XVII CURSO NACIONAL DE NEURORRADIOLOGÍA

Neurorradiología en la Patología Vascular Cerebral

EDICIÓN VIRTUAL

22-26 febrero 2021

Clasificación radiológica de los infartos cerebrales: topografía y etiopatogenia

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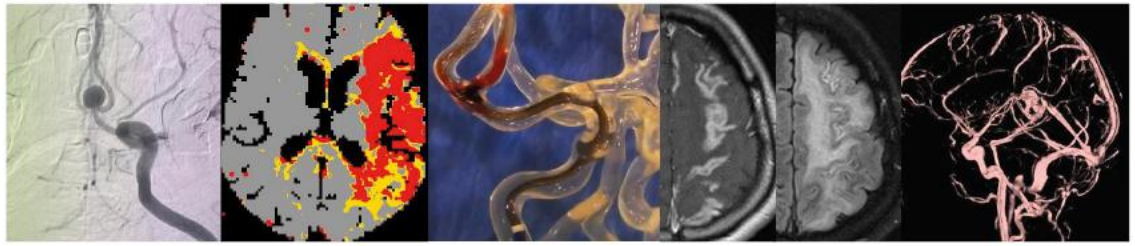
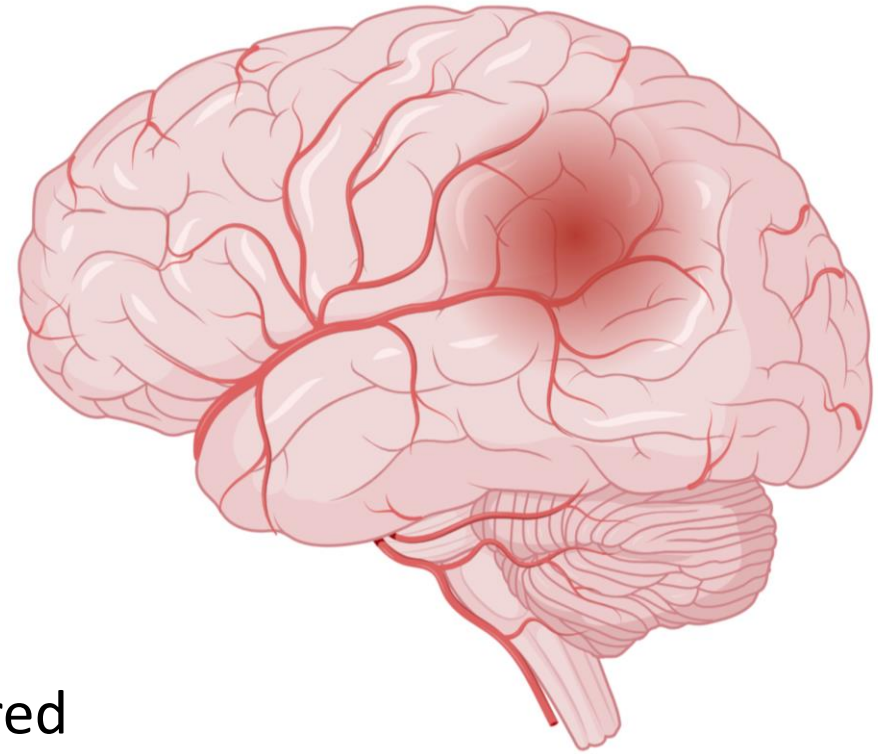


S.E.N.R
Sociedad Española de Neurorradiología

Why is important subtyping ischemic strokes?

- Therapeuthic decision-making (daily practice)
  - Acute phase
  - Secondary prevention measures
- Risk of recurrence, prognosis
- Phenotyping in genetic studies
- Epidemiological studies
- Clinical trials selection

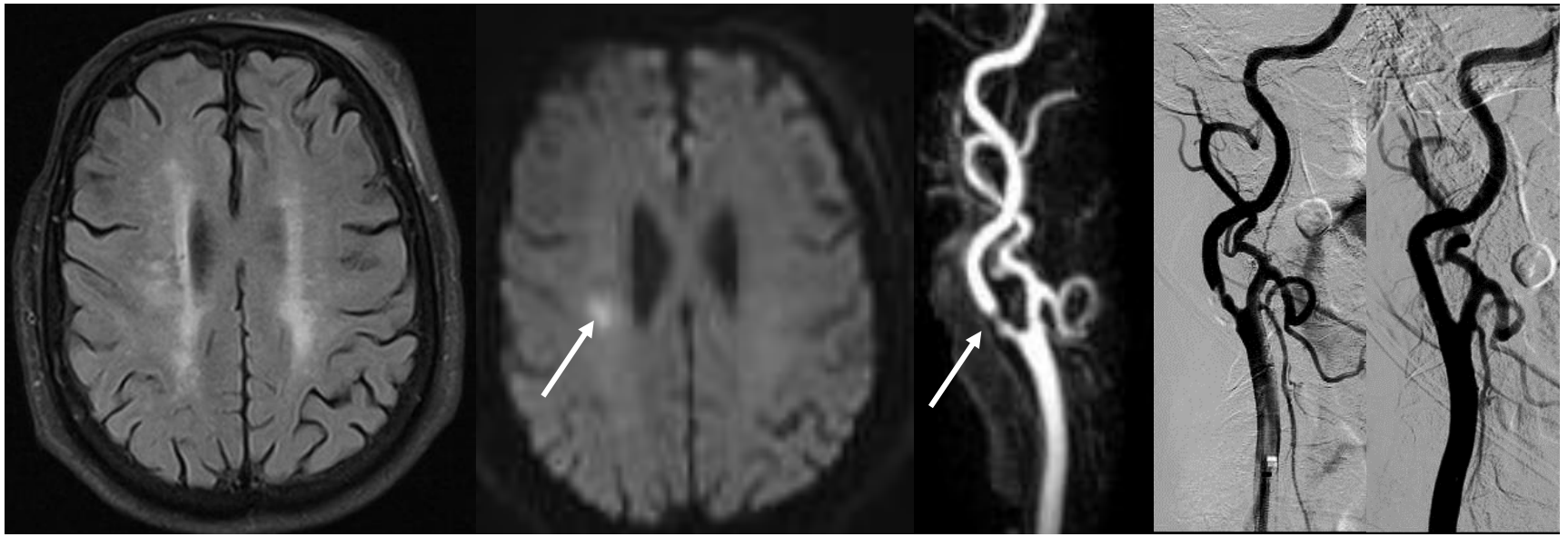


Early stroke classification required

How can we do it?

- Risk factor profiles
- Clinical features
- Biological markers
- Diagnostic imaging tests

- ***Ecocardiography***
- ***Doppler US***
- ***CT scan***
- ***MR imaging***
- ***Angiography***



Oxford classification

- Based on clinical signs and symptoms
- Predicts prognosis
- Good correlation with imaging findings on cranial CT

1. ***Total anterior circulation infarcts (TACI) 15-17%***
2. ***Partial anterior circulation infarcts (PACI) 35%***
3. ***Lacunar infarcts (LACI) 25%***
4. ***Posterior circulation infarcts (POCI) 25%***

- No prediction of mechanism of infarction
- Easy to use in the emergency department

Bamford et al. Lancet 1991

TOAST : causative classification

Guidelines developped for prospectively classifying ischemic strokes into specific subtypes, based on **the mechanisms of infarction**

- Risk factor profiles: age, diabetes, hypertension, cholesterol,…
- Clinical features
- **Results of diagnostic tests**

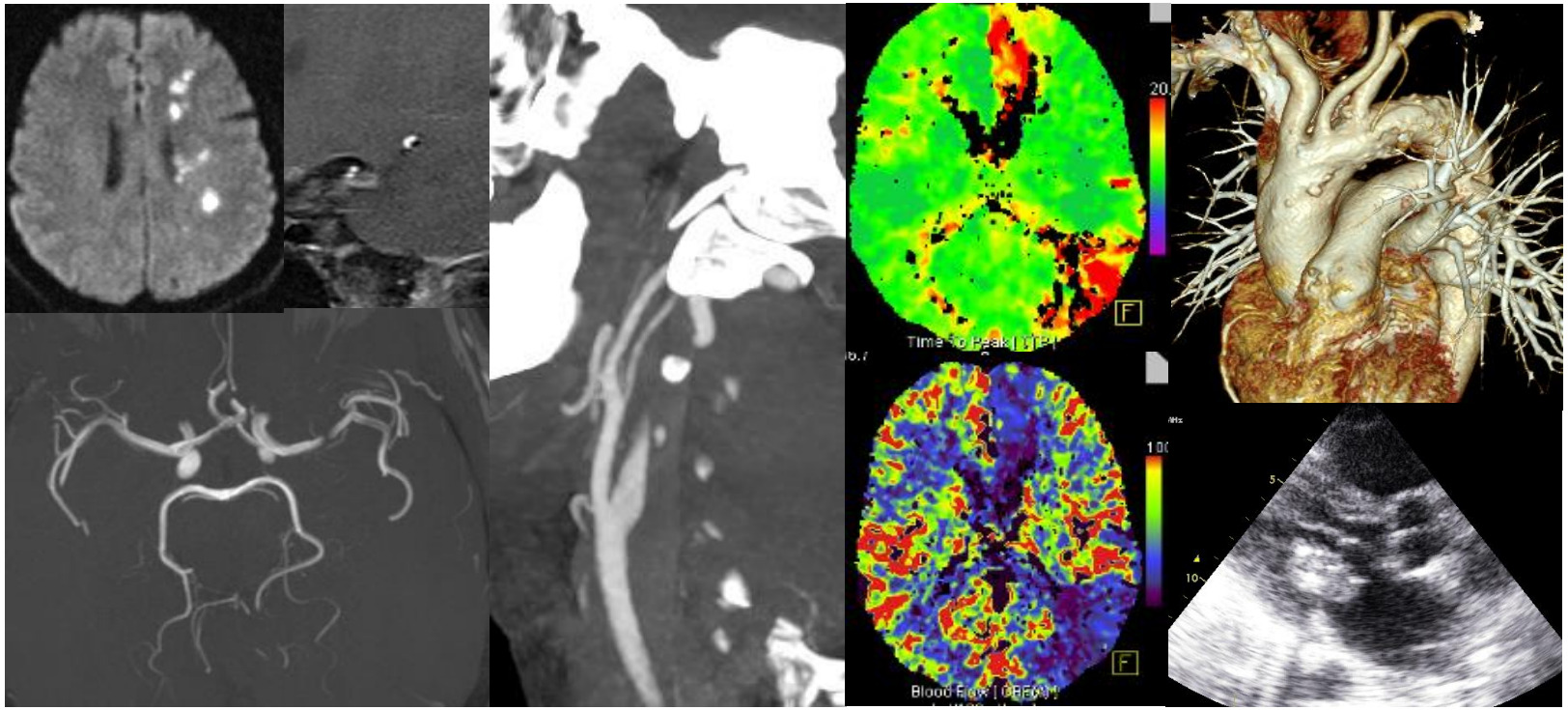
1. **Large-vessel disease (15%)**
2. **Small-vessel disease (25%)**
3. **Cardioembolism (15-27%)**
4. **Other etiology (2%)** **(vasculitis, craniocervical arterial disection,…)**
5. **Undetermined or multiple possible etiologies (~35%)**

Adams et al. Stroke 1993

TOAST classification (causative)

- Identification of the mechanisms of infarction can be challenging
- More than 150 known causes.
- A definite cause not identified in 25–39% of patients ('cryptogenic strokes'),
- Definite cause identification depends on the diagnostic work-up:
  - *quality*
  - *extension*
  - *rapidity*

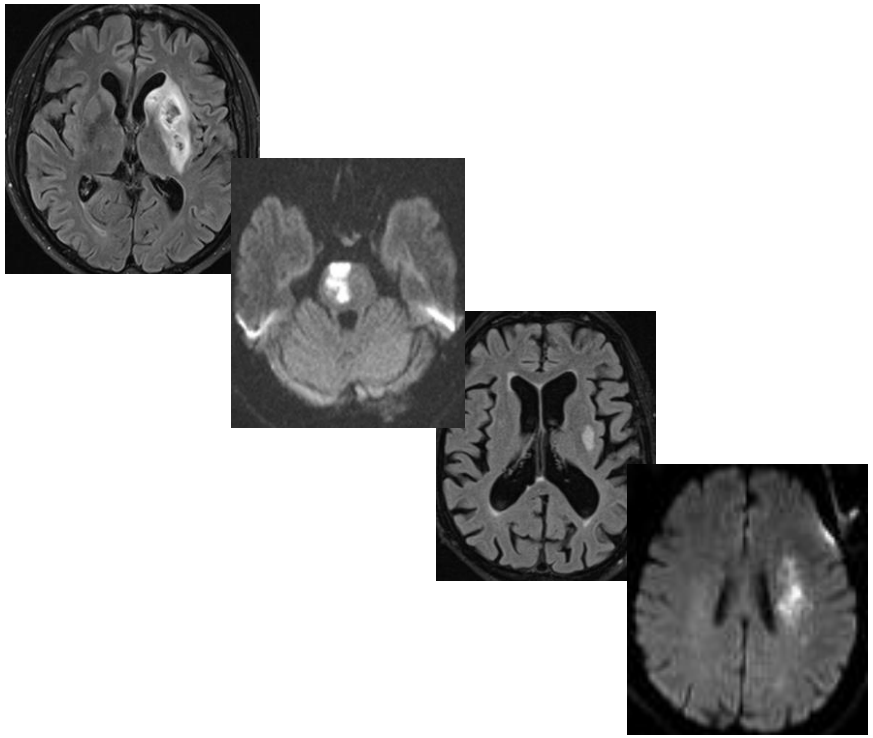
Brain
Heart
Vessels: lumen, wall



Infarct classification: Imaging

Topography (Oxford classification)

1. Territorial anterior circulation infarcts
2. Territorial posterior circulation infarcts
3. Lacunar infarcts
4. Border zone infarcts

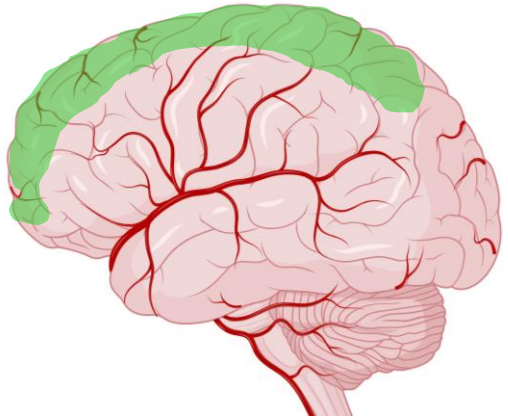


Causative mechanisms (TOAST, ASCOD classification):
Multimodal CT /MRI (angio CT, angio MR)

Lee et al. Stroke 2000

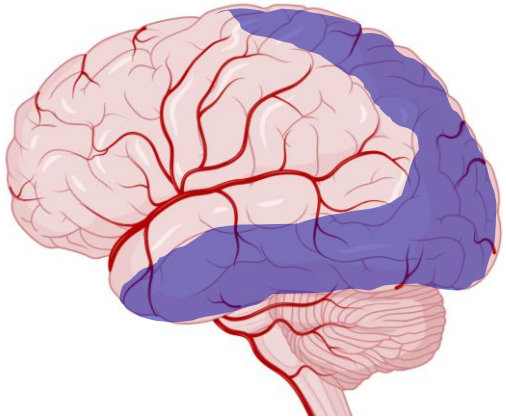
Kim et al. JAMA Neurol 2018

Territorial infarctions: supratentorial

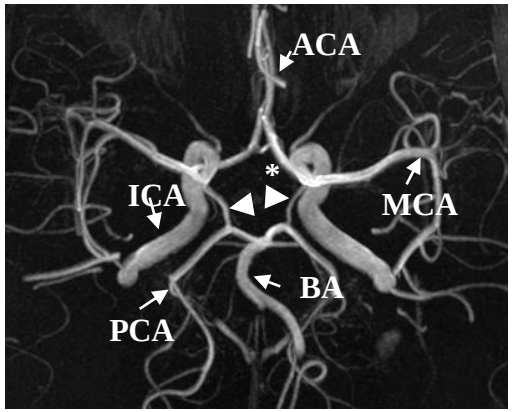


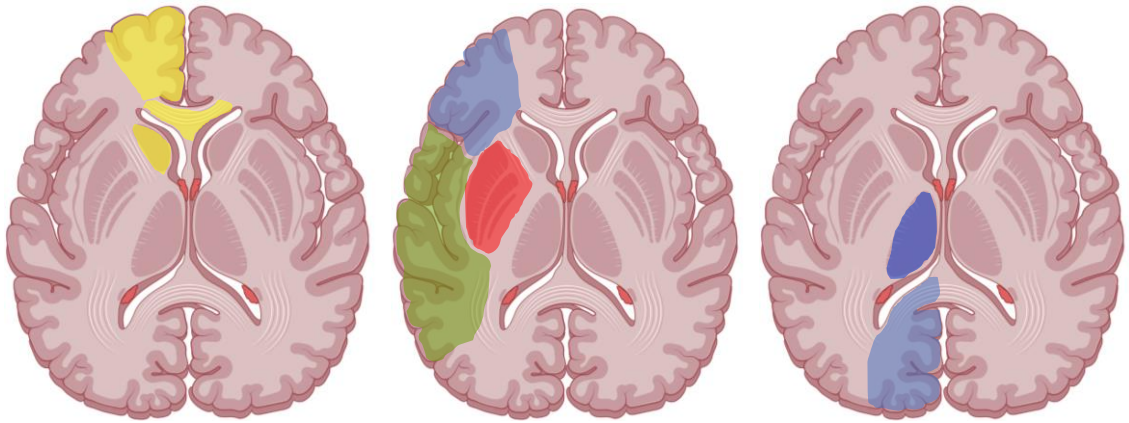
Anterior cerebral artery

Middle cerebral artery



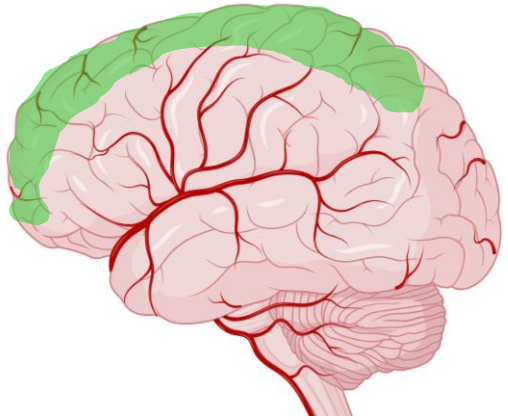
Posterior cerebral artery





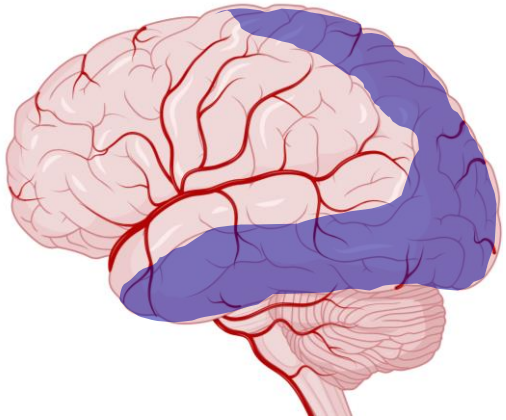
Territorial infarctions: supratentorial

Kim et al. JAMA Neurol 2018

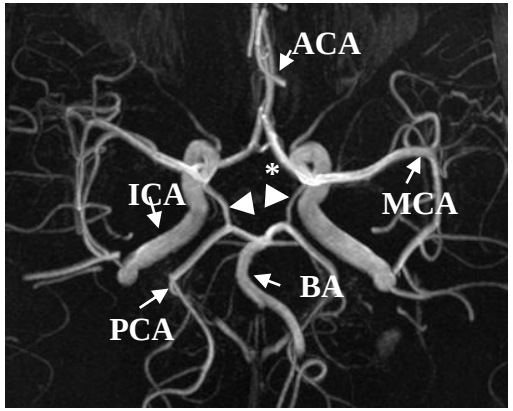


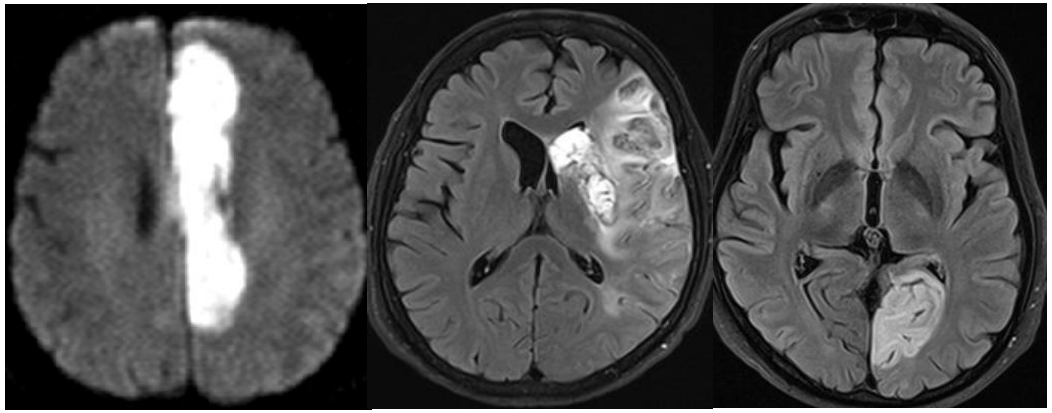
Anterior cerebral artery

Middle cerebral artery



Posterior cerebral artery



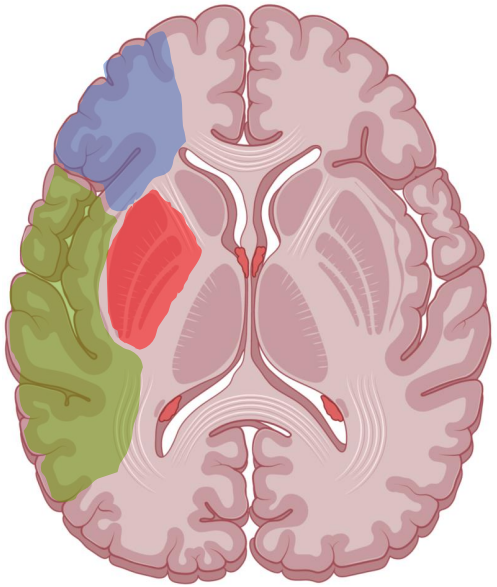


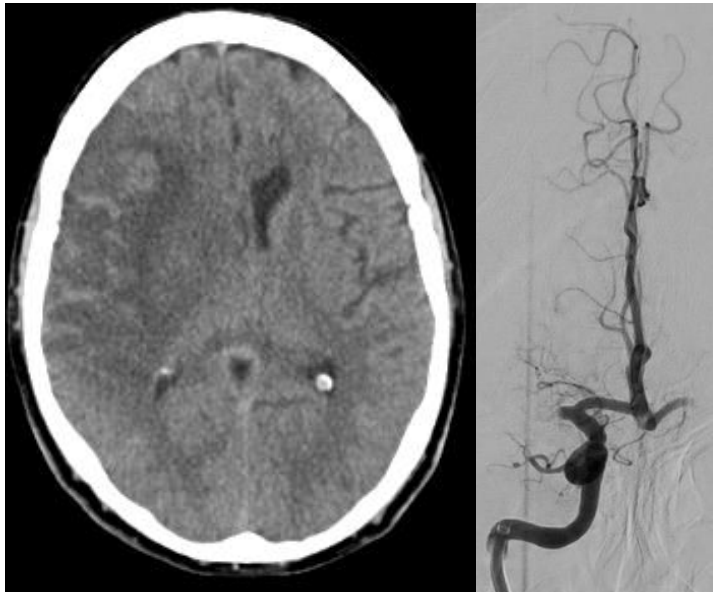
Territorial infarctions: anterior circulation

- **Large**
- **Limited**

Large infarcts

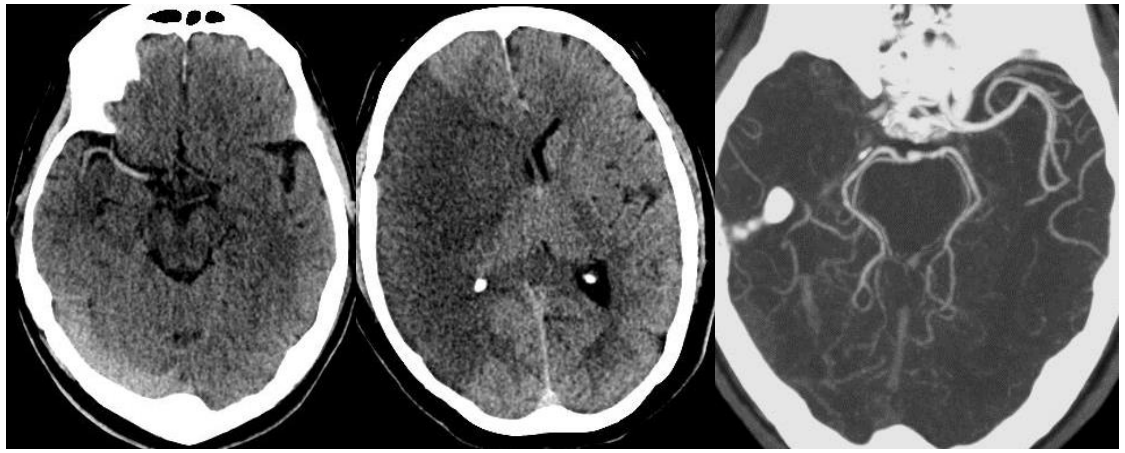
- Covering at least 2 of the 3 MCA territories
- Clinical deterioration frequent
- Minimum chance of good outcome
- High mortality rate



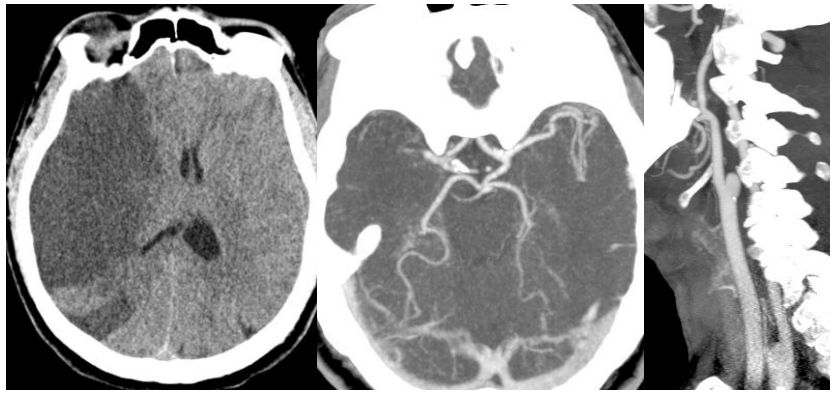


Large anterior territorial infarctions:

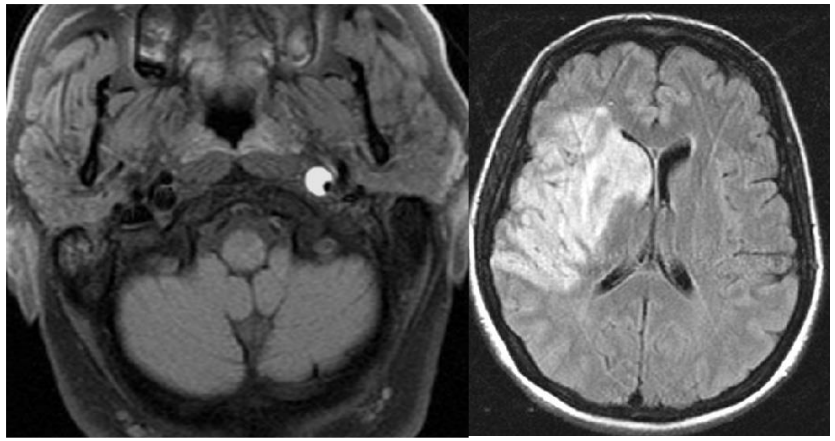
- **Cardioembolism**
- ICA Occlusion
- ICA Dissection



Cardioembolism



ICA occlusion



ICA Dissection

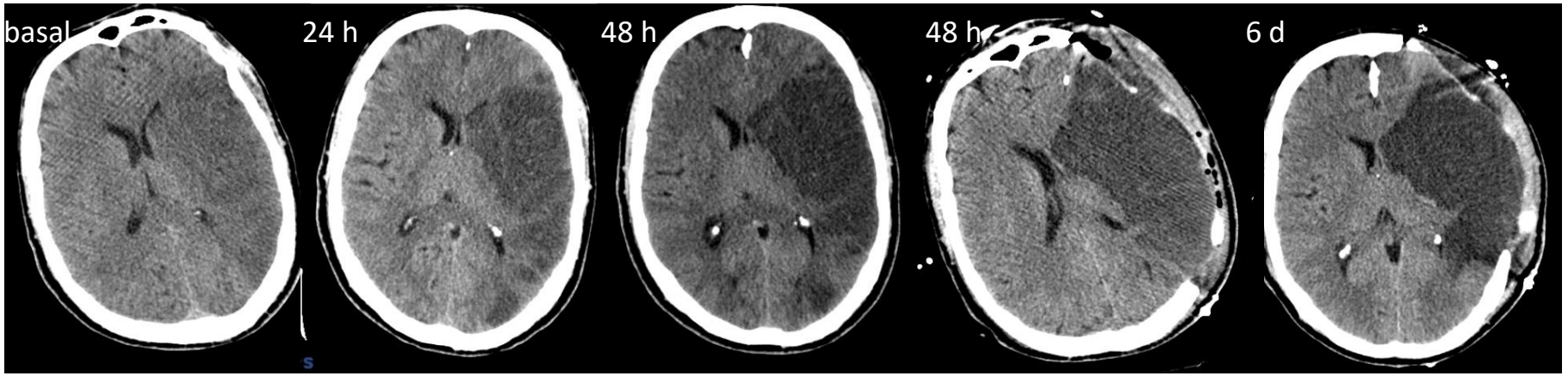
Large territorial infarctions anterior circulation: malignant infarction

- Complete or almost complete MCA infarction
- 10% of all stroke patients
- Clinical deterioration within 2-5 days
- 80% associated mortality
- Hemicraniectomy reduces mortality

Vahedi et al. Lancet Neurol 2007

Selection criteria:

- NIHSS ≥ 16-21
- Infarct volumen: >145mL (DWI) or at least 2/3 MCA territory CT

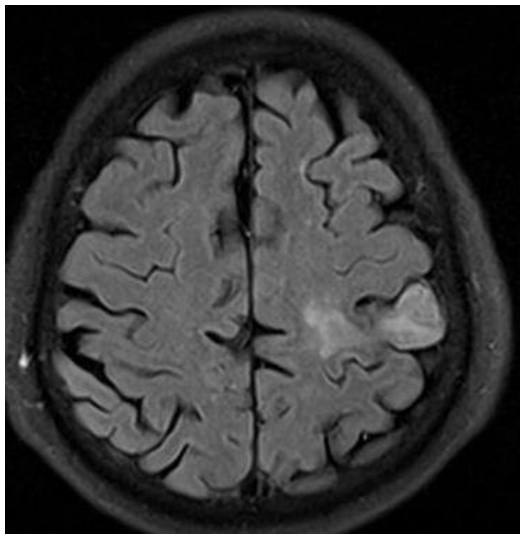


Limited territorial infarctions: anterior circulation

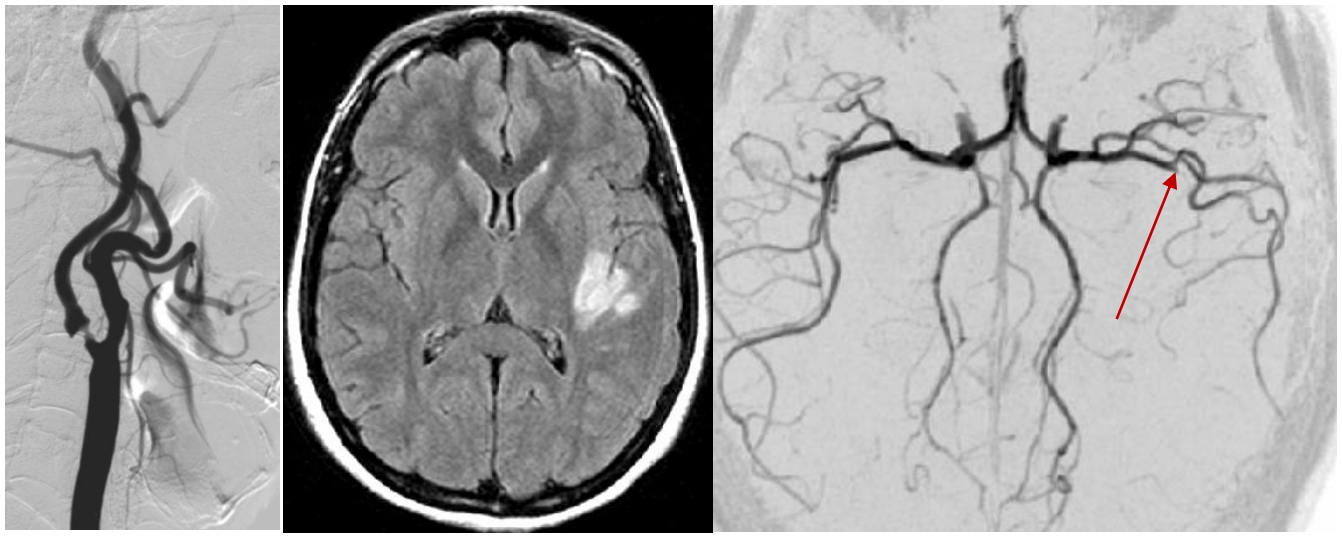
Cover only partially the MCA territories
Low frequency of clinical deterioration
Low mortality

Origin:

✓**Cardioembolism and large-artery atheroesclerosis**

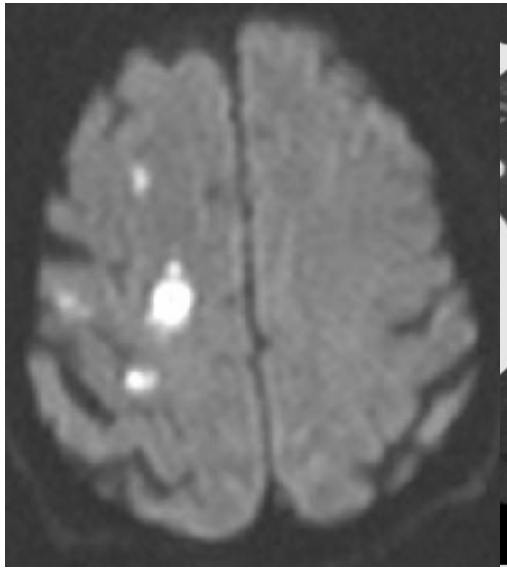
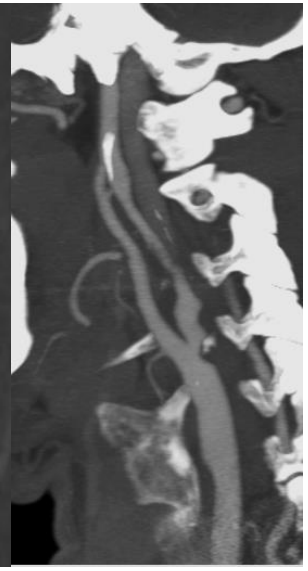
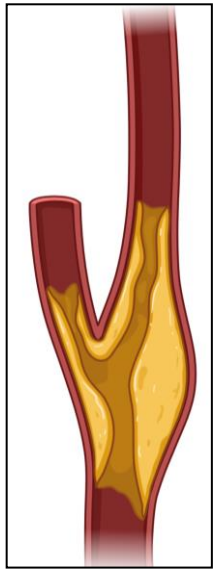


Atherothrombotic infarction: LVD



Cardioembolic infart: Branch occlussion MCA

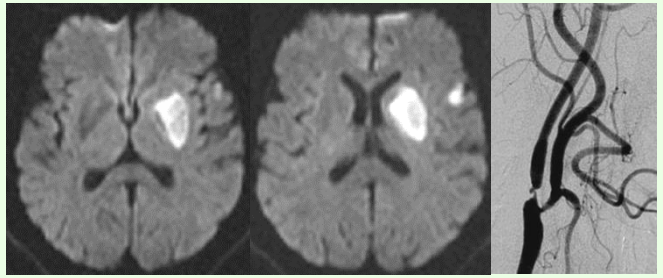
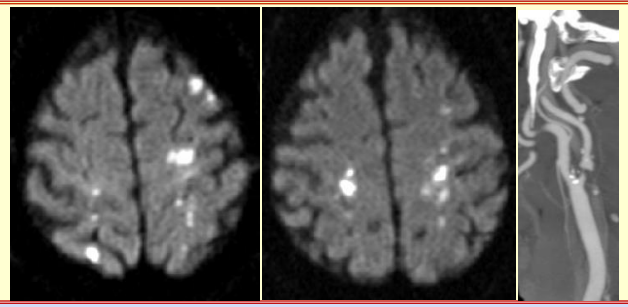
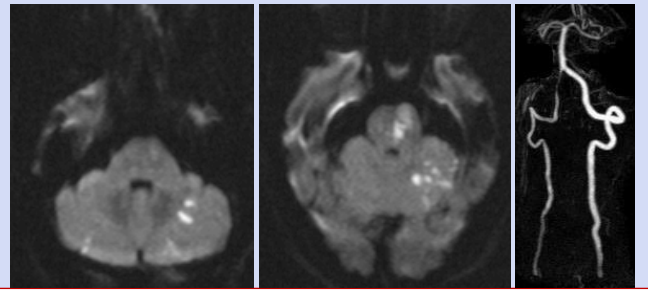
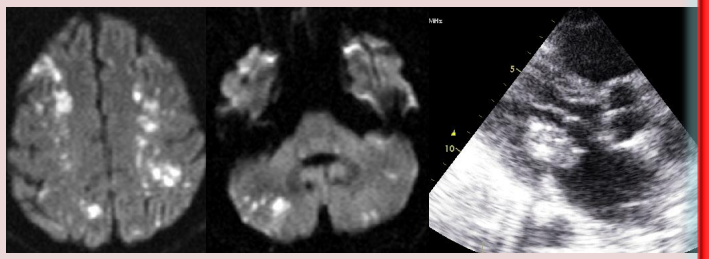
Limited vs large territorial infarctions anterior circulation


Artery-to-artery embolism (proximal ICA disease)


Cardioembolism (auricular mixoma)

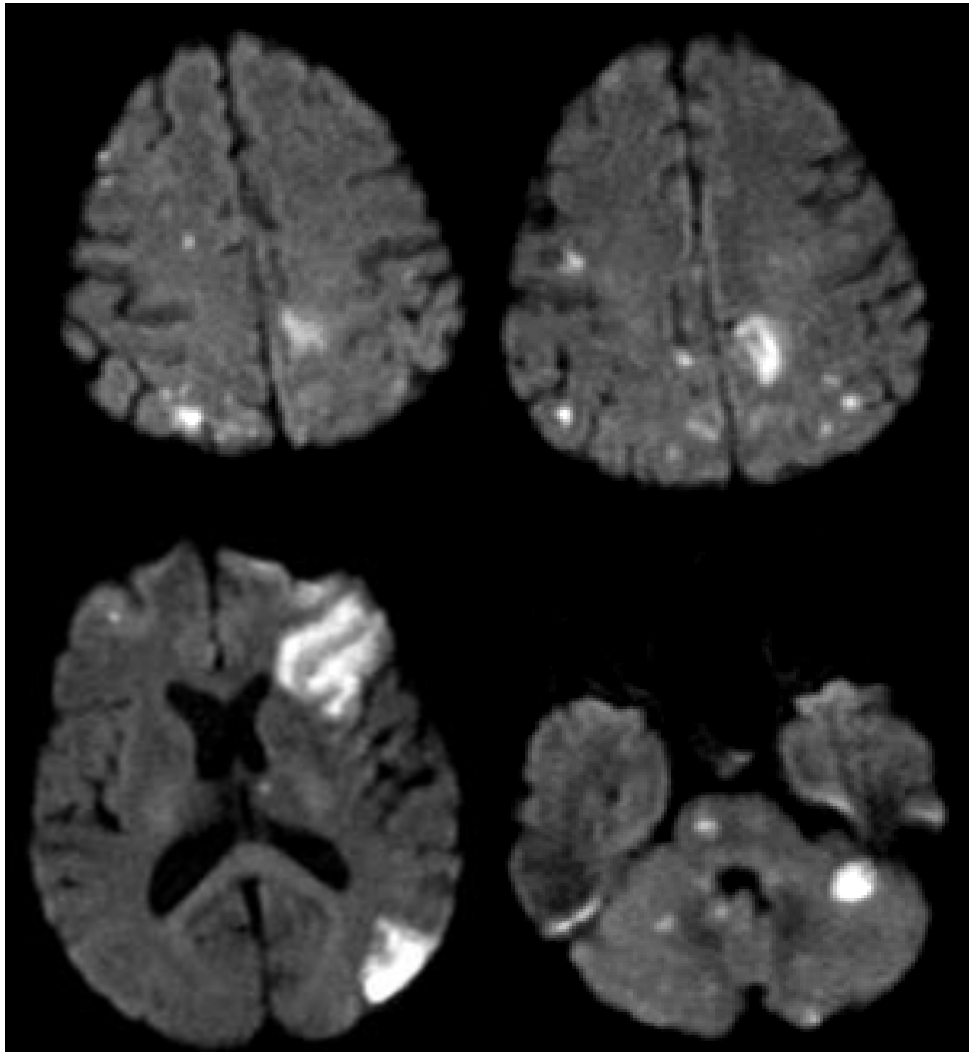
Multiple acute cerebral infarcts (MACI)

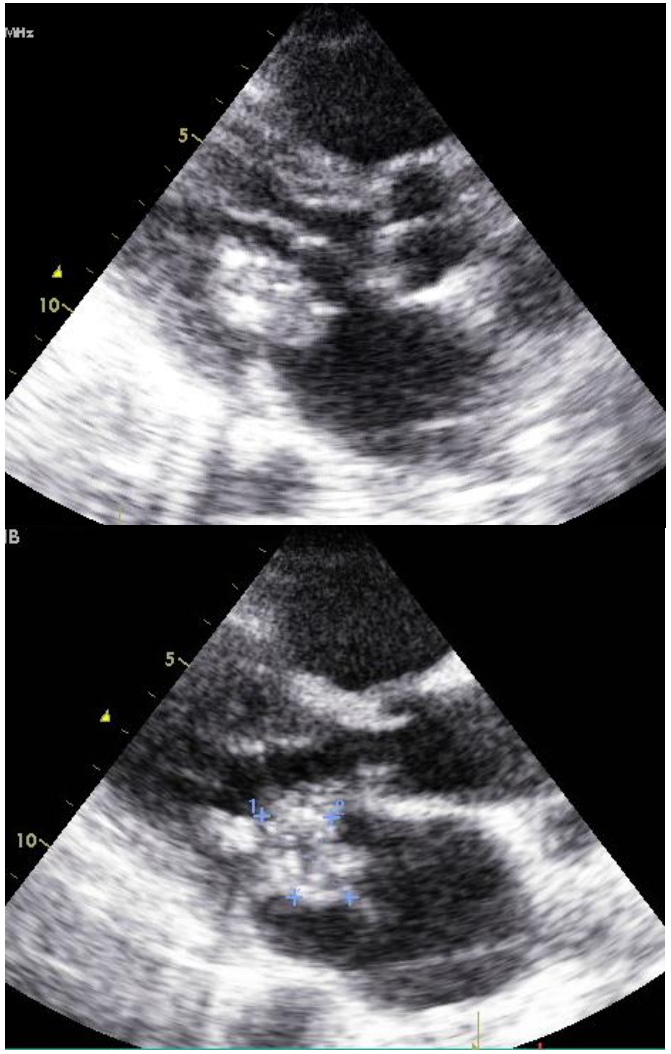
Anterior circ. / one side 44%		Cardioembolism
Anterior circ. / both sides 21%		1. Cardioembolis 2. Small vessel disease 3. Elevated fibrinogen or hematocrit, thrombotic microangiopathy 4. Anatomic variations of anterior cerebral arteries
Posterior circ. 23%		Cardioembolism
Anterior and posterior circ. 12%		•Cardiac •Aortic arch 1. Large artery atherosclerosis 2. Patent PComA or fetal-type PCA

Large vessel disease

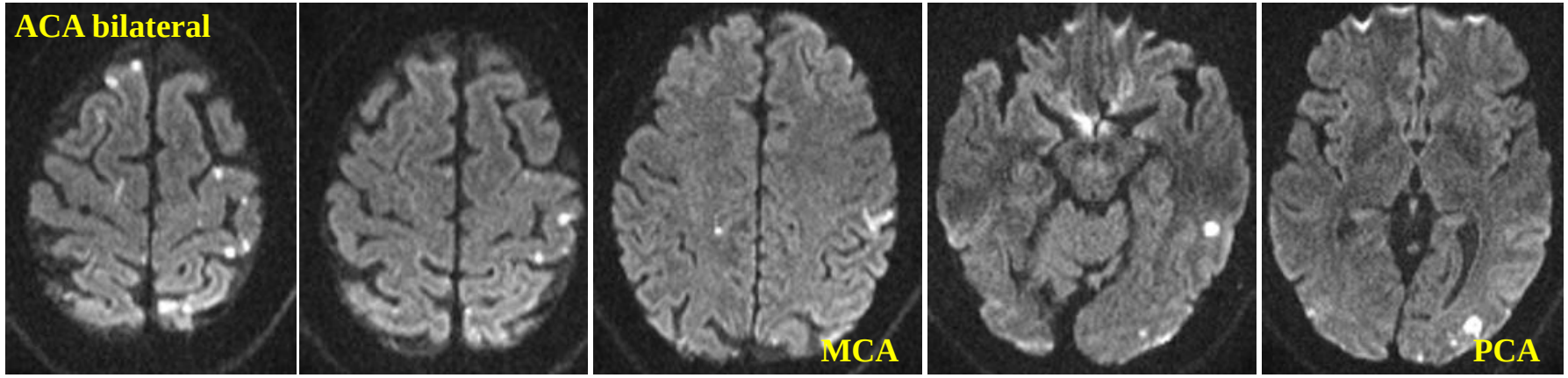
Cardioembolism

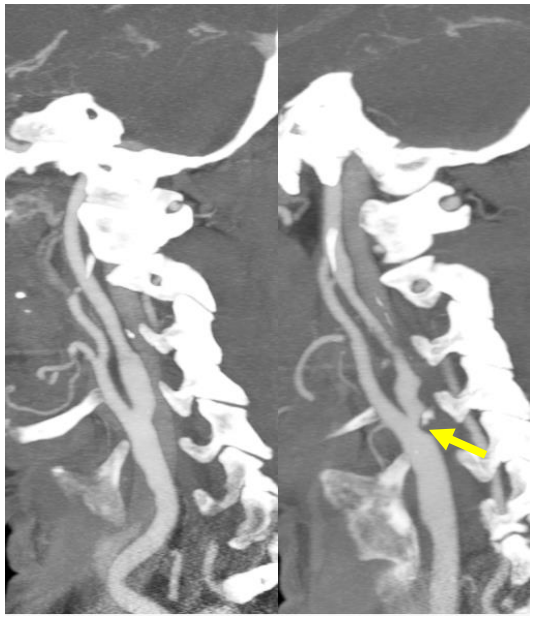
Cardioembolic infarcts (MACI): mitral valve vegetation

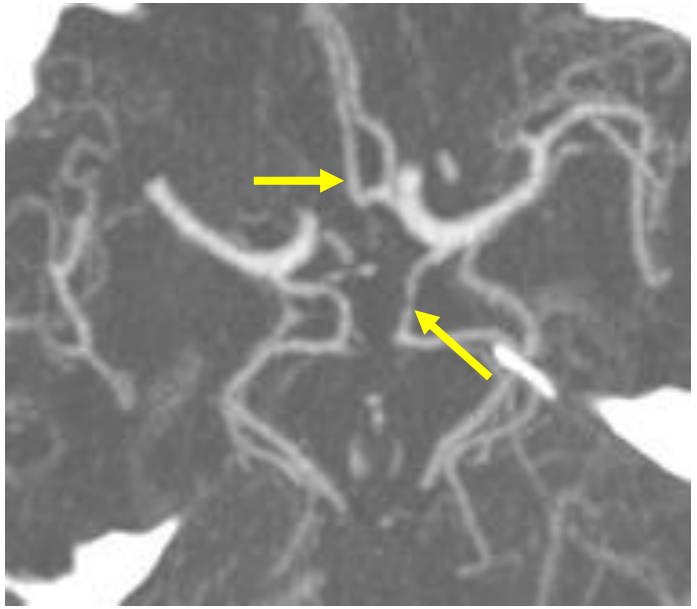


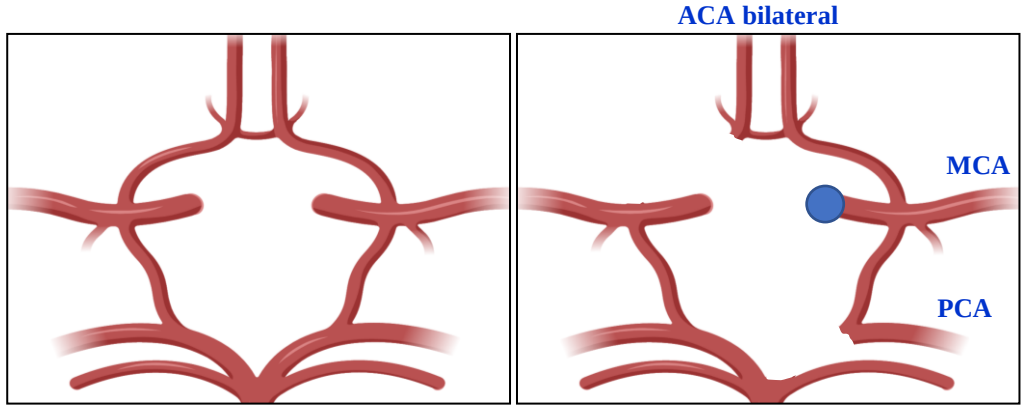


Multiple acute cerebral infarcts (MACI)



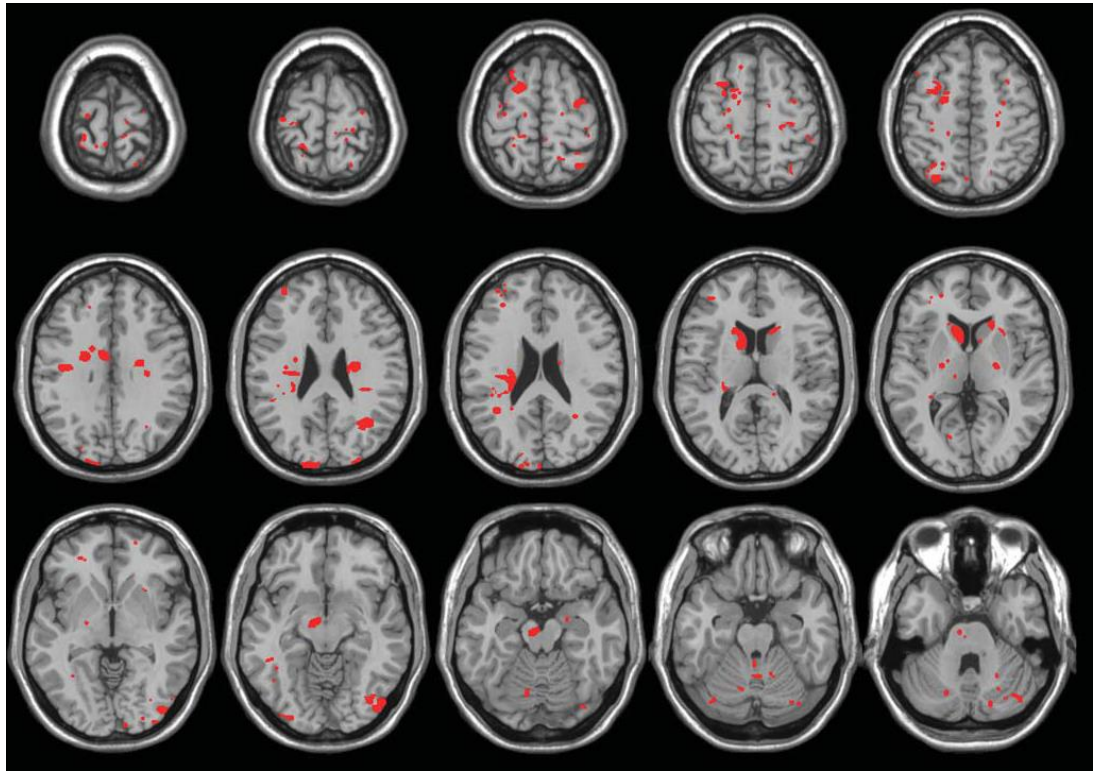






Multiple acute cerebral infarcts (MACI)

Aortic arch atheromatosis (AAA)



Lesion probability map in AAA

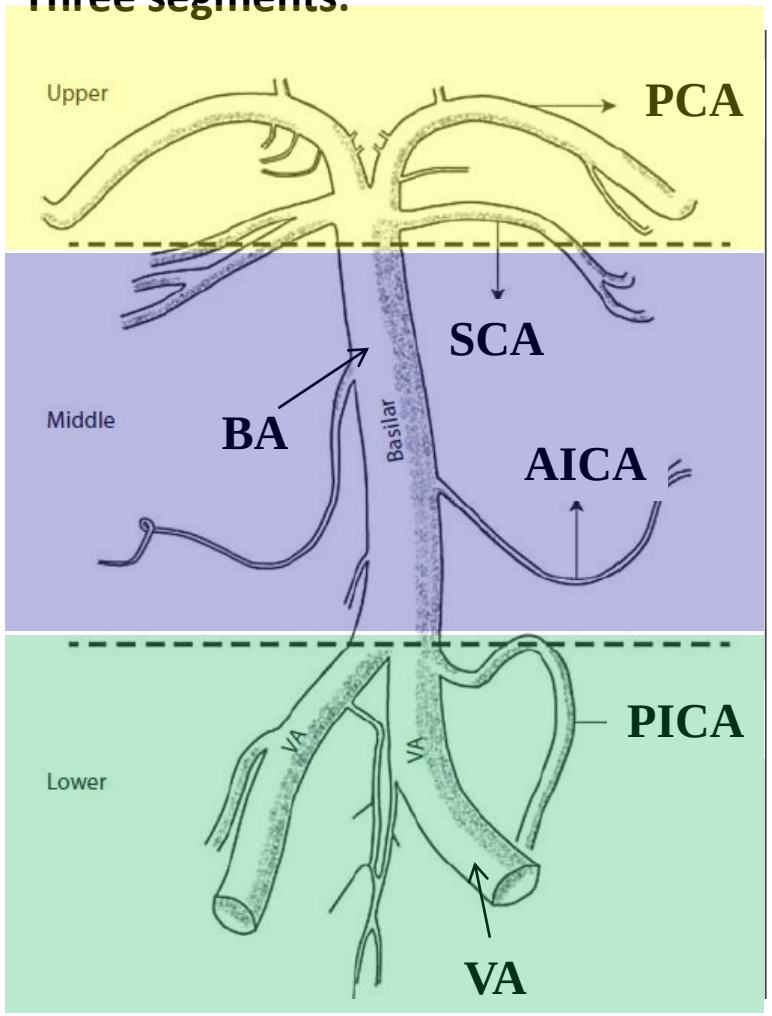
- AAA in 24% of cryptogenic infarcts
- Old age
- Multiple and small multiterritotial infarcts (cortical, border zone)

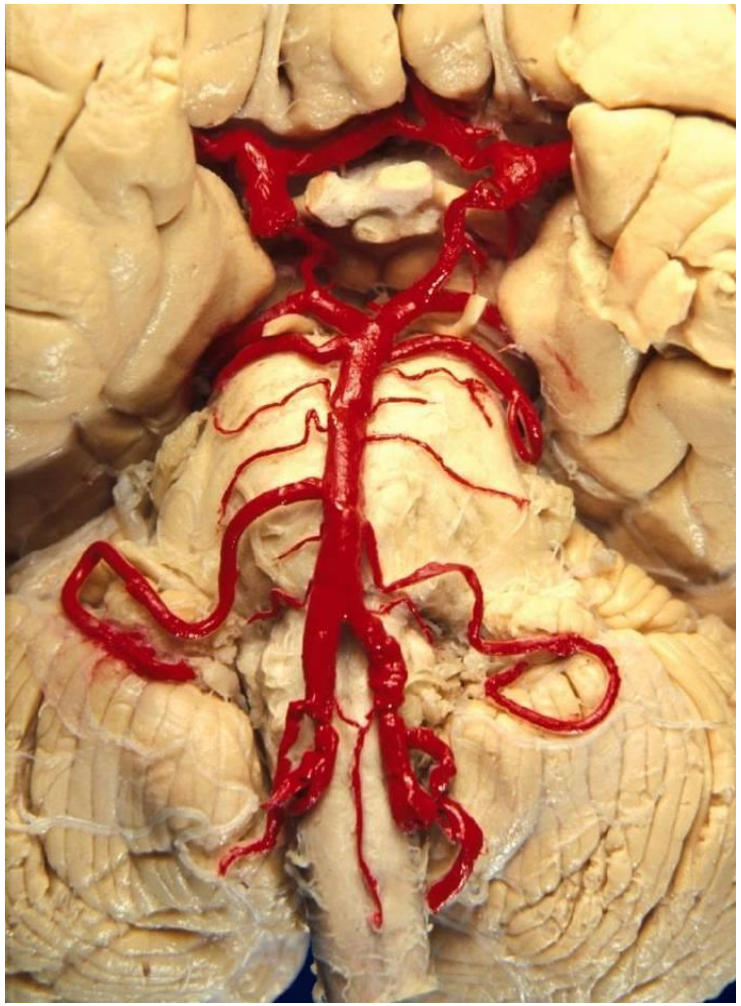
Kim et al. Cerebrovasc Dis 2012

Posterior circulation infarcts

Caplan LR. et al. Ann Neurol 2004; Caplan LR. Cerebrovasc Dis 2012

Three segments:





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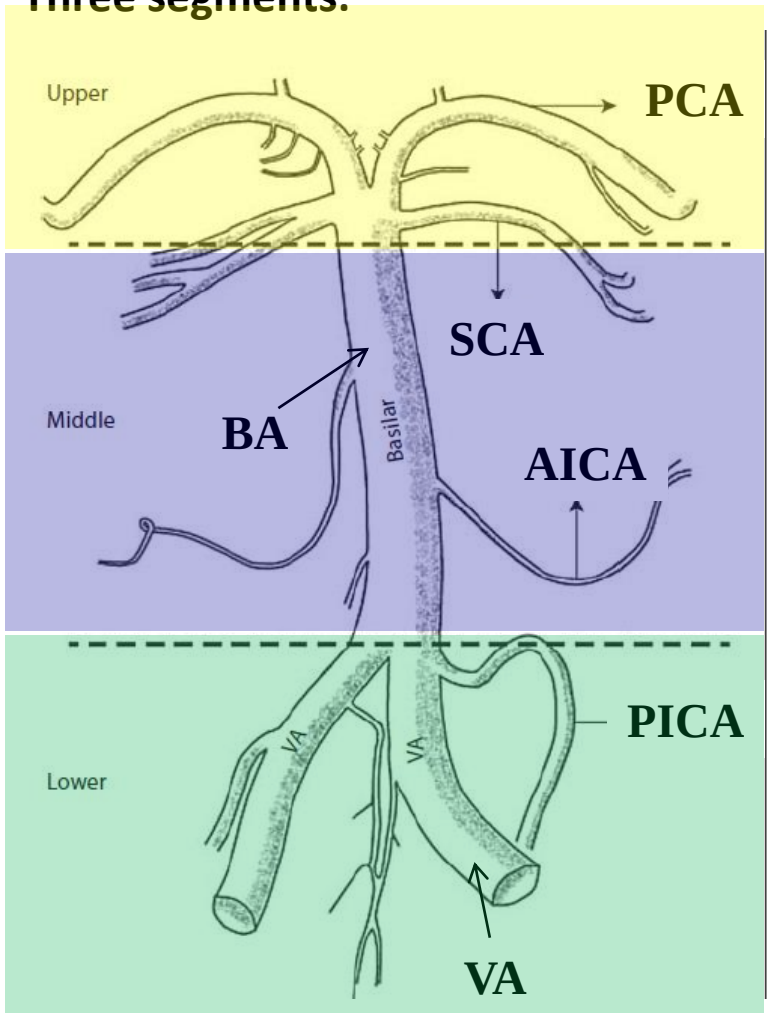
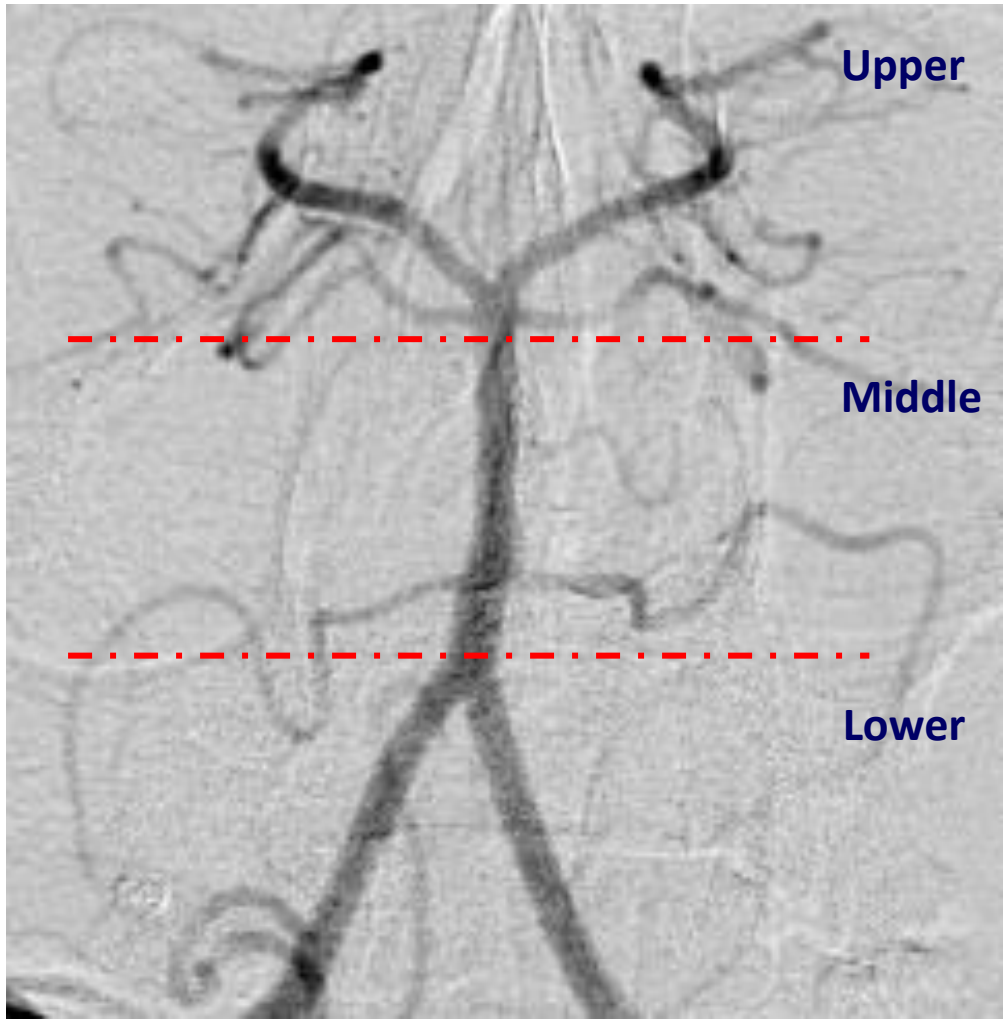
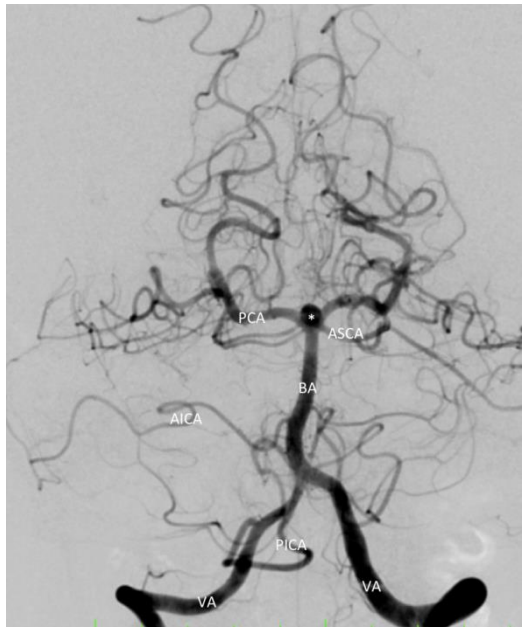
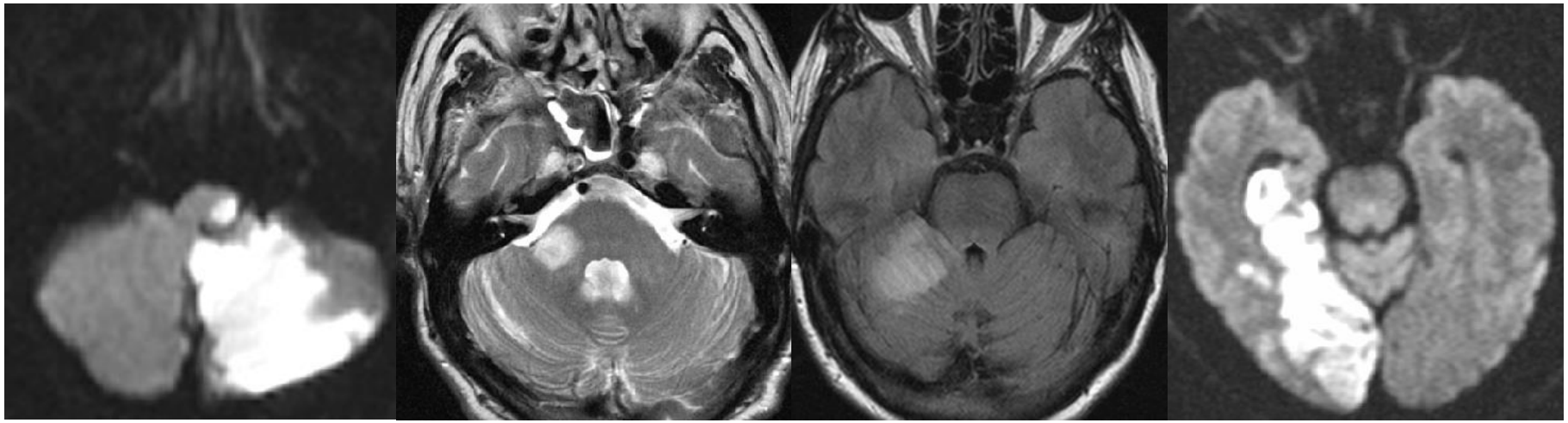




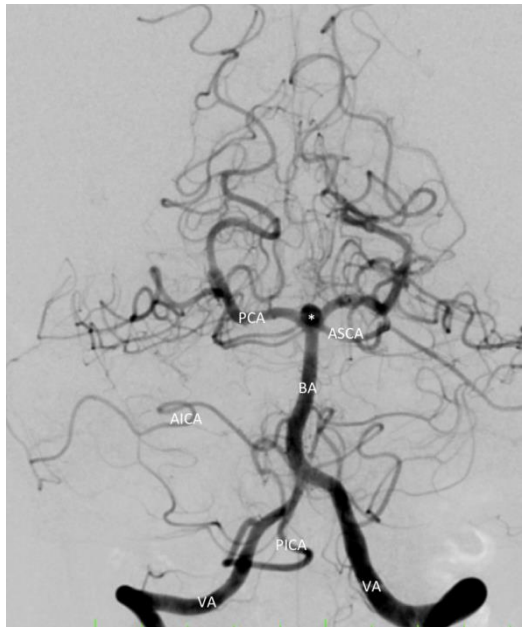
Posterior circulation infarcts

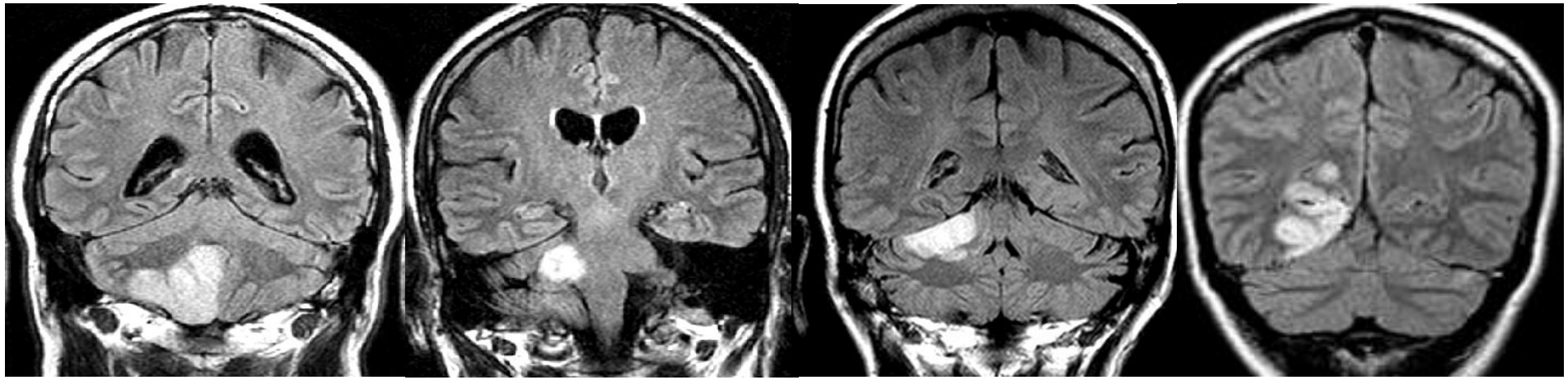




PICA AICA SCA PCA

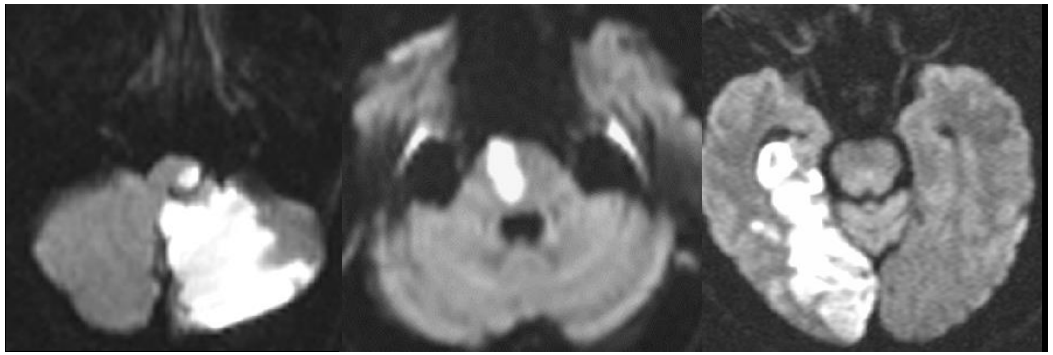
Posterior circulation infarcts

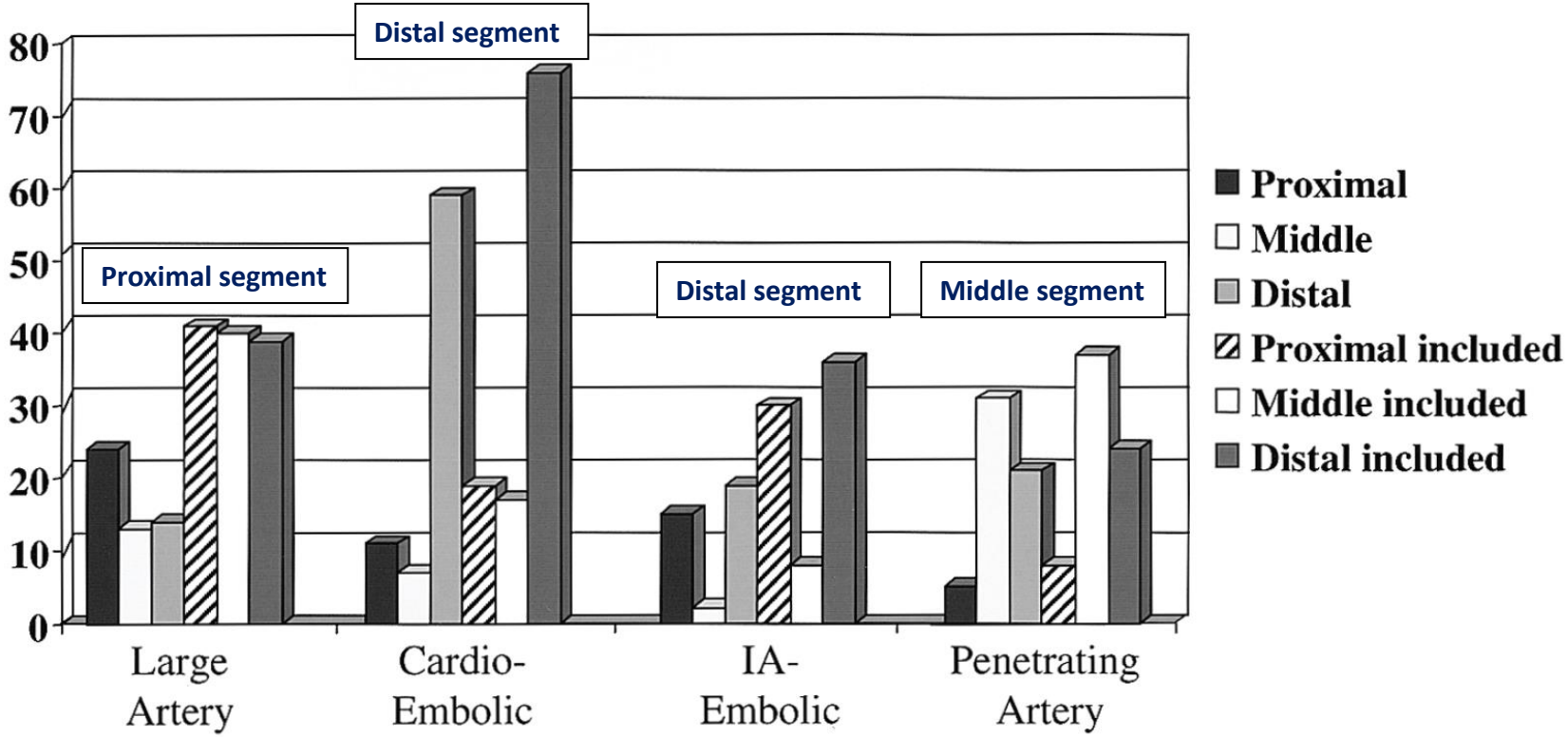




PICA AICA SCA PCA

Posterior circulation infarcts





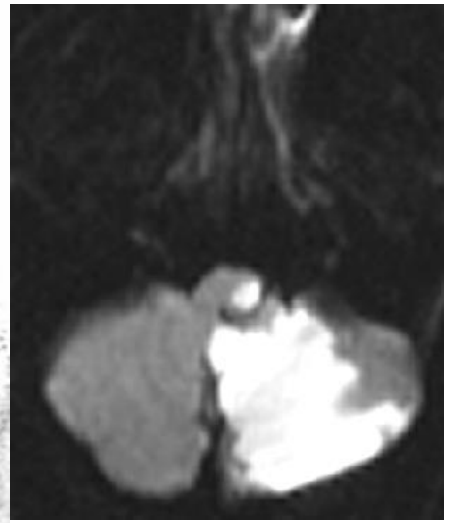
Caplan LR. et al. Ann Neurol 2004; Caplan LR. et al. J Clin Neurol 2005

VA occlusion: atherosclerosis vs dissection

Infarcts involving PICA territory tend to be larger in atherosclerotic disease compared to those secondary to VA dissection (Lee et al. Arch Neurol 2006)

Atherosclerosis

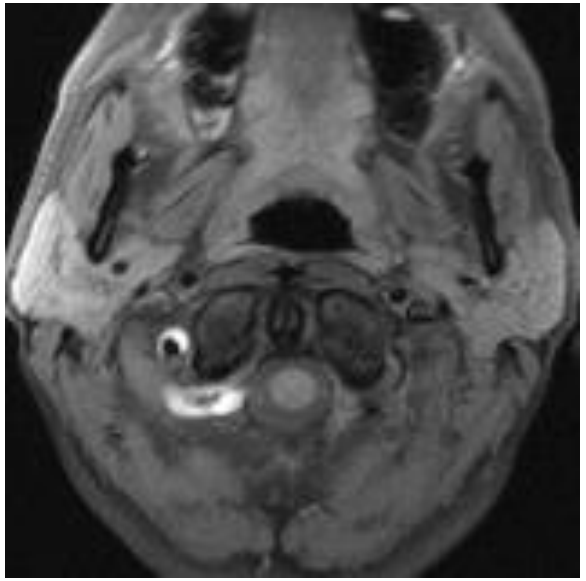
Large



Severe atherosclerotic disease of VA

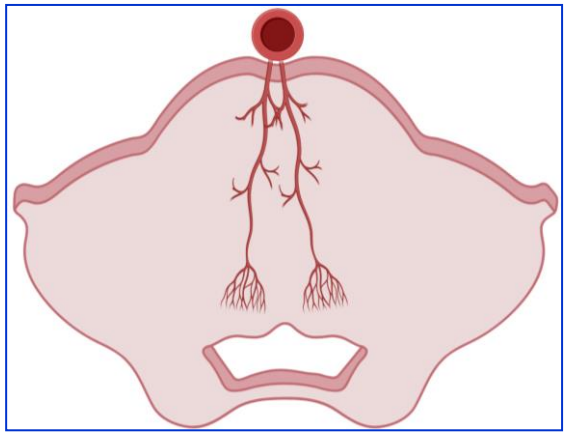
Small

Brainstem infarct

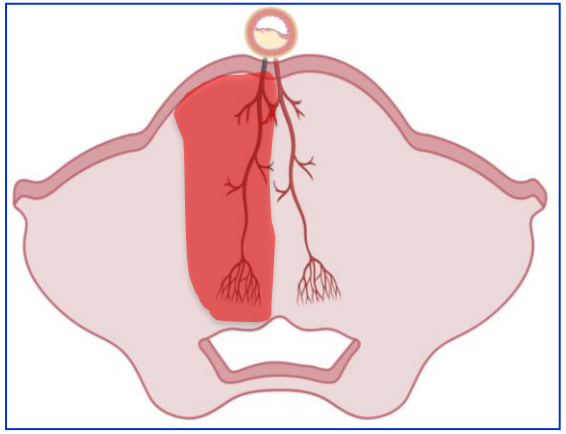


Dissection

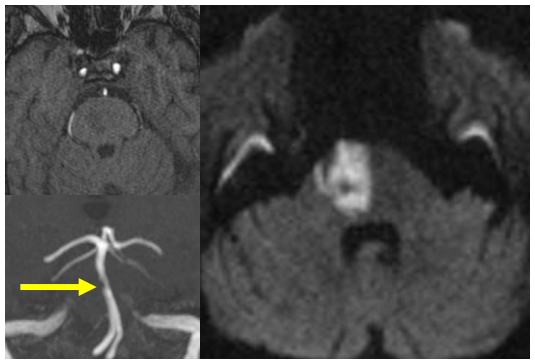
Paramedian pontine infarctions



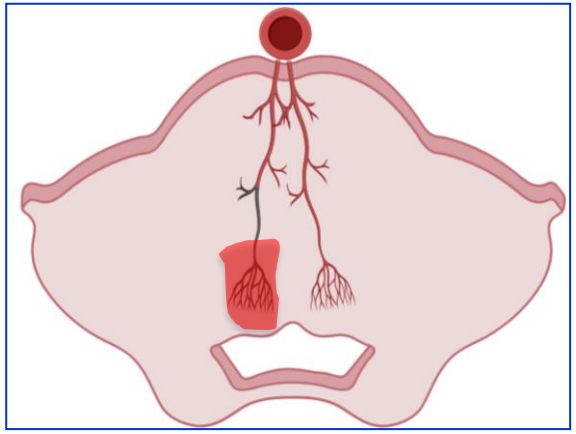
Anterior paramedian infarction secondary to atheromatosis of BA



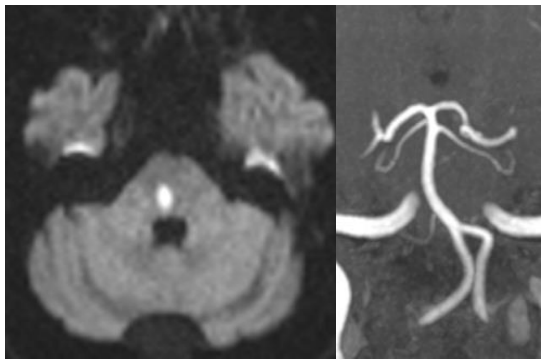
Proximal oclussion of a perforating artery



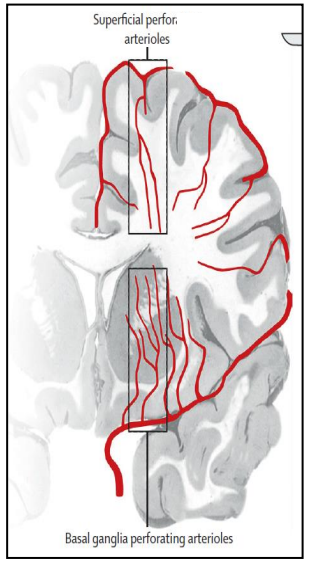
Posterior paramedian infarct secondary to SVD



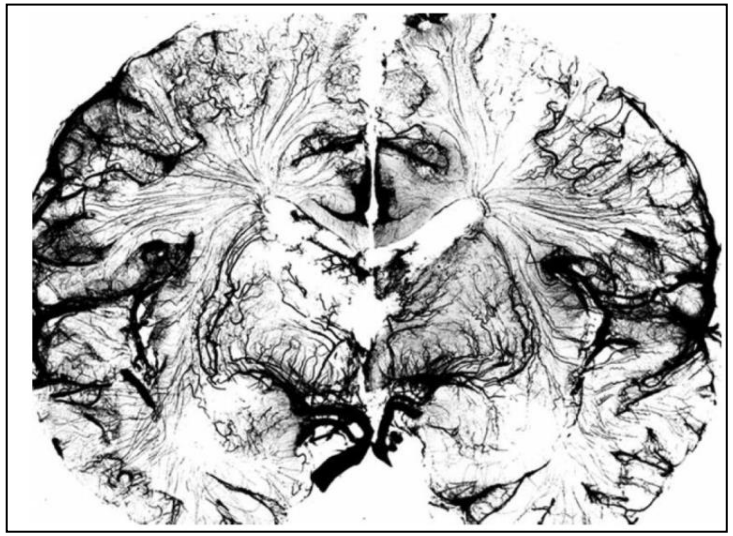
Distal oclussion of a perforating artery



Perforating arterioles from basal arteries



Wardlaw et al. Lancet Neurol 2013



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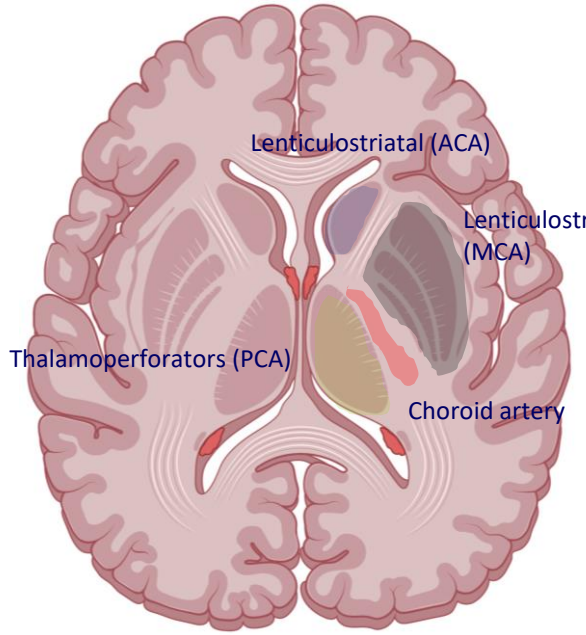
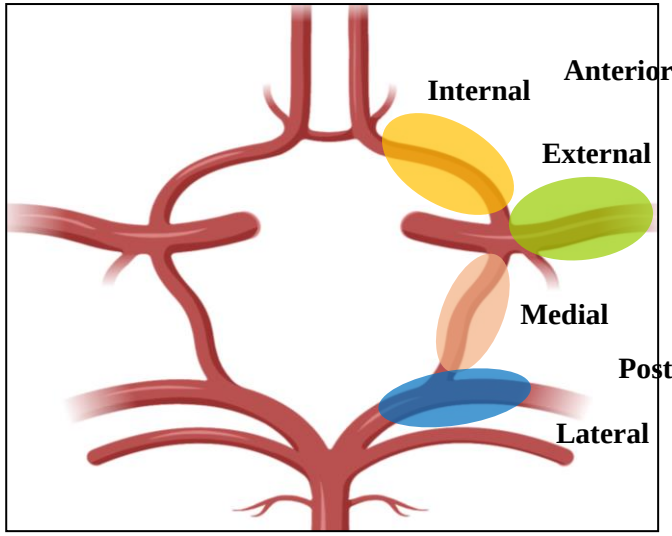
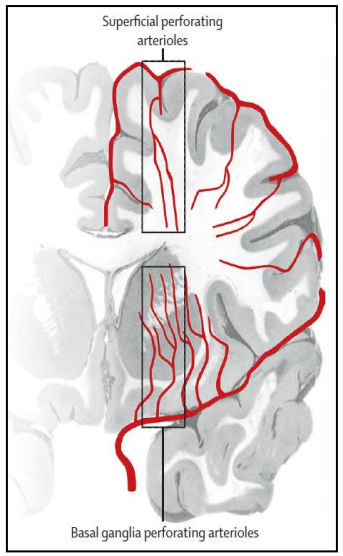




Lacunar infarcts

- Small deep infarct (<1.5cm) due to occlusion of a single penetrator artery arising from the circle of Willis or basilar artery
- Account for 11-25% of all strokes
- Most are asymptomatic
- Associate with cognitive impairment
- Causative mechanism: small-vessel disease (75%)



Wardlaw et al. Lancet Neurol 2013

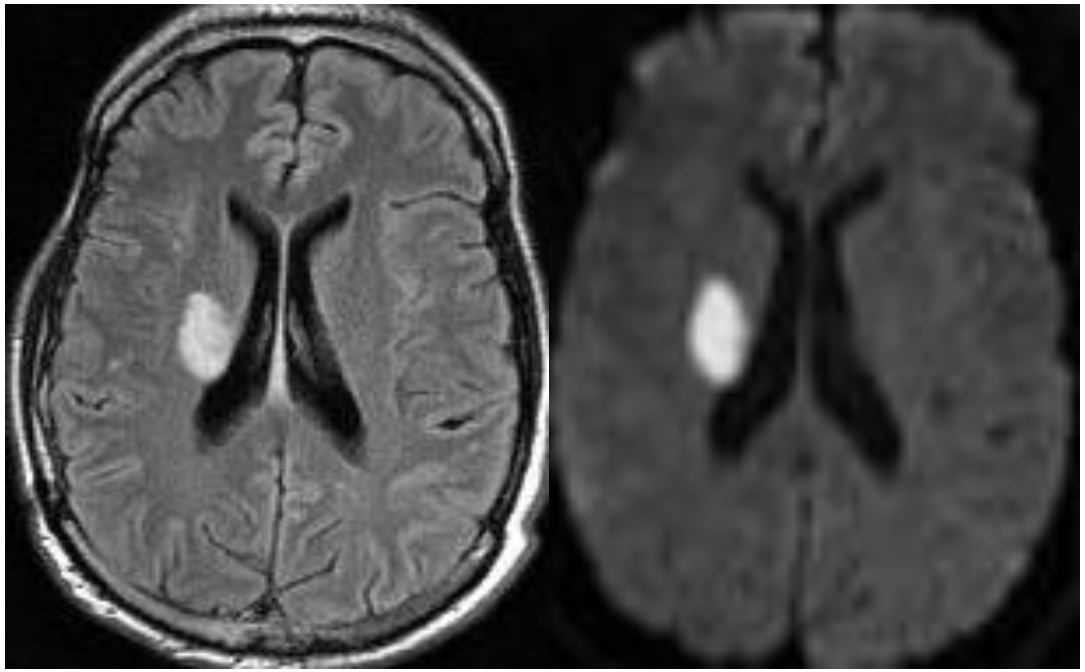
- ✓Atheroesclerosis
- ✓Cardioembolis
- ✓Arterial disse
- ✓Local thr percoagulable states)

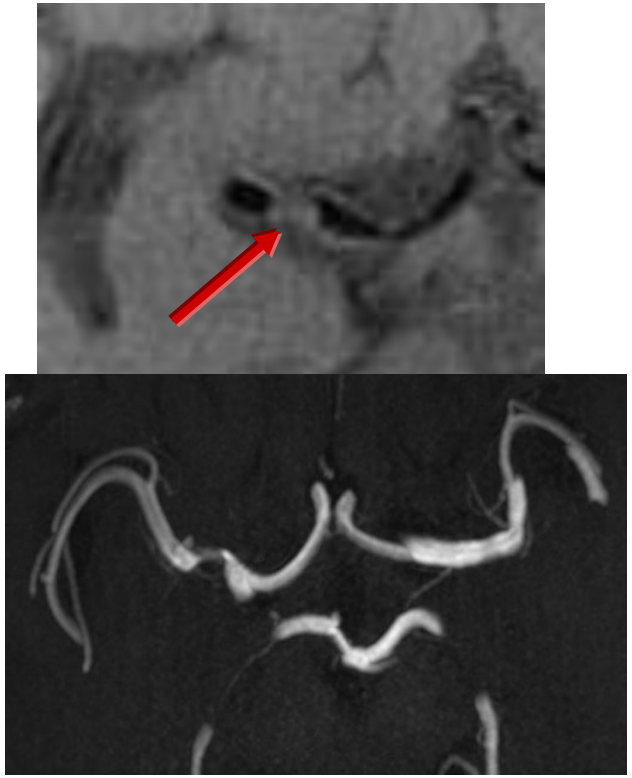
Worse prognosis
Extensive diagnostic work-up needed

Micheli et al. J Neurol 2008; Rajapakse et al. Stroke 2011; Huitjs et al. Front Aging Neurosci 2013

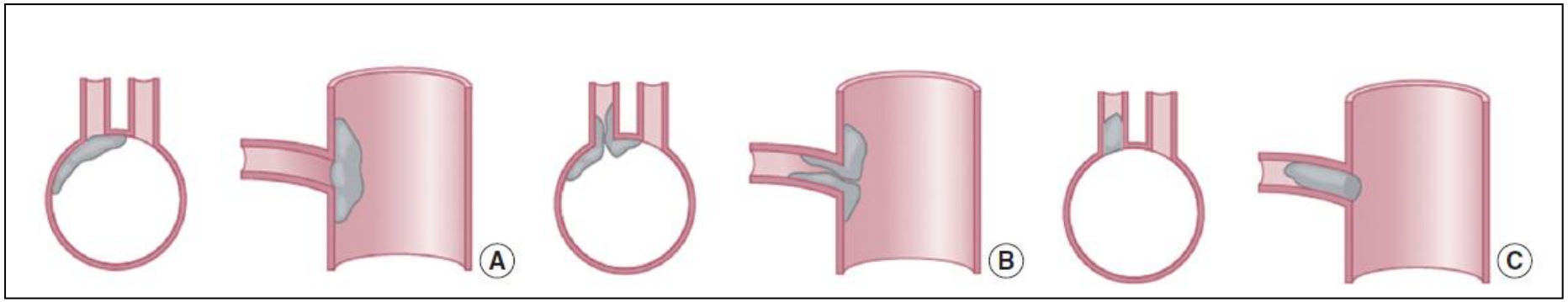
Lacunar infarcts: large

- Microatheromatosis
- Proximal occlusion of a large penetrating artery
- Frequently symptomatic
- Not strongly associated with hypertension
- No additional chronic ischemic lesions on CT/MRI

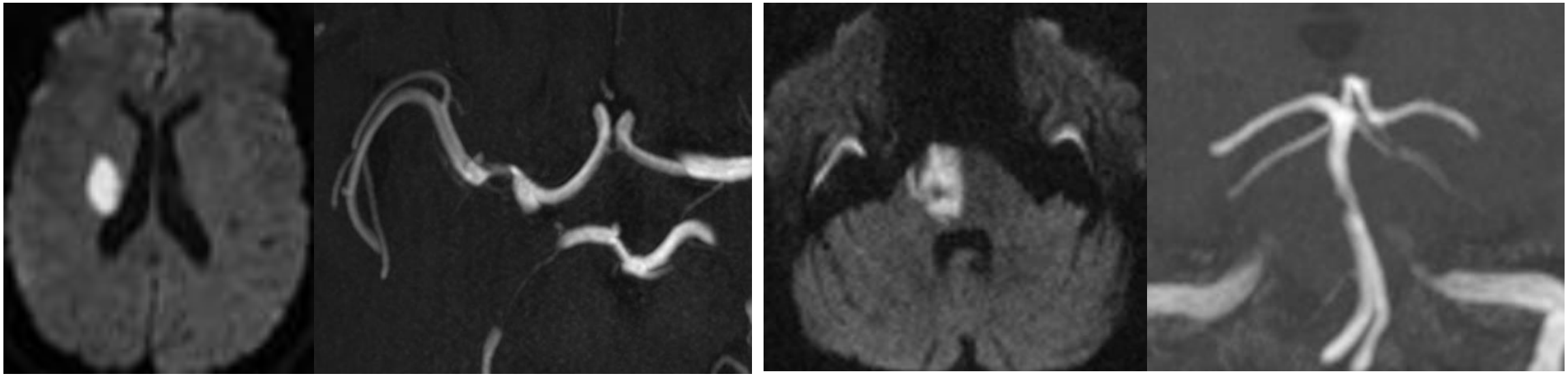




Arterial pathology in atheromatous branch disease



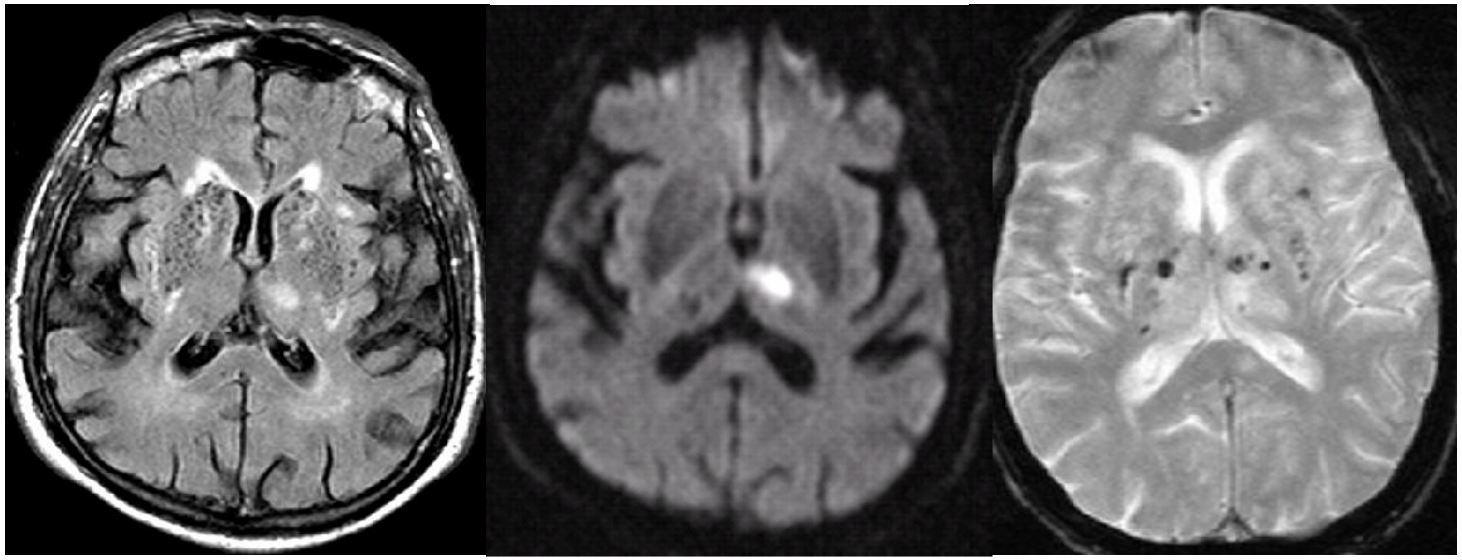
Louis R Caplan. JOS 2015



Lacunar infarcts: large

Arauz et al. Stroke 2003; Jackson et al. Stroke 2010

- Destructive lesion of the small penetrating arteries (<200µm) lipohyalinosis
- Commonly asymptomatic
- Associated with long-lasting severe hypertension, diabetes mellitus, high hematocrit levels, leukoaraiosis
- Multiple microbleeds and old asymptomatic lacunar infarcts (MRI)
- Higher rate of recurrence (24.3% vs 7.7%), less favorable outcome

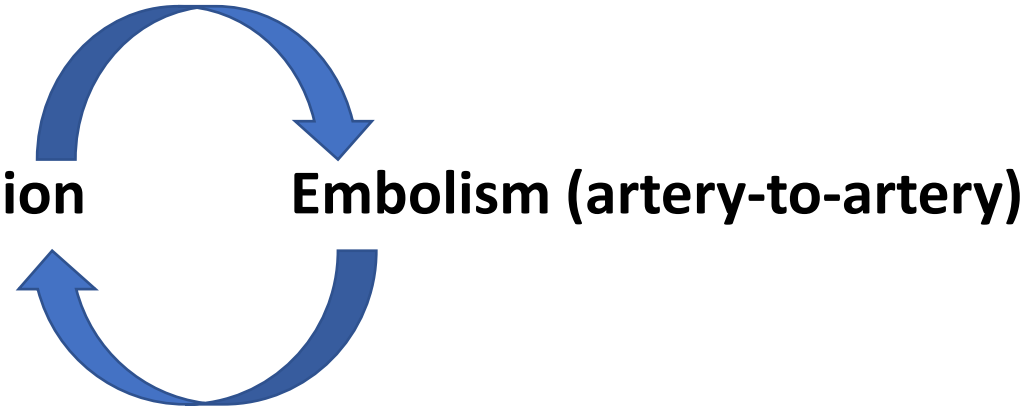


Border zone infarcts

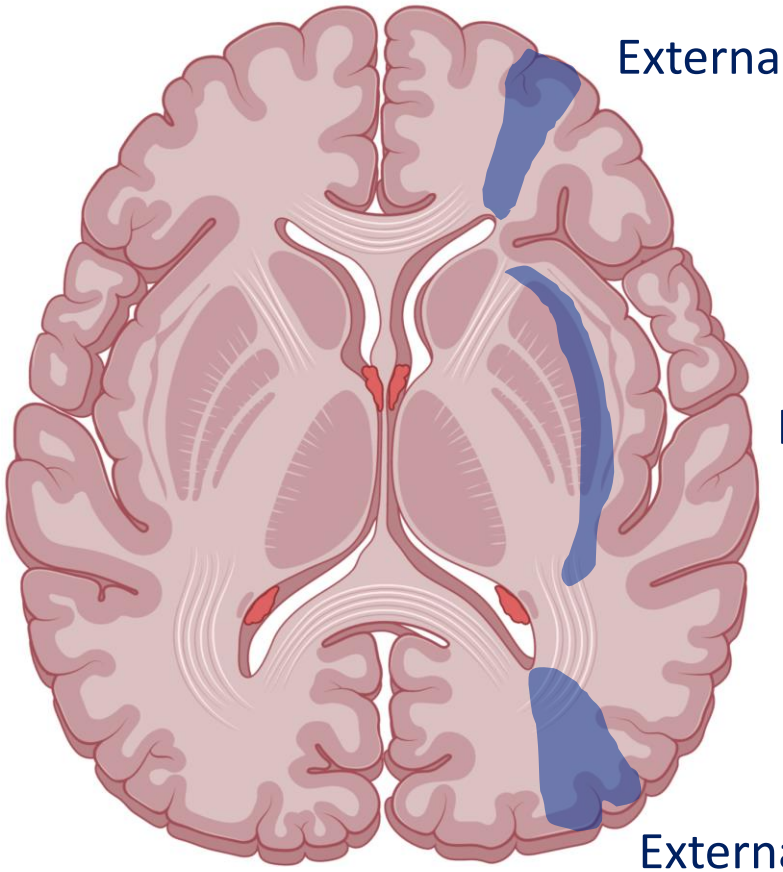
Involve the junction of the distal fields of 2 non-anastomosing arterial systems:
perfussion pressure is lowest

- 10% of first-ever strokes
- 75% of late strokes in occlusions of the ICA
- 5% of initial strokes in occlusions of the ICA
- Causal mechanisms not completely known

Mangla et al. Radiographics 2011



Border zone infarcts

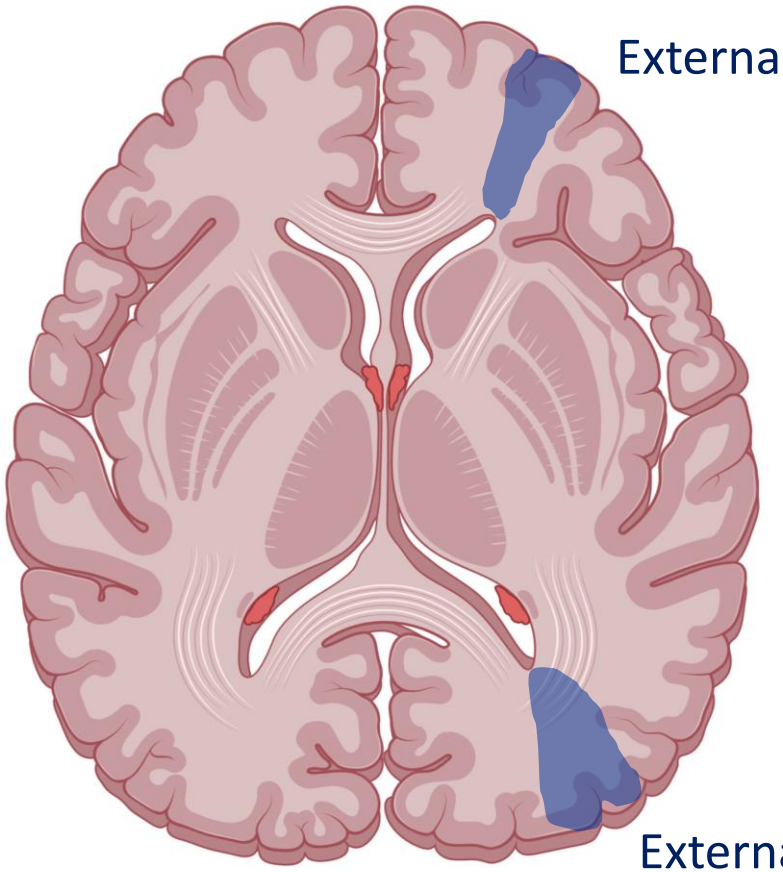


External (cortical) anterior: ACA-MCA

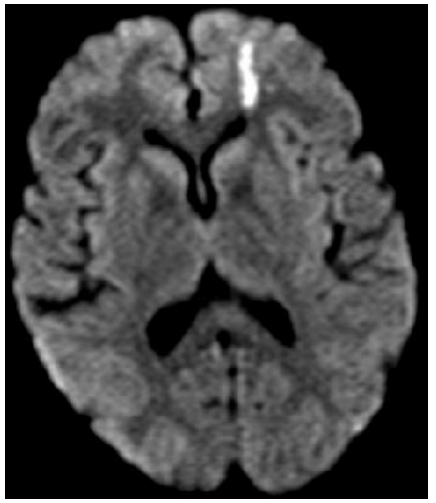
Internal (subcortical): deep-superficial MCA

External (cortical) posterior: MCA-PCA

Border zone infarcts: external



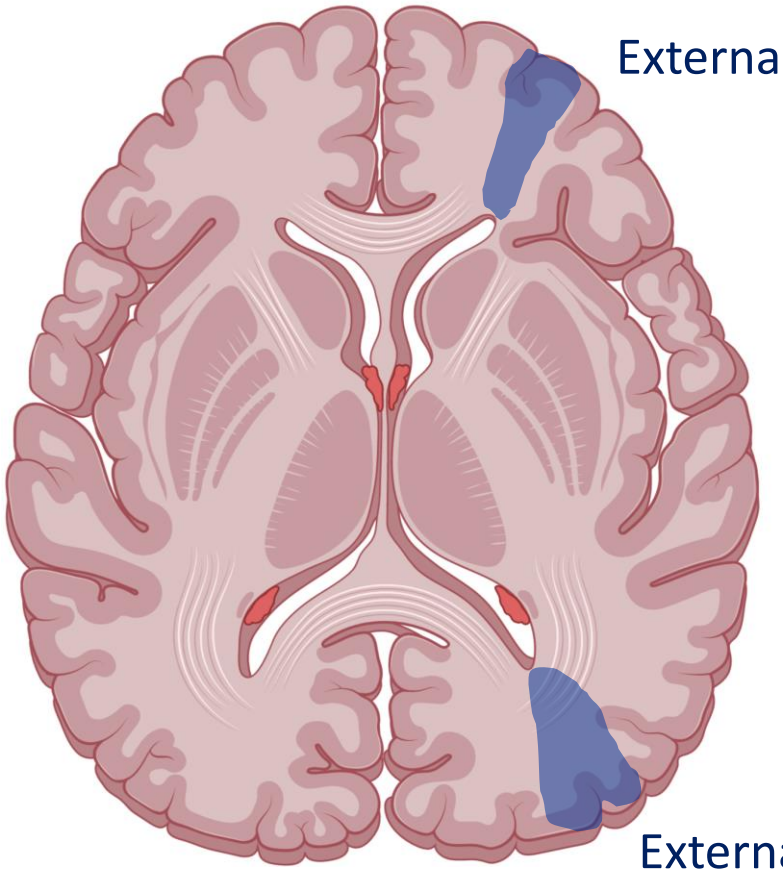
External (cortical) anterior: ACA-MCA



- Variable location
  - *Collateral leptomeningeal circulation*
  - *Individual differences in vascular territories*
- Difficult to differentiate from limited territorial infarcts

External (cortical) posterior: MCA-PCA

Border zone infarcts: external



External (cortical) anterior: ACA-MCA

External (cortical) posterior: MCA-PCA

Mechanisms:

Embolism
Not associated with hemodynamic compromise

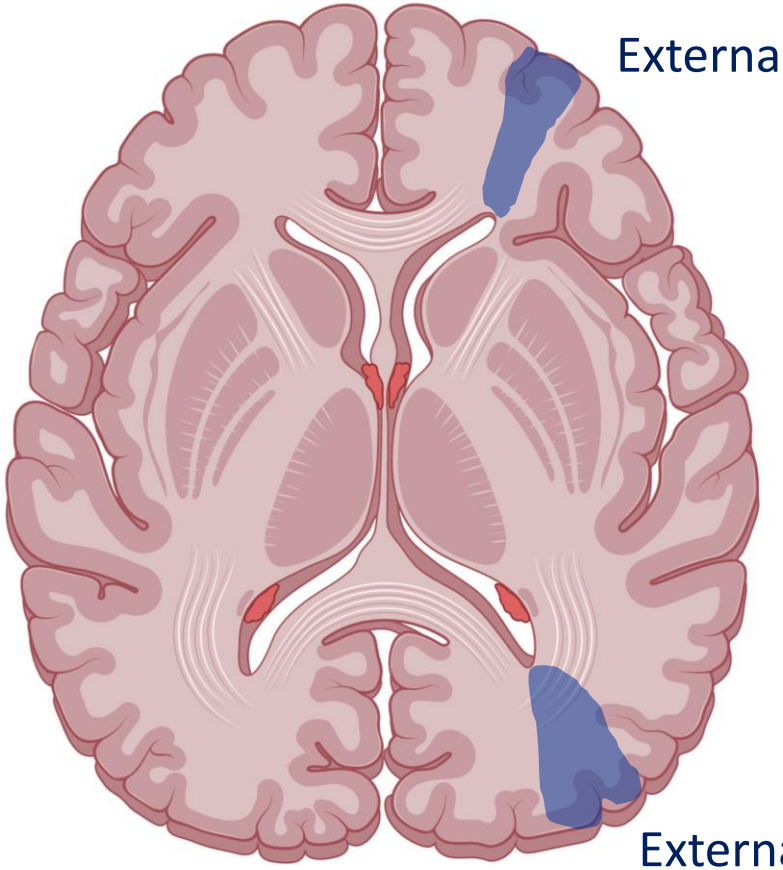
Microemboli (heart or atherosclerotic plaques)

⇩

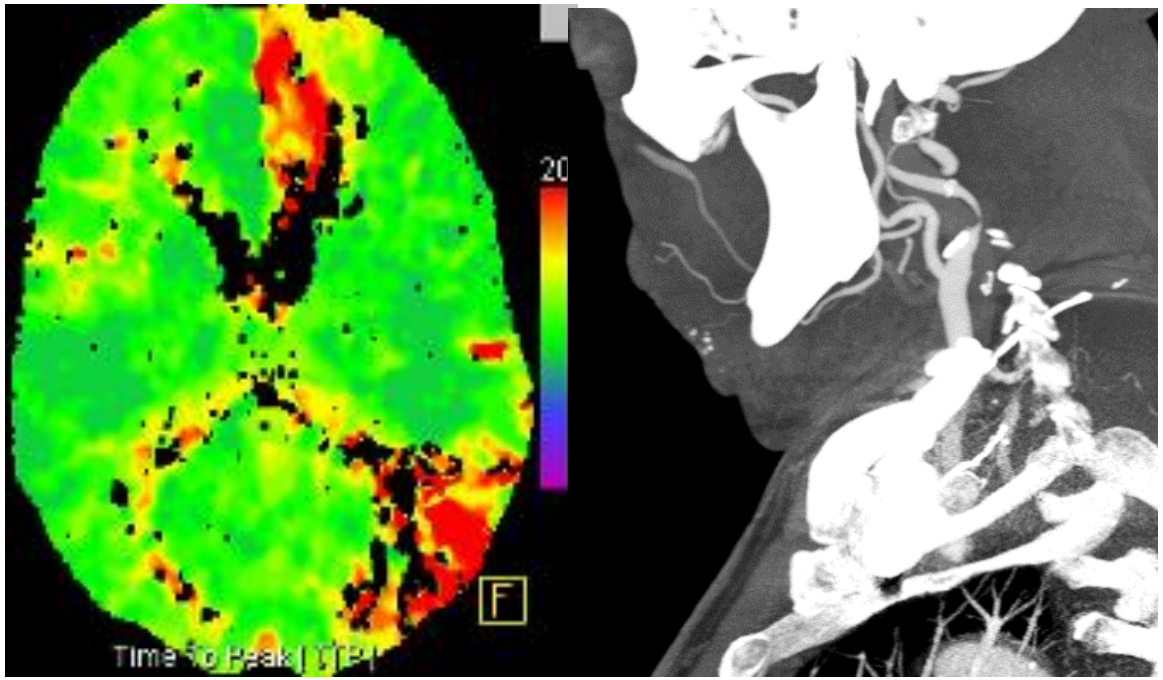
Low perfusion areas (limited ability to wash out)

Momjian-Mayor I, et al. Stroke 2005; Yong SW. et al. Stroke 2006

Border zone infarcts: external

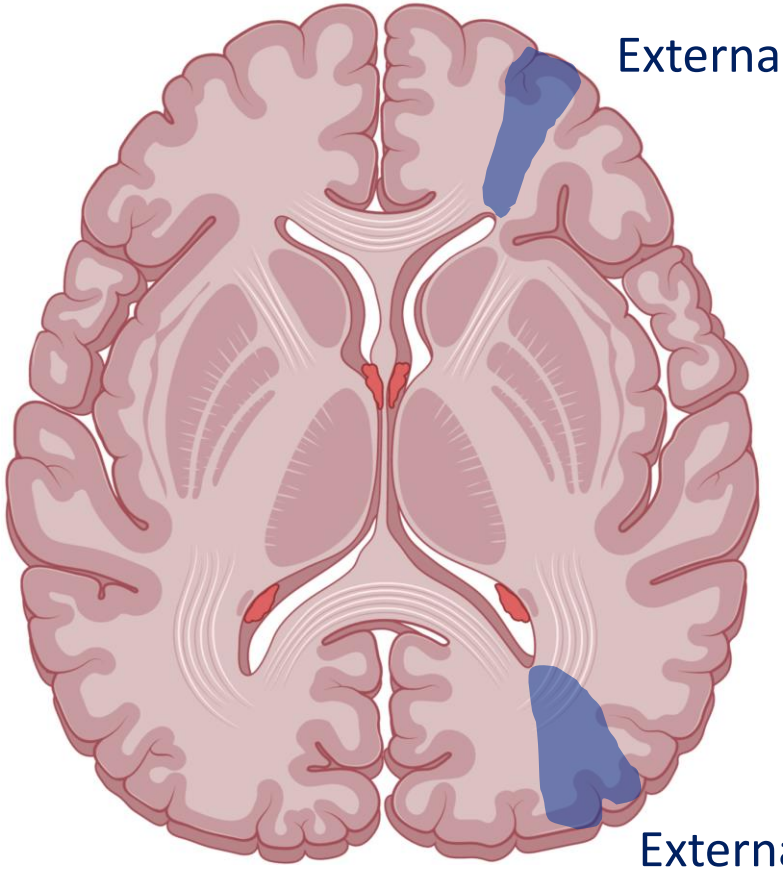


External (cortical) anterior: ACA-MCA

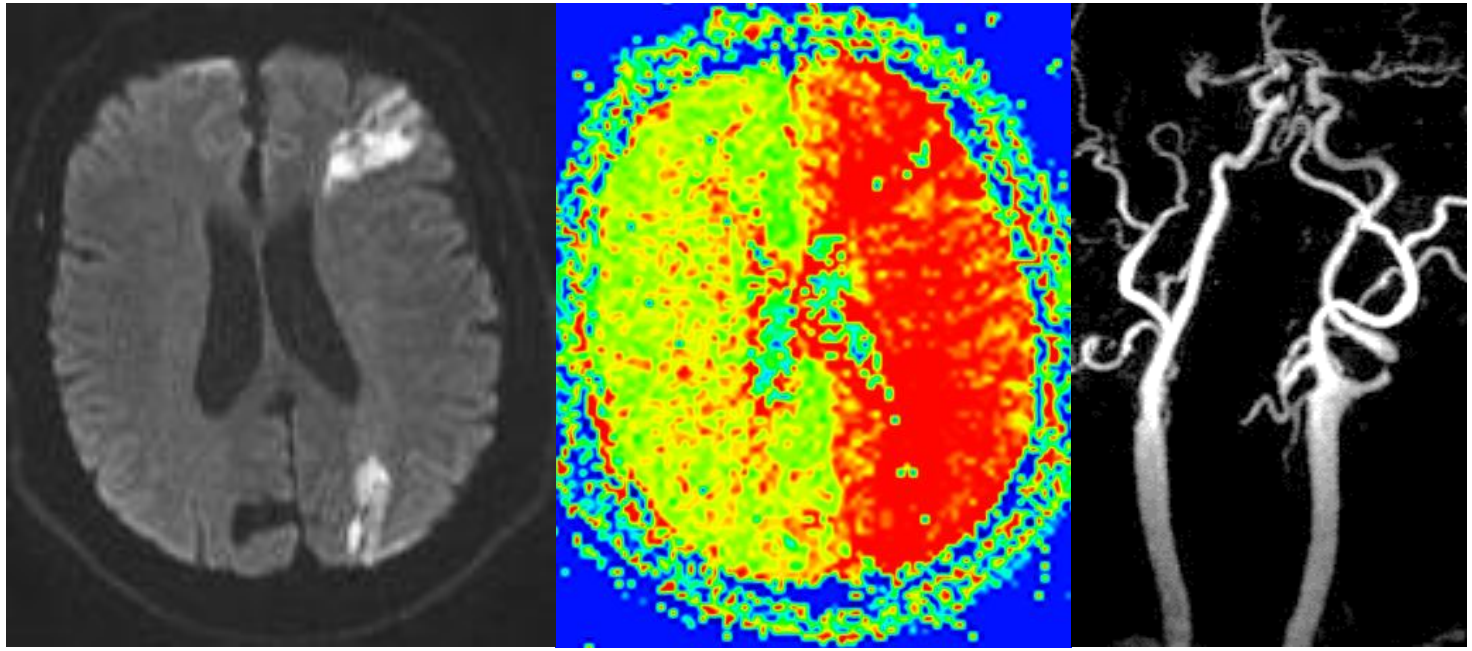


External (cortical) posterior: MCA-PCA

Border zone infarcts: external



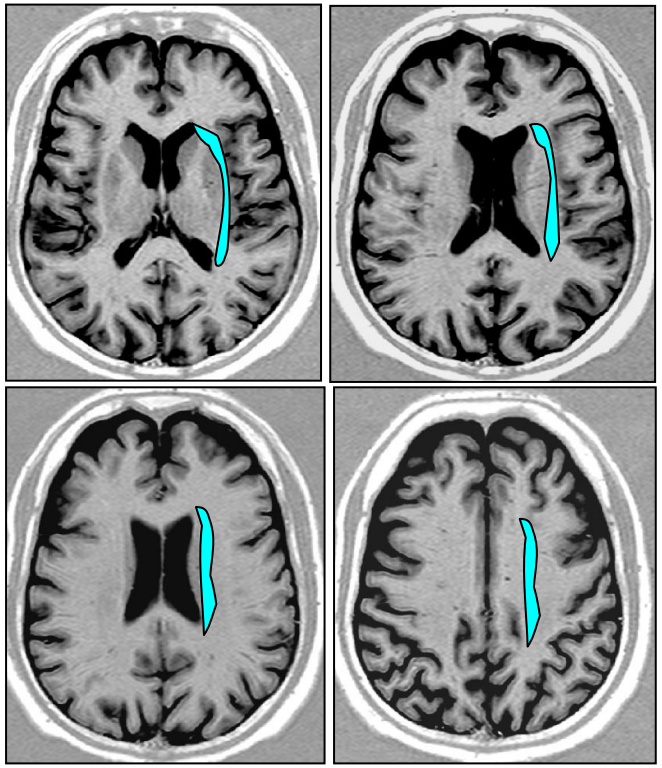
External (cortical) anterior: ACA-MCA

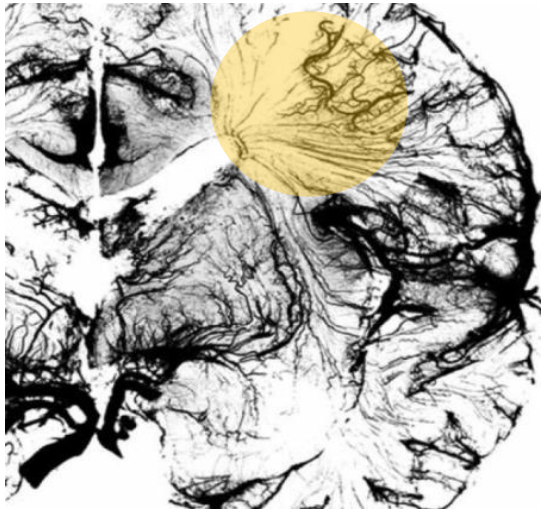


External (cortical) posterior: MCA-PCA

Border zone infarcts: internal

- Most commonly between lenticulostriate and MCA, ACA and MCA
- Paraventricular: cigar shape or rosary-like pattern





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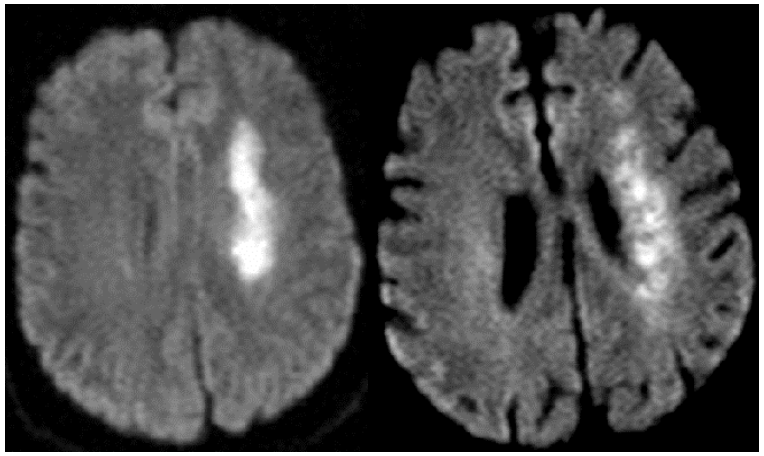
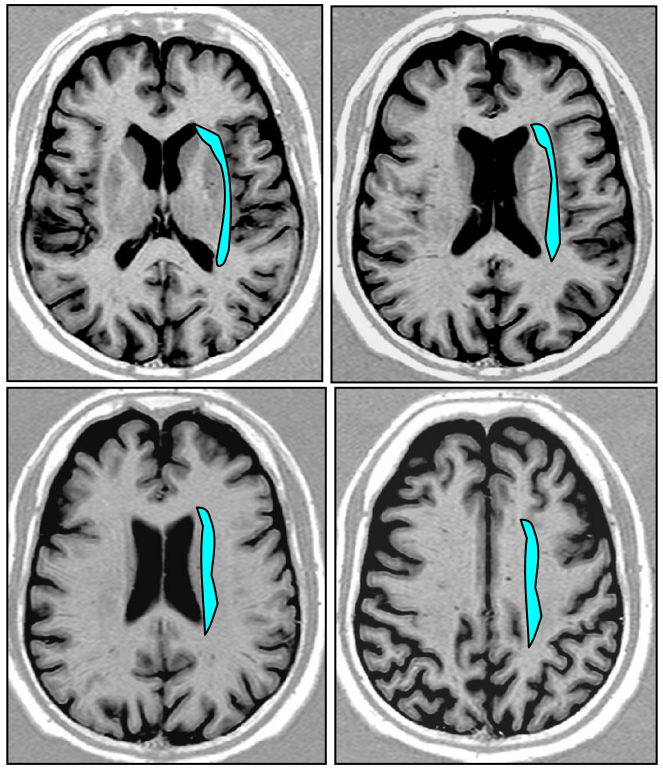


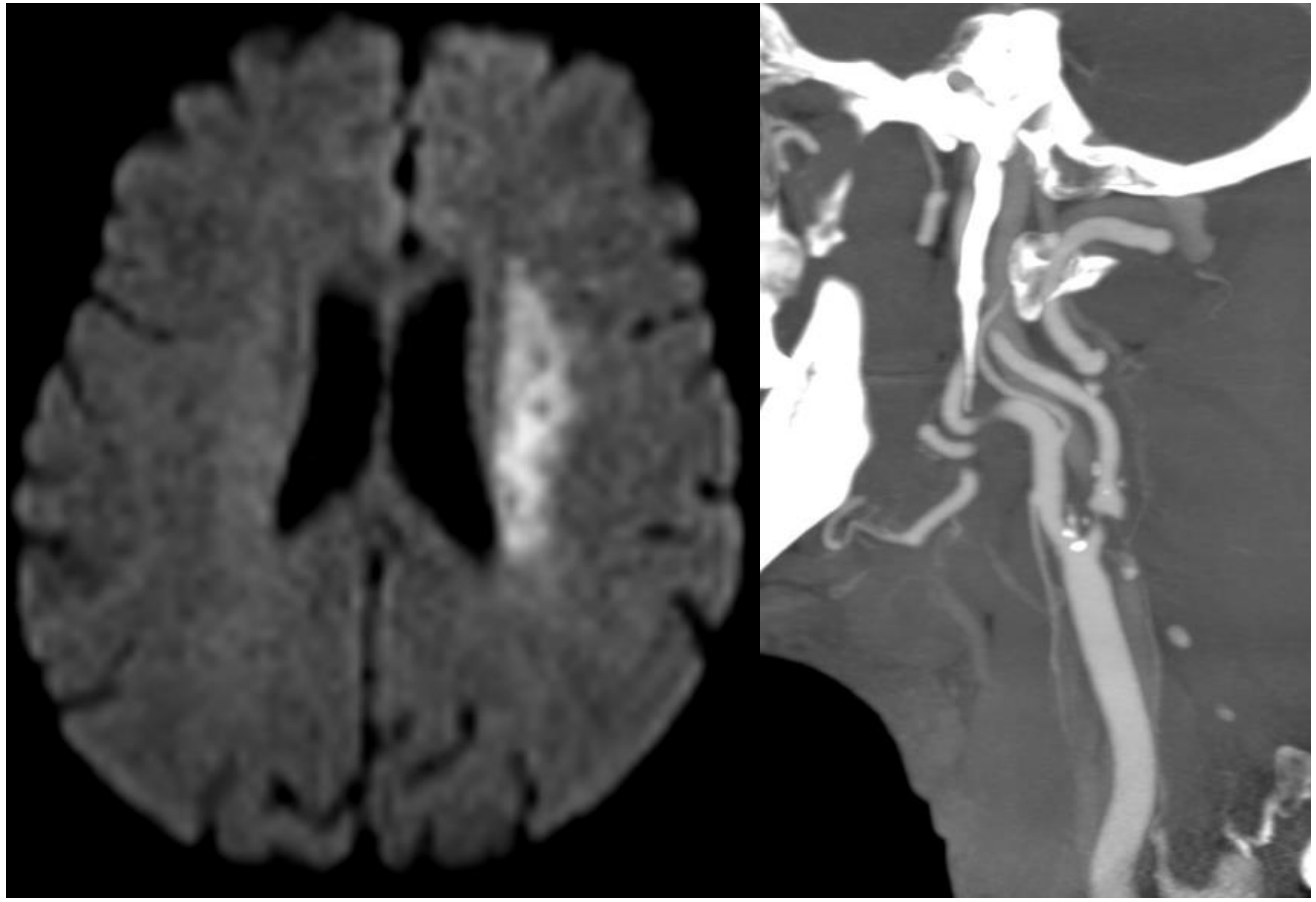
Mechanisms:

- Hemodynamic compromise (arterial stenosis, occlusion)
- Poor prognosis
- Clinical deterioration
- Missery perfusion (perfusion imaging)

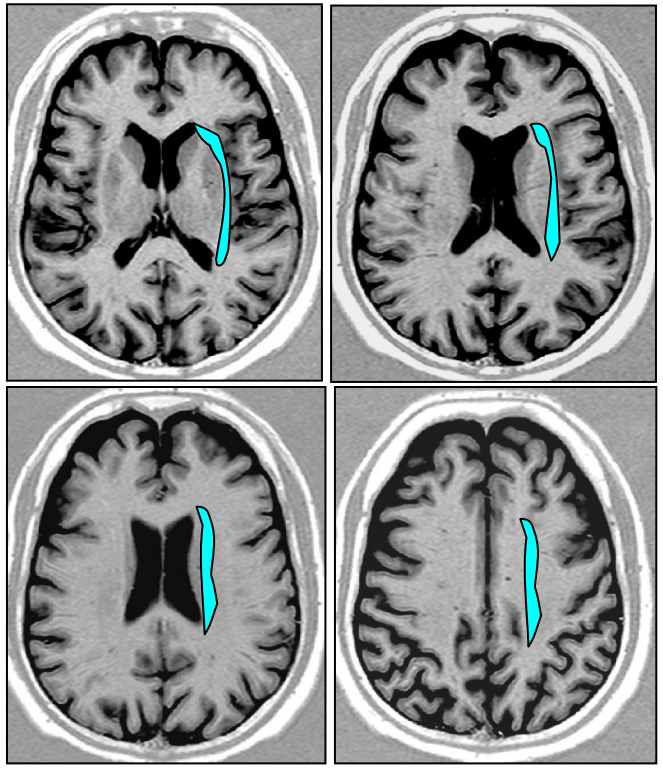
Momjian-Mayor I, et al. Stroke 2005;Yong SW. Et al. Stroke 2006; López-Cancio et al. Cerebrovasc Dis 2014

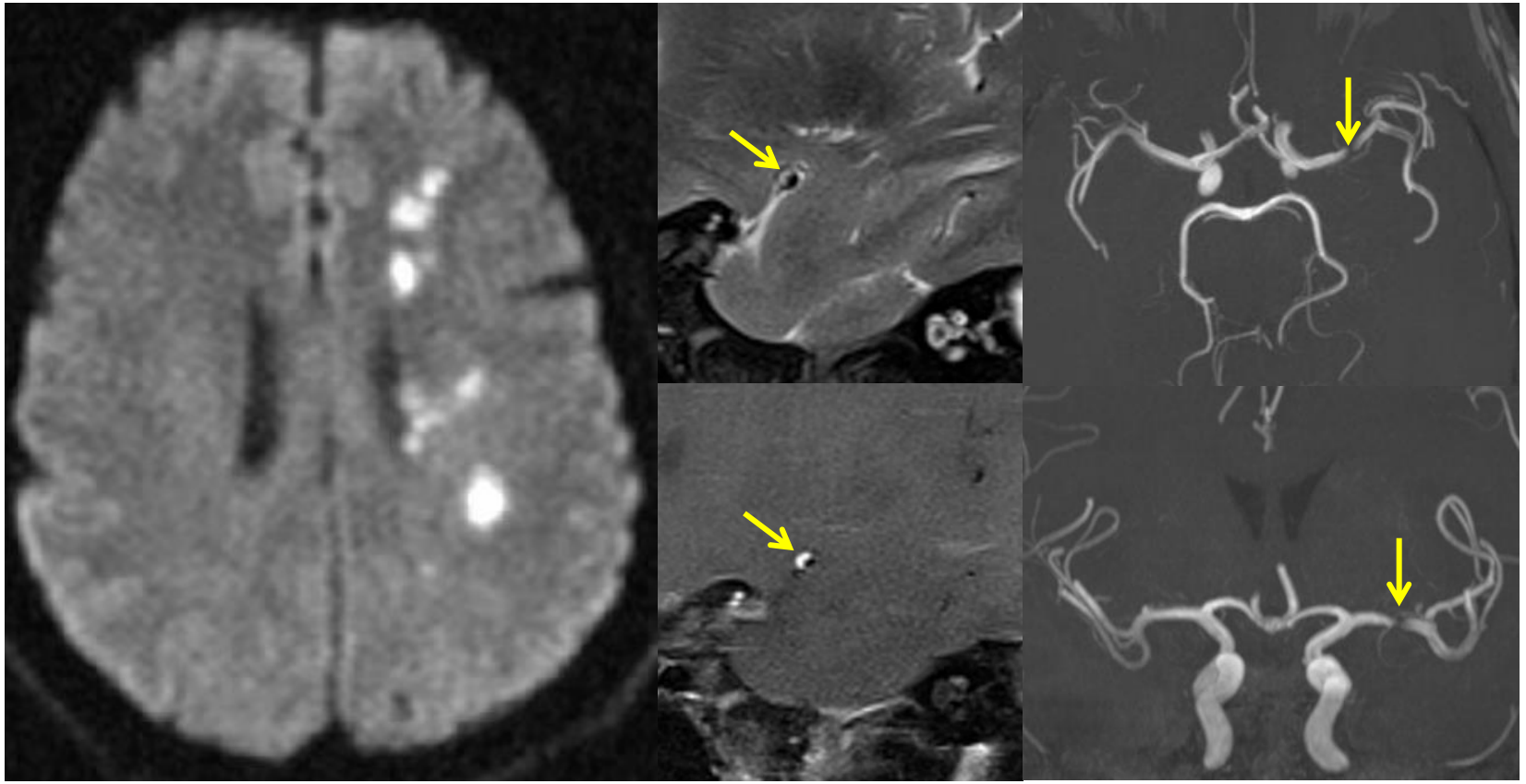
Border zone infarcts: internal



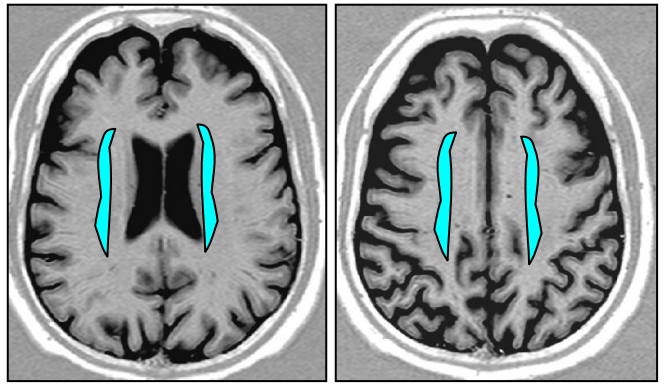


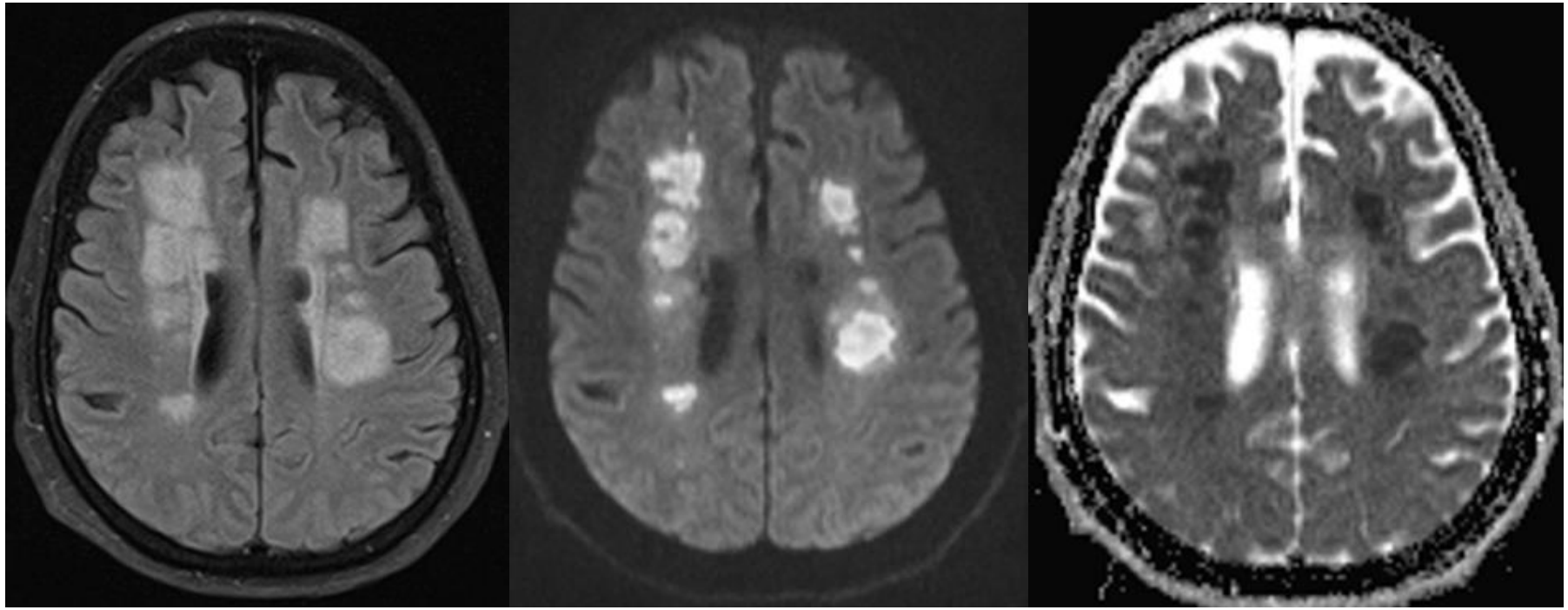
Border zone infarcts: internal





Border zone infarcts: bilateral internal





Systemic causes

- Global hypoperfusion
- Cardiac surgery
- Toxics (benzodiazepinas)

Summary

▪CT/MR imaging (with vascular imaging) facilitates the identification of acute ischemic lesions and the most likely causative mechanism

▪Radiological reports must use a proper nomenclature regarding the type and likely mechanism of an acute infarction

▪This information may have an impact on prognosis and in selecting the most appropiate therapy