any of them.

Oftentimes, lifestyle changes, medication, or both can help offset your risk of stroke.

Stop Smoking

Smoking accelerates the forming of clots, thickens blood, and increases plaque buildup in the arteries. If you smoke, stop!

- Ask your doctor about nicotine patches, counseling, or programs that have worked for others.
- Don’t get discouraged – It could take several attempts.
- Keep trying – Quitting smoking can have almost immediate beneficial effects on your health.

Get to Your Healthy Weight

Carrying extra weight can make you more apt to develop high blood pressure, heart problems, and diabetes – all increasing your risk of stroke.

- Talk to your doctor about your ideal weight, body mass index, and percentage of body fat to make sure you're in a healthy range.
- Losing just 10 pounds can improve your health and reduce your risk of stroke.

Be Active

Physical activity can help you lose weight and reduce stress which can lower blood pressure and cholesterol, control diabetes, and improve your overall health.

- Talk to your doctor about starting an exercise program.
- Try to be active for 30 minutes every day.
- If you can’t do it all at once, try to be active for 10 to 15 minutes at a time.

Watch What You Eat

This is about nutrition – not dieting. The food choices you make can improve your health and reduce your risk of stroke.

- Eat plenty of fruits and vegetables, which are high in fiber.
- Limit salt to help lower your blood pressure.
- Eat less cholesterol and fat which can create plaque buildup in your arteries.

Limit Alcoholic Drinks

Drinking too much alcohol can increase blood pressure and the risk of stroke.

- Drink in moderation – No more than two drinks a day for men and one drink a day for women.
- Know your portions – A standard portion is 5 ounces of wine, 12 ounces of beer, or 1.5 ounces of hard liquor.
- Opt for red wine – It contains resveratrol which can protect the heart and brain.

Reduce Your Risk Recap

At the doctor

Assess the 4 Hs:

- ❑ Heredity
- ❑ High blood pressure
- ❑ Heart disease
- ❑ High cholesterol

Take steps to treat:

- ❑ Sleep Apnea
- ❑ Diabetes
- ❑ Circulation problems
- ❑ Hormone issues
- ❑ Heart issues, such as , AFib, fibromuscular dysphasia, or patent foramen ovale.

At home

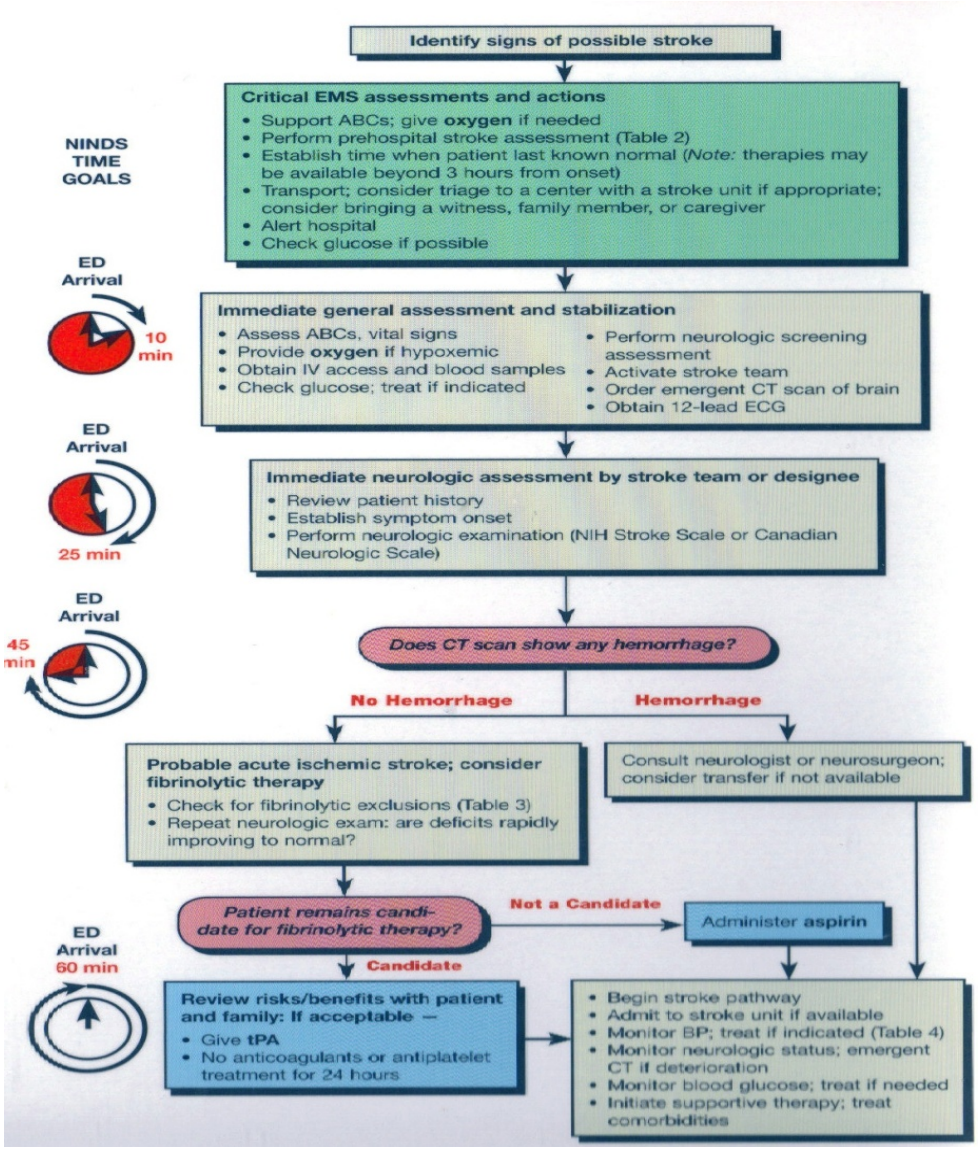
- ❑ Stop smoking
- ❑ Maintain a healthy weight
- ❑ Be Active
- ❑ Watch what you eat
- ❑ Drink less alcohol

A collaboration between the American Association of Colleges of Nursing and Khan Academy

Ischemic Sindroms

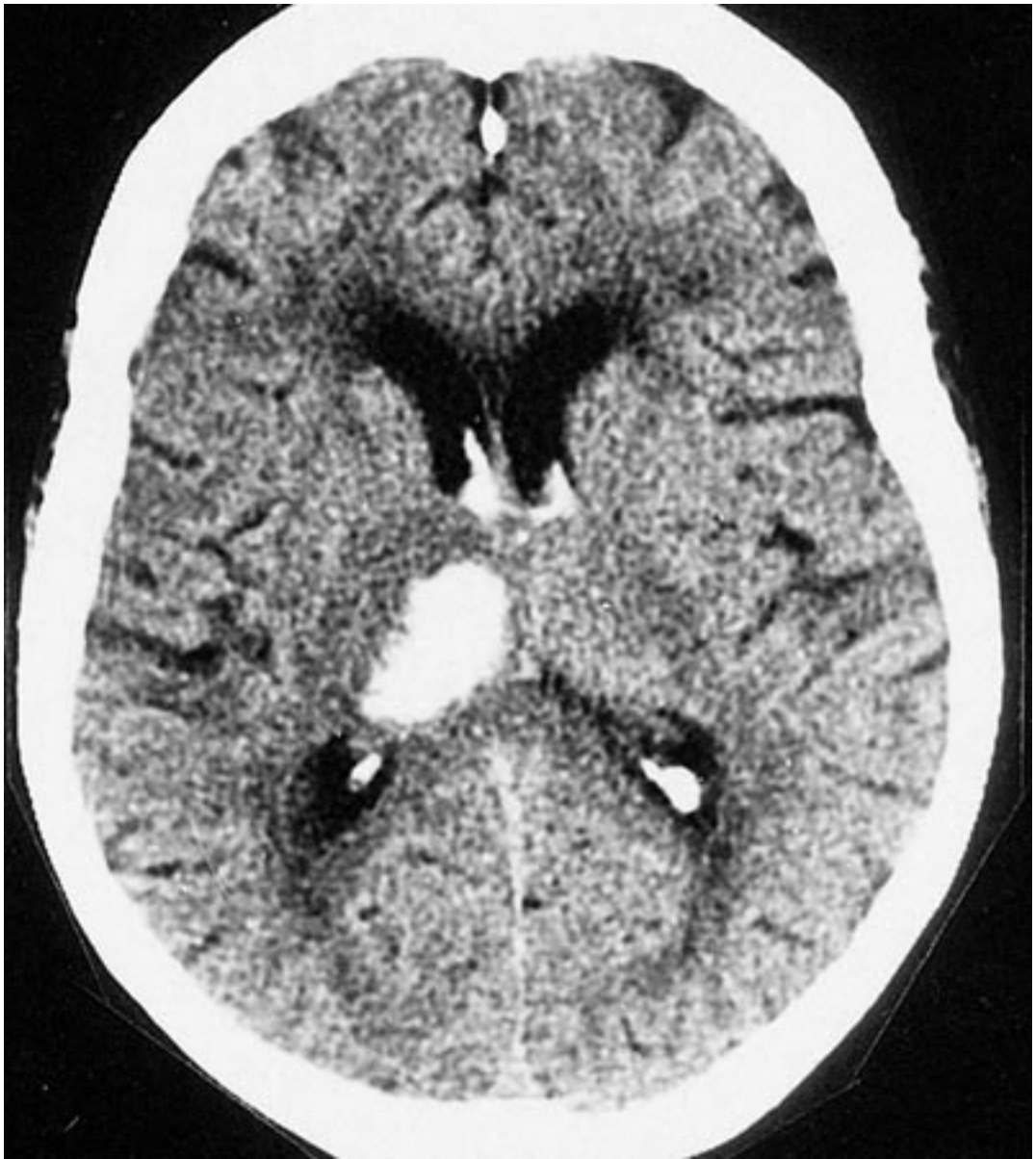
- Transient ischemic attack (TIA), isolated o multiple
- Acute infarct
- Infarct with hemorrhagic complication

Stroke Algorithm



Intracranial Hemorrhages

Hemorrhage at CT

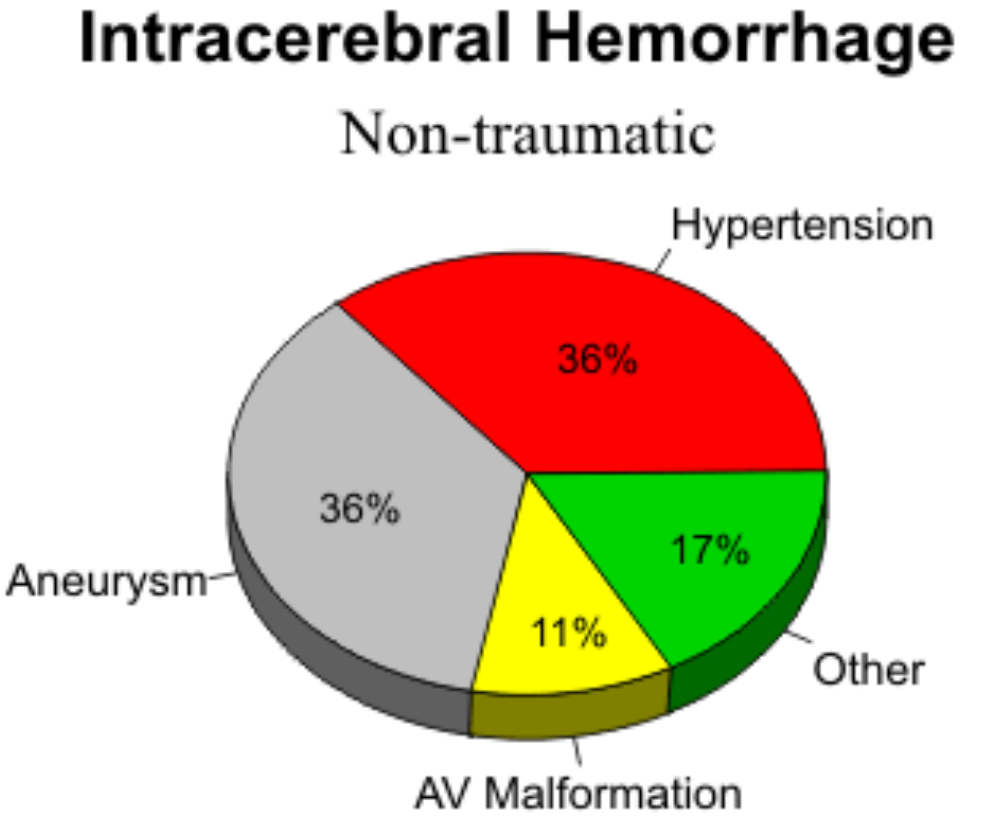


nucleus
MEDICAL MEDIA

Etiology of ICH

- Traumatic
- Spontaneous
  - Hypertensive
  - Amyloid angiopathy
  - Aneurysmal rupture
  - Arteriovenous malformation rupture
  - Bleeding into tumor
  - Cocaine and amphetamine use

Causes of ICH



Other causes: bleeding into tumor, hypocoagulable state, hemorrhagic infarction, iatrogenic, and trauma

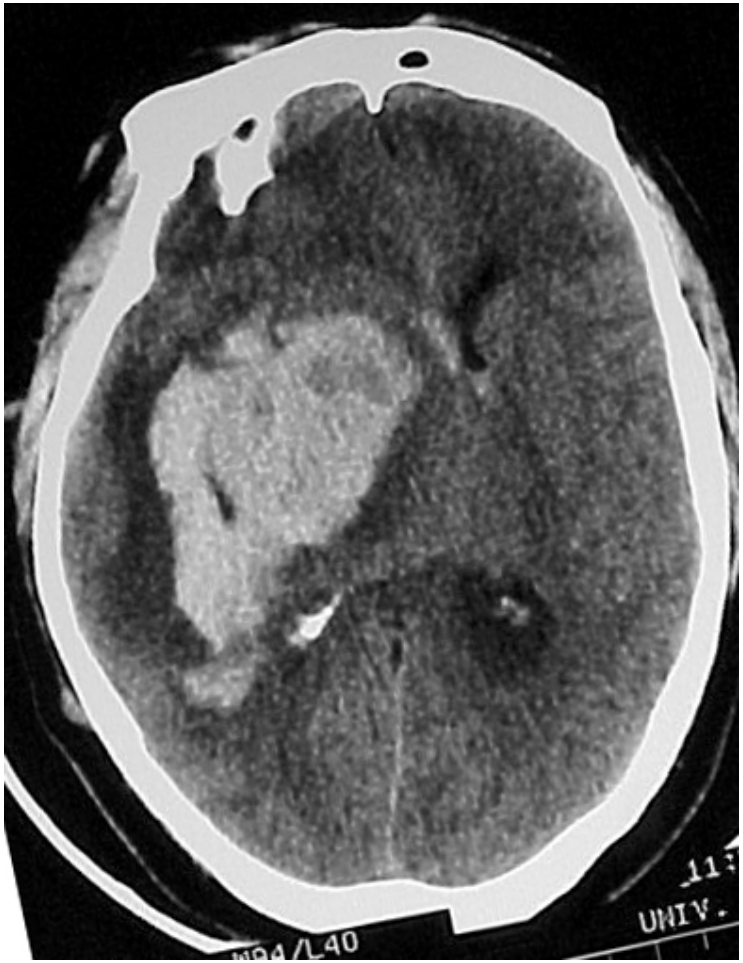
Hypertensive ICH

- Spontaneous rupture of a small artery deep in the brain
- Typical sites
  - Basal Ganglia
  - Cerebellum
  - Pons
- Typical clinical presentation
  - Patient typically awake and often stressed, then abrupt onset of symptoms with acute decompensation

Ganglionic Bleed

- Contralateral hemiparesis
- Hemisensory loss
- Homonymous hemianopia
- Conjugate deviation of eyes toward the side of the bleed or downward
- AMS (stupor, coma)

Cerebral Hemorrhage



Cerebellar Hemorrhage

- Vomiting (more common in ICH than SAH or Ischemic CVA)
- Ataxia
- Eye deviation toward the opposite side of the bleed
- Small sluggish pupils
- AMS

Cerebellar Hemorrhage

Pontine Hemorrhage

- Pin-point but reactive pupils
- Abrupt onset of coma
- Decerebrate posturing or flaccidity
- Ataxic breathing pattern

Pontine Hemorrhage

Subarachnoid Hemorrhage

- “Worst headache of my life”
- AMS
- Photophobia
- Nuchal rigidity
- Seizures
- Nausea and vomiting

Subarachnoid Hemorrhage

American Association
of Colleges *of* Nursing

A collaboration between the American Association of Colleges of Nursing and Khan Academy

Management

Airway

- Most likely related to decreased level of consciousness (LOC), dysarthria, dysphagia
- GCS < 8 - INTUBATE
- Avoid Hyperventilation or Hypoventilation
- NPO until swallow assessment completed- high aspiration risk
- Begin mobilization as soon as clinically safe
- Keep HOB greater than 30 degrees

Imaging

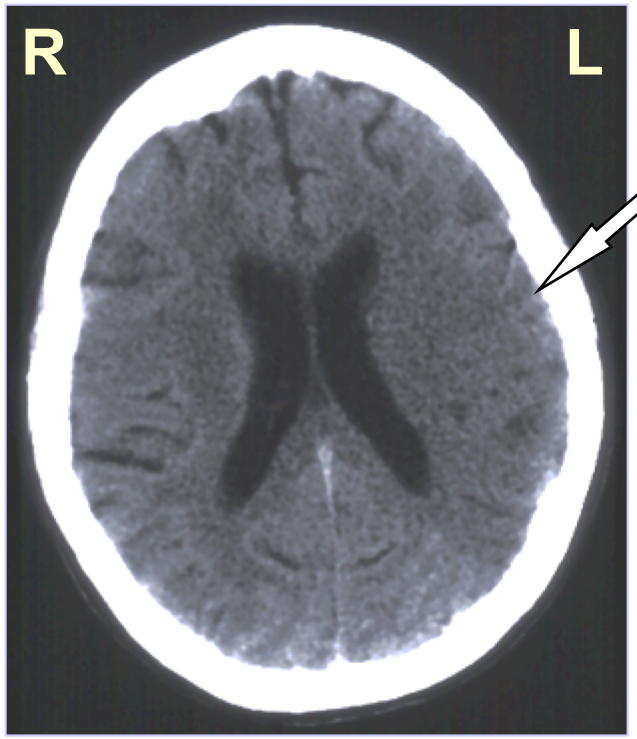
CT scan

- Non- contrast CTH remains the gold standard as it is superior for showing IVH and ICH
- CT with contrast may help identify aneurysms, AVMs, or tumors but is not required to determine whether or not the patient is a tPa candidate

MRI

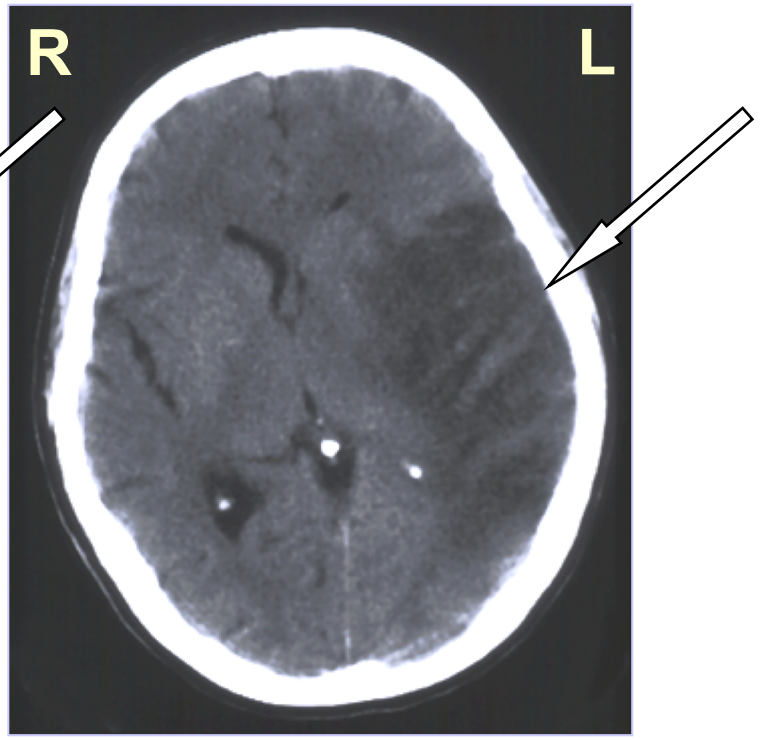
- Superior for showing underlying structural lesions
- Contraindications

Acute (4 hours)
Infarction



Subtle blurring of gray-white junction & sulcal effacement

Subacute (4 days)
Infarction



Obvious dark changes & “mass effect” (e.g., ventricle compression)

Multimodal Imaging

Multimodal CT

- Typically includes non-contrast CT, perfusion CT, and CTA
- Two types of perfusion CT
  - Whole brain perfusion CT
  - Dynamic perfusion CT

Multimodal MRI

- Standard MRI sequences (T1 weighted, T2 weighted, and proton density) are relatively insensitive to changes in cerebral ischemia
- Multimodal adds diffuse-weighted imaging (DWI) and PWI (perfusion-weighted imaging)

Trattamento della fase acuta

- Il trattamento con r-tPA e.v. (0,9 mg/kg, dose massima 90 mg, il 10% della dose in bolo, il rimanente in infusione di 60 minuti) è indicato entro tre ore dall'esordio di un ictus ischemico. Nei casi trattati ben selezionati c'è un miglioramento della prognosi.
- Stroke Unit

Stroke unit

- La trombolisi va effettuata in centri esperti, dotati di caratteristiche organizzative che consentano di minimizzare l'intervallo di tempo fra arrivo del paziente e inizio del trattamento, e che assicurino una monitorizzazione accurata dello stato neurologico e della pressione arteriosa per le 24 ore successive al trattamento.

tPa

Fast Facts

- Tissue plasminogen activator
- “clot buster”
- IV tpa window 3 hours
- IA tpa window 4.5 hours
- Disability risk ↓ 30% despite ~5% symptomatic ICH risk

Contraindications

- Hemorrhage
- SBP > 185 or DBP > 110
- Recent surgery, trauma or stroke
- Coagulopathy
- Seizure at onset of symptoms
- NIHSS >21
- Age?
- Glucose < 50

Mechanical Thrombolysis

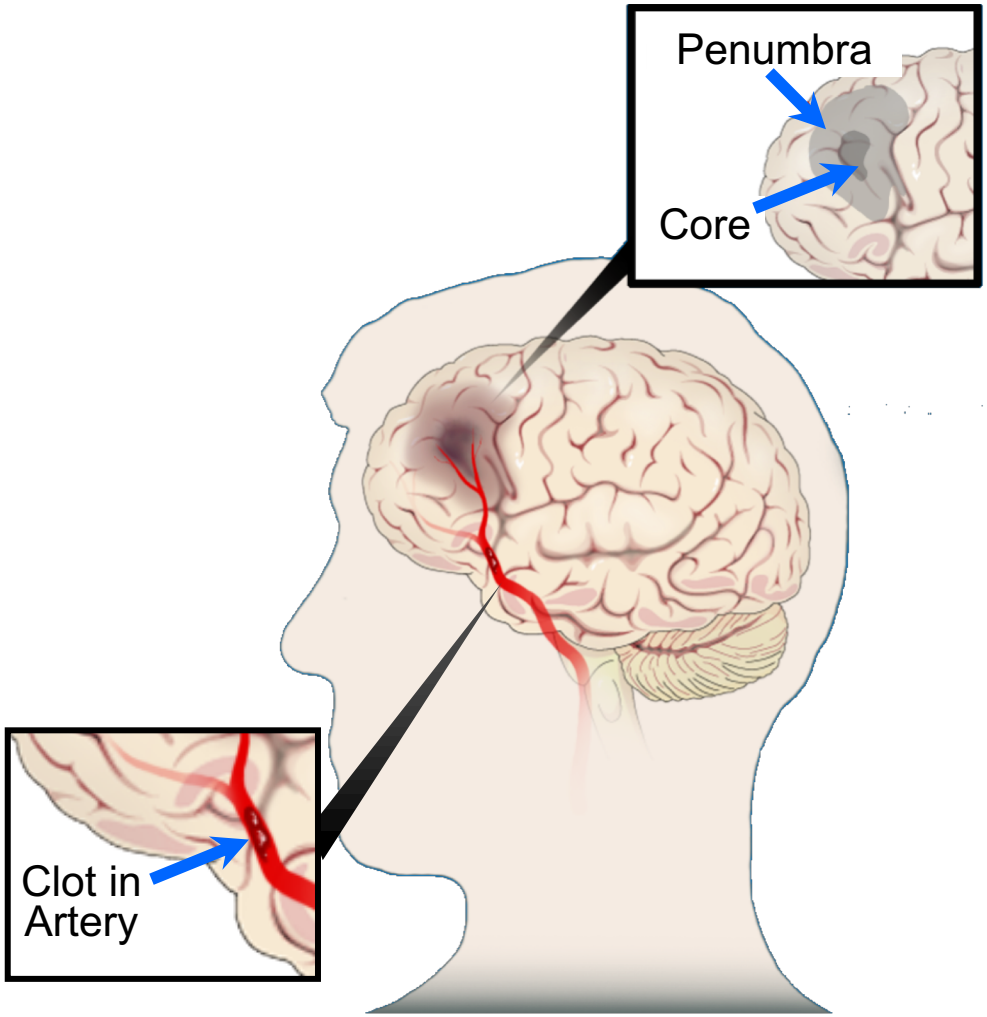
- Often used in adjunct with tPa
- MERCI (Mechanical Embolus Removal in Cerebral Ischemia) Retrieval System is a corkscrew-like apparatus designed to remove clots from vessels
- PENUMBRA system aspirates the clot

Blood Pressure Management

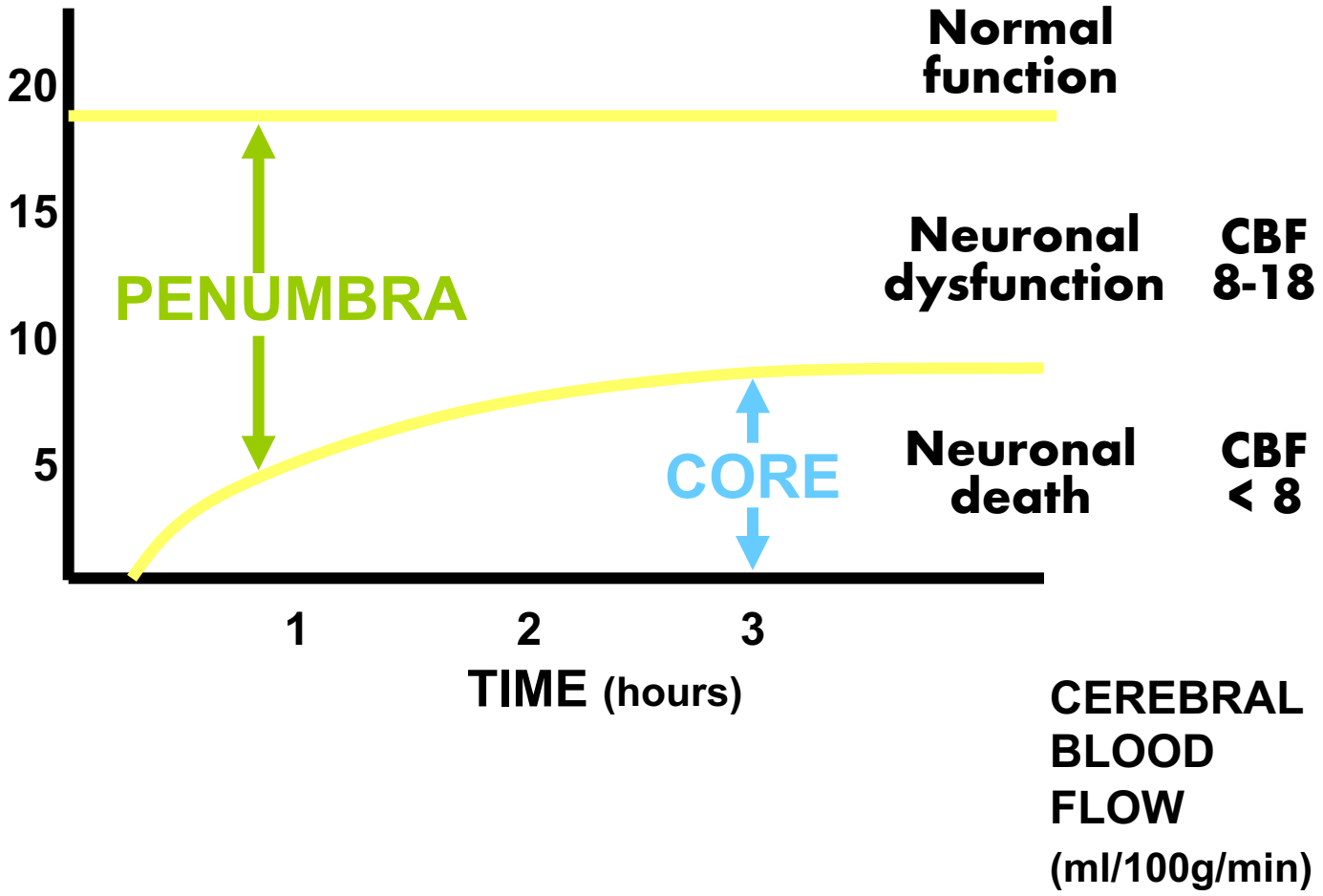
- BP Management
  - **The goal is to maintain cerebral perfusion!!**
  - CPP = MAP – ICP (needs to be at least 70)
  - Higher BP goals with Ischemic stroke
  - Lower BP goals with Hemorrhagic stroke (avoid hemorrhagic expansion, especially in AVMs and aneurysms)

BP-AIS Relationship

- BP increase is due to arterial occlusion (i.e., an effort to perfuse penumbra)
- Failure to recanalize (w/ or w/o thrombolytic therapy) results in high BP and poor neuro outcomes
- Lowering BP starves penumbra, worsens outcomes



Save the Penumbra!!



Supportive Therapy

- Glucose Management
  - Infarction size and edema increase with acute and chronic hyperglycemia
  - Hyperglycemia is an independent risk factor for hemorrhage when stroke is treated with t-PA
- Antiepileptic Drugs
  - Seizures are common after hemorrhagic CVAs
  - ICH related seizures are generally non-convulsive and are associated to with higher NIHSS scores, a midline shift, and tend to predict poorer outcomes

Prevenzione secondaria

- L’aspirina alla dose di 325 mg/die è indicata come terapia di prevenzione secondaria precoce dopo un ictus cardioembolico in tutti i casi nei quali la terapia anticoagulante è controindicata o non possa essere adeguatamente monitorata al momento della dimissione.

Prevenzione secondaria

- Correzione dei fattori di rischio modificabili
- Aspirina o altri antiaggreganti piastrinici
- Anticoagulanti orali quando indicato
- Tecniche chirurgiche