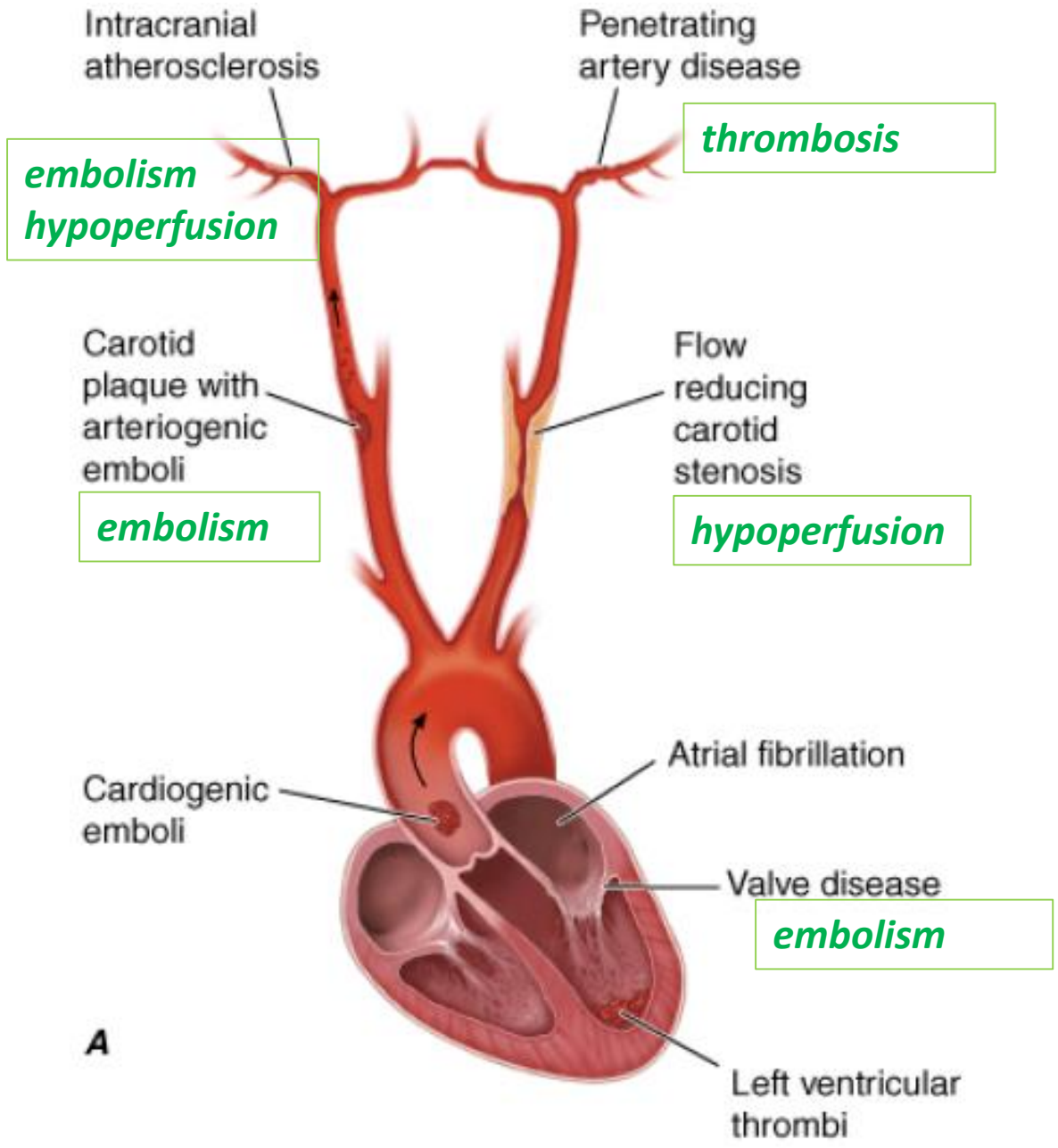


Pathophysiology of Brain Ischemic Infarction

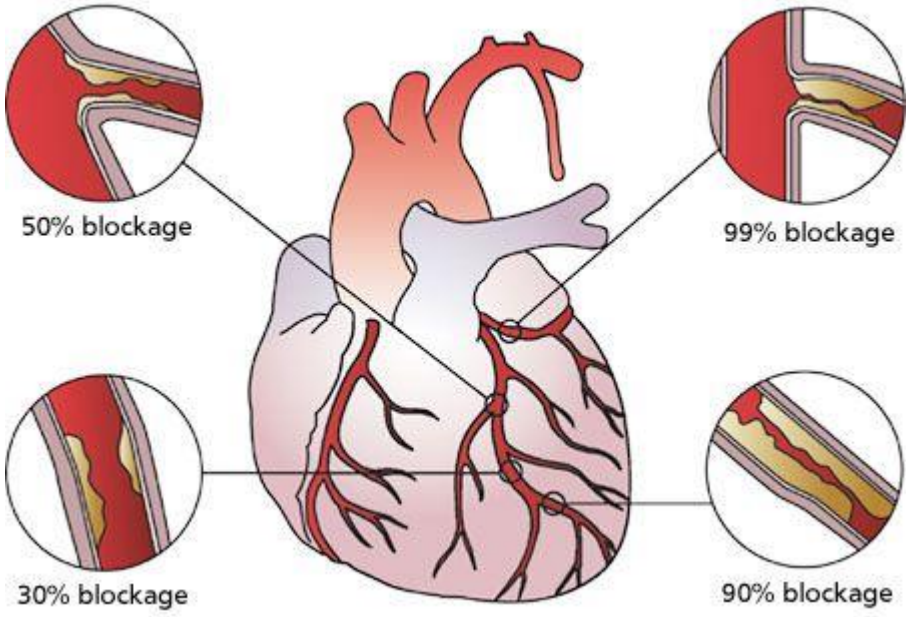
中醫大 附設醫院
醫學影像部

沈戊忠教授

Etiology of Coronary Artery Disease

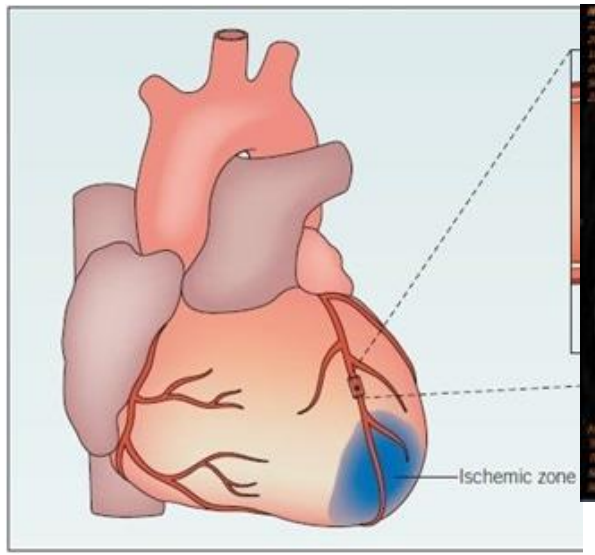
Usually, coronary artery disease is due to
Coronary artery atherosclerosis: Subintimal deposition of atheromas in large and medium-sized coronary arteries

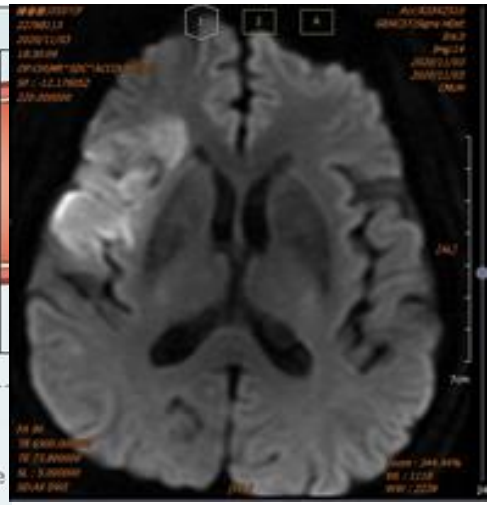
Less often, coronary artery disease is due to
•Coronary artery spasm (see Variant Angina)
Rare causes include coronary artery embolism, dissection, aneurysm (eg, in Kawasaki disease), and vasculitis (eg, in systemic lupus erythematosus, syphilis).



USC Surgery
https://www.pinterest.com/pin/556405728937009278/

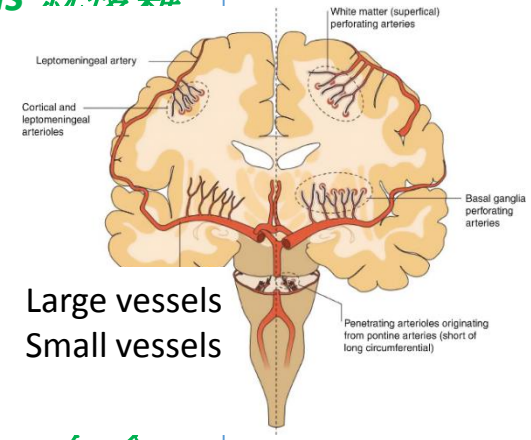
Myocardial infarction 是 coronary artery occlusion,
類似 brain infarction,
主因: atherosclerosis of coronary arteries 引起stenosis, thrombosis, occlusion.
只一種血管(coronary artery), 一種 mechanism (atherothrombosis)





但 brain infarction的pathogenesis 就複雜很多，

包含: thrombosis
embolism
hypoperfusion
三種 mechanisms.



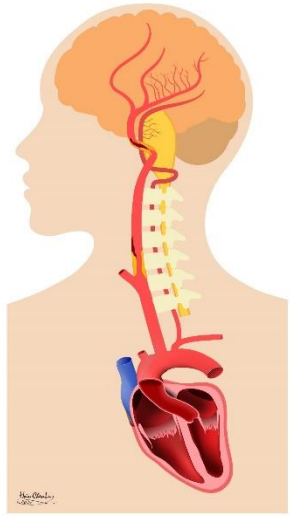
Large vessels
Small vessels

而且牽涉到的anatomic structures 包含:
Intracranial arteries
Large vessels:
(MCA, ACA, PCA,SCA, PICA,basilar art)
Small vessels (perforating arteries)

Extracranial arteries (ICA, MCA, vertebral arteries)

Aorta

Heart



Intracranial art.
Extracranial art.
Aorta
Heart

Thrombosis

atherosclerosis of
main intracranial arteries (large vessels)
and
perforating arteries (small vessels)

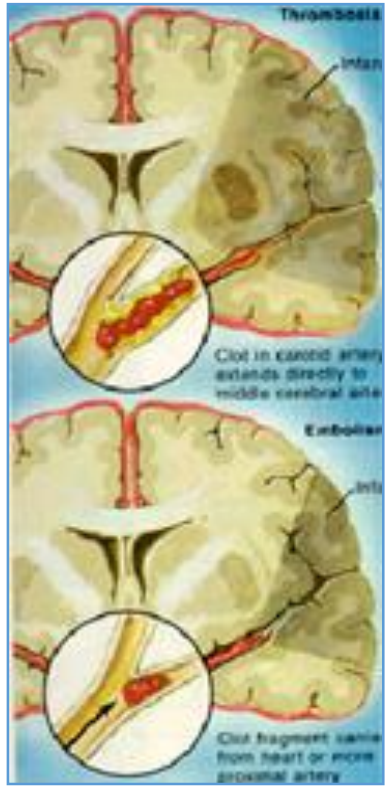
Embolism

- from heart--- valve disease, arrhythmia (AF)
- from bifurcation of carotid arteries
- .....

Hypoperfusion (diffuse brain edema or watershed edema)

- Heart failure, Shock

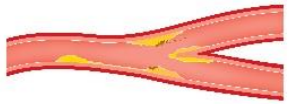
- Large vessel stenosis--- hemodynamic insufficiency



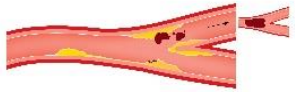
Thrombosis occurs when a thrombus, or blood clot, develops in a blood vessel and reduces the flow of blood through the vessel.
Arterial thrombosis is often associated with atherosclerosis.
….. Atherothrombosis: the formation of a blood clot within an artery as a result of atherosclerosis

Embolism occurs when a piece of a blood clot, foreign object, or other bodily substance becomes stuck in a blood vessel and largely obstructs the flow of blood.

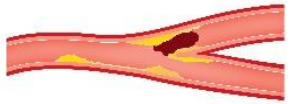
….. Thromboembolism: the blocking of a blood vessel by a particle that has broken away from a blood clot at its site of formation



athecrosclerosis

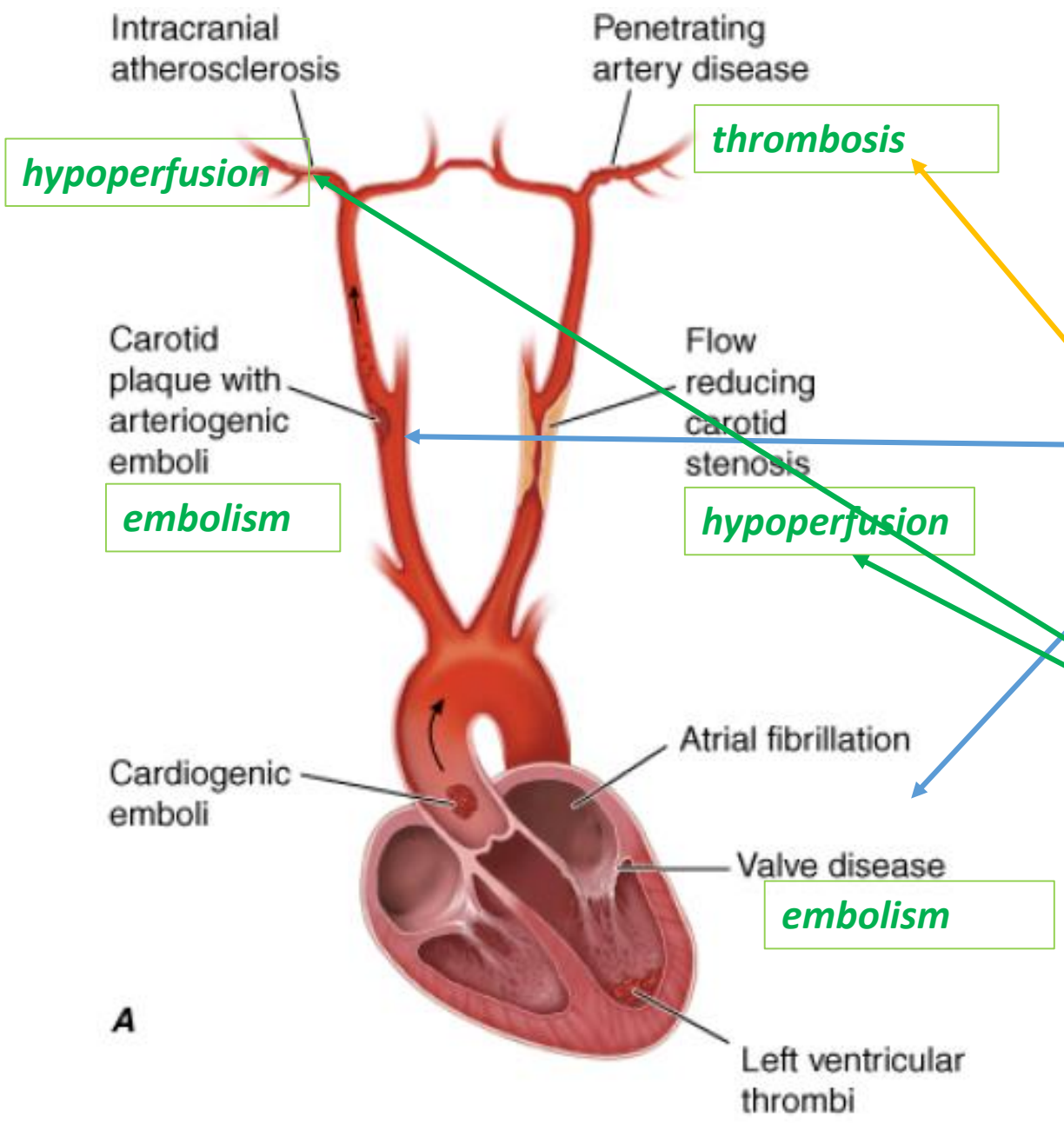


thromboembolism (artery to artery embolism)



thrombosis----reduces blood flow (hypoperfusion of its supply area)
-----total occlusion

引用 Harrison 的圖表說明
brain infarction的pathophysiology



Pathophysiology of ischemic stroke:

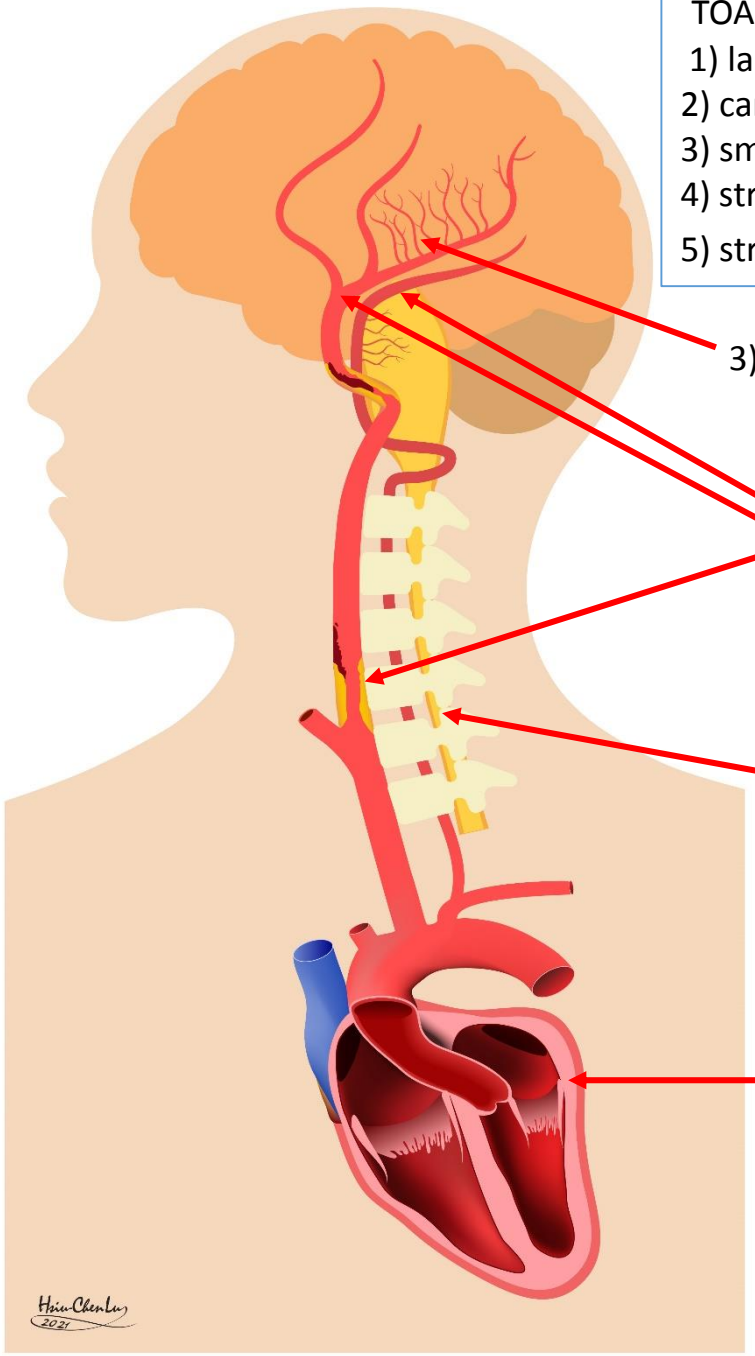
Three major mechanisms that underlie ischemic stroke:

(1) occlusion of an intracranial vessel by an embolus that arises at a distant site (e.g., cardiogenic sources such as atrial fibrillation or artery-to-artery emboli from carotid atherosclerotic plaque), often affecting the large intracranial vessels;

(2) in situ thrombosis of an intracranial vessel, typically affecting the small penetrating arteries that arise from the major intracranial arteries;

(3) Hypoperfusion caused by flow-limiting stenosis of a major extracranial (e.g., internal carotid) or intracranial vessel, often producing "watershed“ ischemia.

----Harrison’s Principle of Internal Medicine, 17th ed.

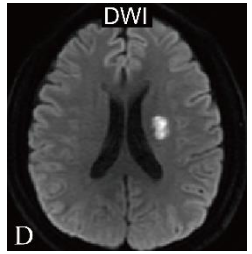


TOAST classification:
1) large-artery atherosclerosis,
2) cardioembolism,
3) small-vessel occlusion,
4) stroke of other determined etiology,
5) stroke of undetermined etiology.

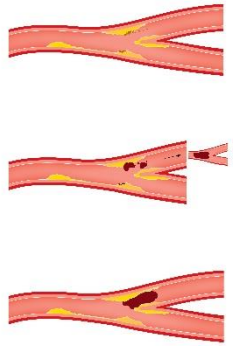
Infarction mechanism

Images

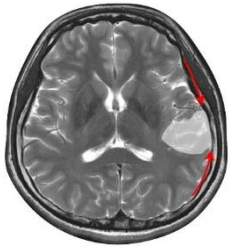
3) Small vessel (lacunar stroke)--- → atherothrombosis
embolism



1) Large vessel disease —
Intracranial arterial system
(MCA,ACA,PCA, PICA…)
Extracranial (CCA, ICA, vertebral)



→ thrombosis
hypoperfusion
embolism.



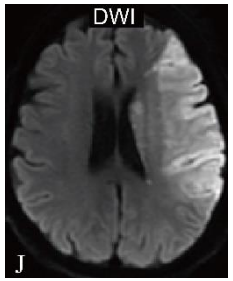
thrombosis

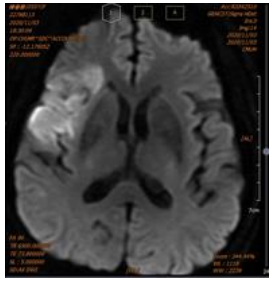
hypoperfusion

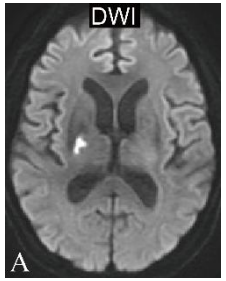
4) Others:
Arterial dissection

2) Cardioembolic
AF, Mural thrombosis
MI, Dilated myopathy
Valve disease
Bacterial endocarditis

→ embolism

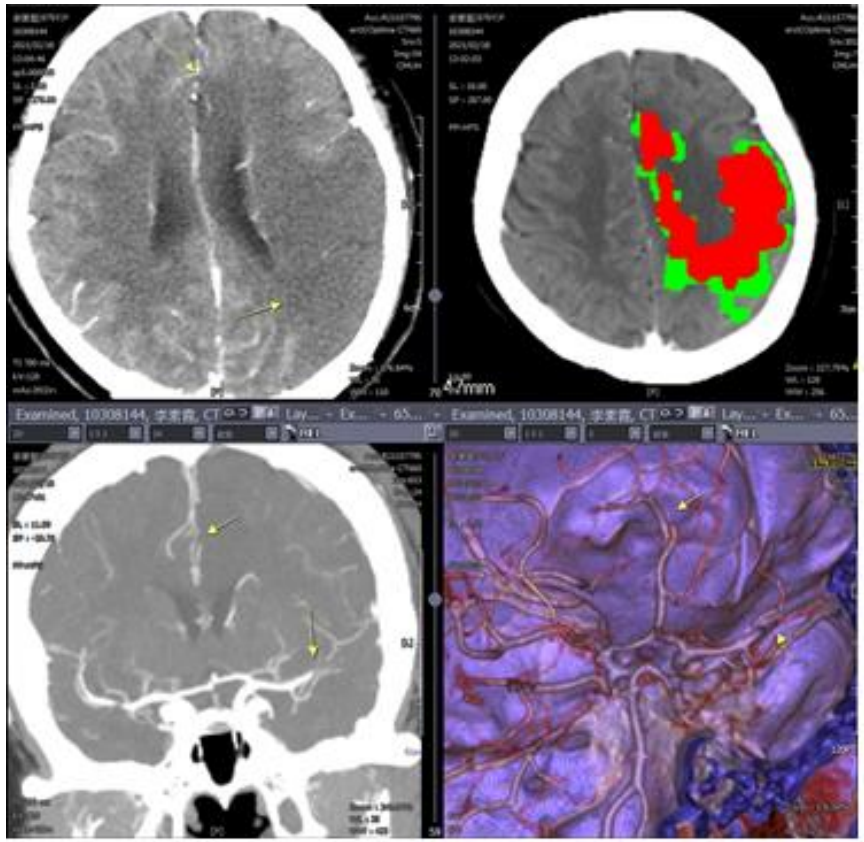


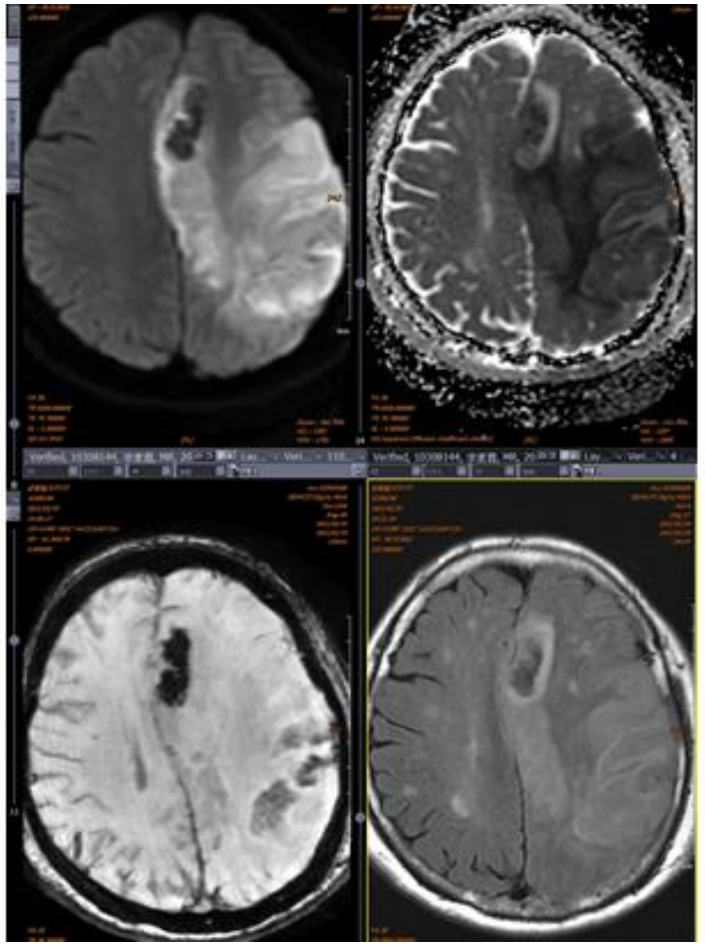


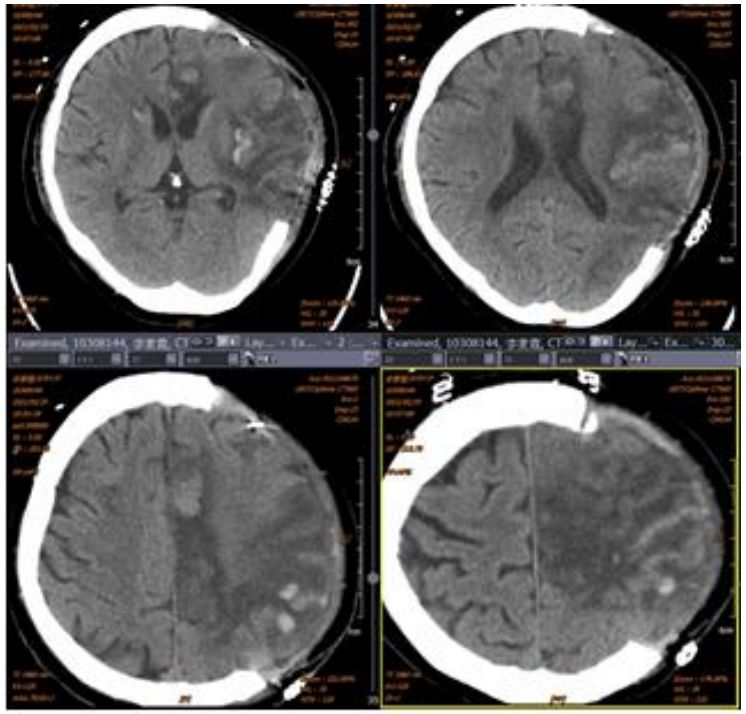


Embolism case:
(cardioembolism)

F75 arrhythmia
Sudden onset of right hemiplegia
2021,2,18 CT: early sign of left MCA, ACA infarction.
CTP: cores are large.
CTA: occlusion of left MCA and ACA.
2021,2,19 MRI: hemorrhagic transformations.
2021,2,25 CT: S/P craniectomy.
Acute infarction edemas with hemorrhagic transformation.

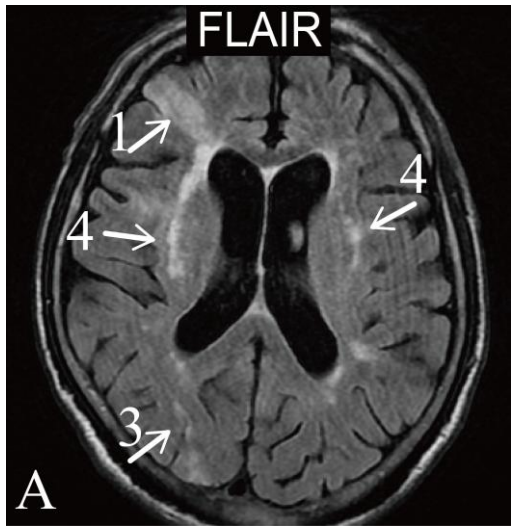


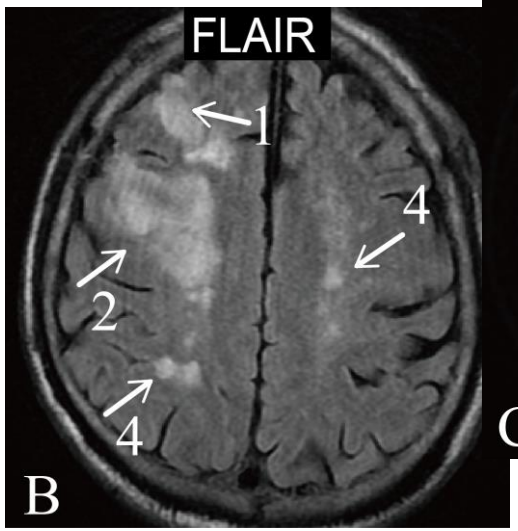


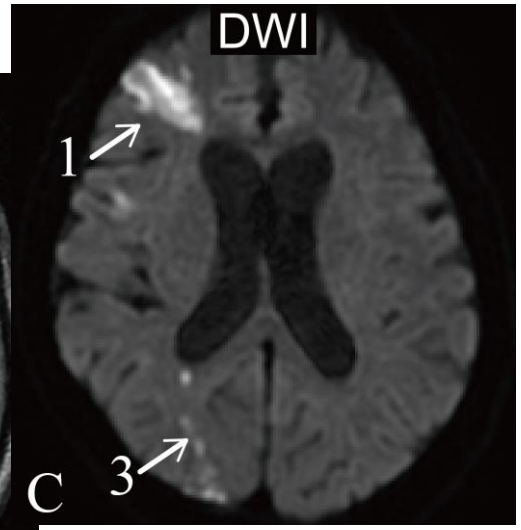


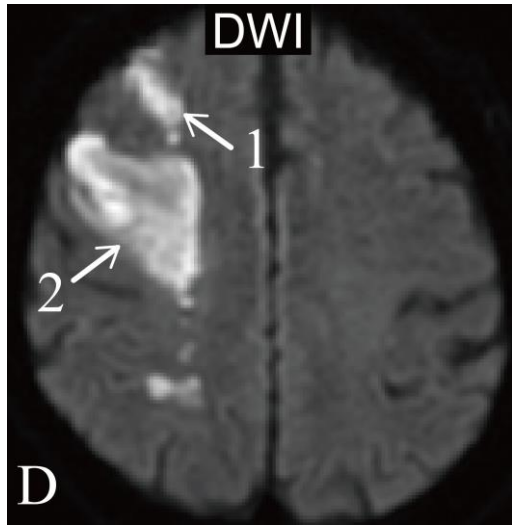
Extracranial artery atherosclerosis:

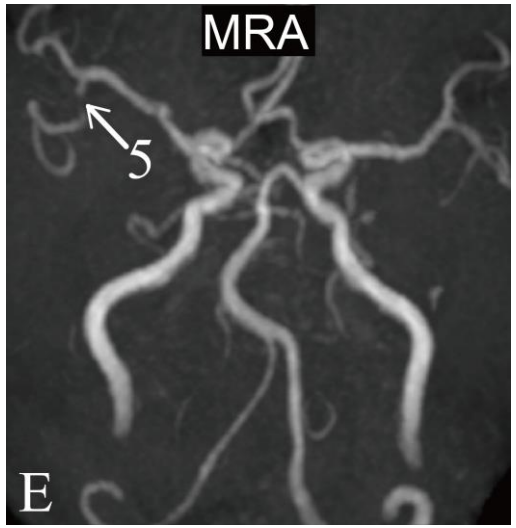
(hypoperfusion and embolism)

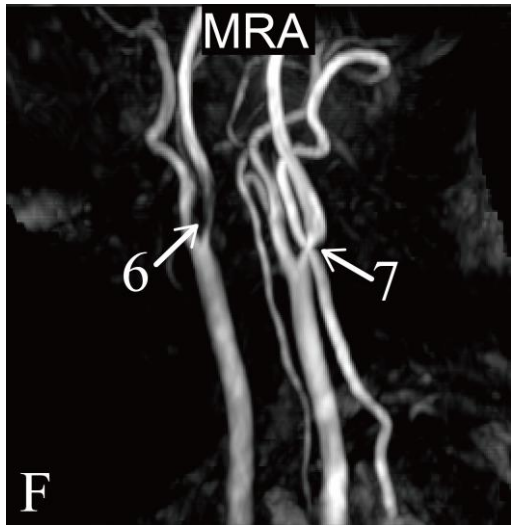


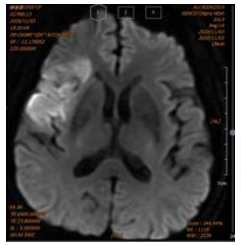












男/72，前後watershed infarctions及MCA infarction

糖尿病、慢性腎衰竭患者，近十年來已發生過多次右側小中風。這次又突然發生左側肢體無力，發音困難。

(A-D) MRI: FLAIR可見右大腦及左放射冠有許多大小不一的高訊號病灶，很難分辨新舊梗塞及leukoaraiosis。DWI 可見額葉有二個區域有diffusion-restriction，代表急性腦梗塞之cytotoxic edema，較前是位於MCA及ACA之分水嶺區域(watershed)(1)，較後是MCA前1/3灌溉區的急性腦梗塞之cytotoxic edema (2)，是embolism。另外在右側枕葉也有一患念珠狀的急性梗塞(3)，這是MCA-PCA之watershed infarction。FLAIR另有許多高訊號病灶，在DWI沒有diffusion-restriction，都是leukoaraiosis (4).

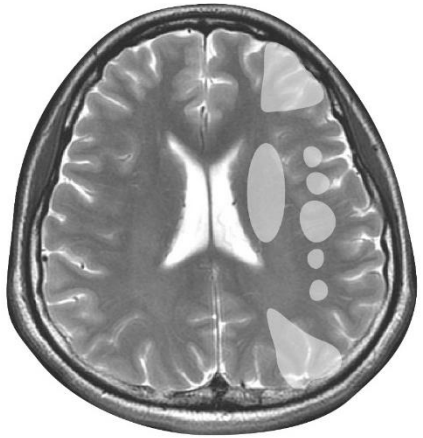
(E) 顱內MRA顯示右MCA一分支有明顯狹窄(5)。

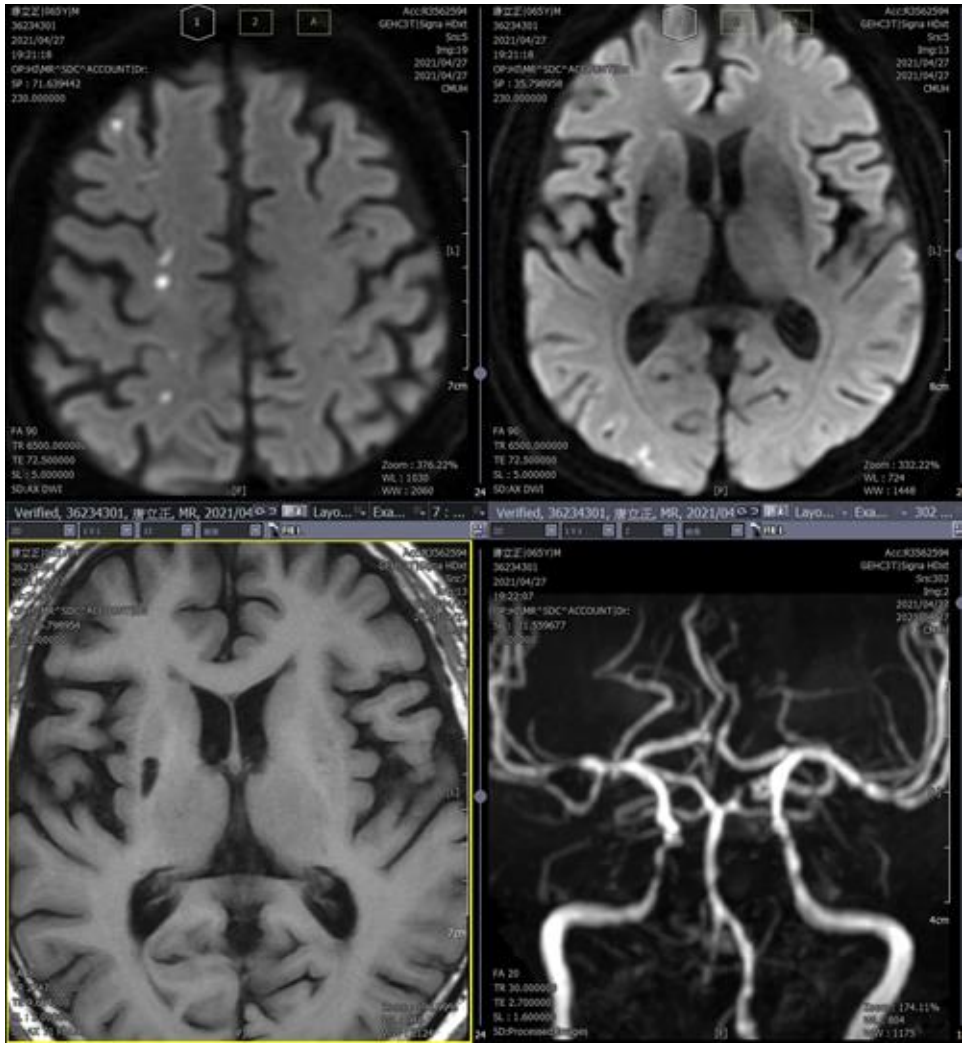
(F) 頸部MRA顯示右ICA近端，在bifurcation之上有嚴重約90%狹窄(6)，左ICA近端，在bifurcation之上有約80%狹窄(7)。

所以這是同時有anterior及posterior border zone infarctions，都是因Rt. ICA嚴重狹窄所引起的。而左側 ICA狹窄並沒有引起症狀。所以此病患之Rt. ICA stenosis is symptomatic; Lt. ICA stenosis is asymptomatic.

Extracranial and intracranial artery atherosclerosis:
(hypoperfusion)

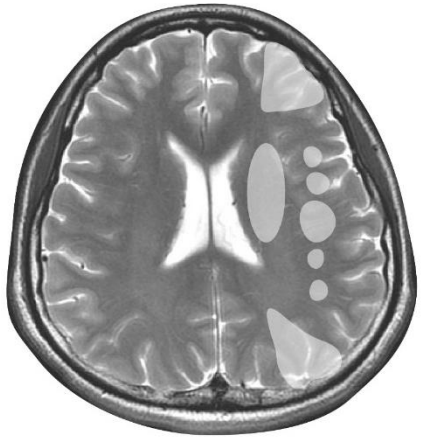
M65 sudden onset of left limbs weakness, clumsy
DM, hypertension, CKD under dialysis.
2021,4,27 MRI:
Multiple lacunar infarctions in Rt. F-P-O lobes, typical watershed infarctions
MRA: severe stenosis of Rt. ICA, which cause hemodynamic impairement.
Also stenosis of bil. MCAs, Lt.ICA, basivertebral arteries.

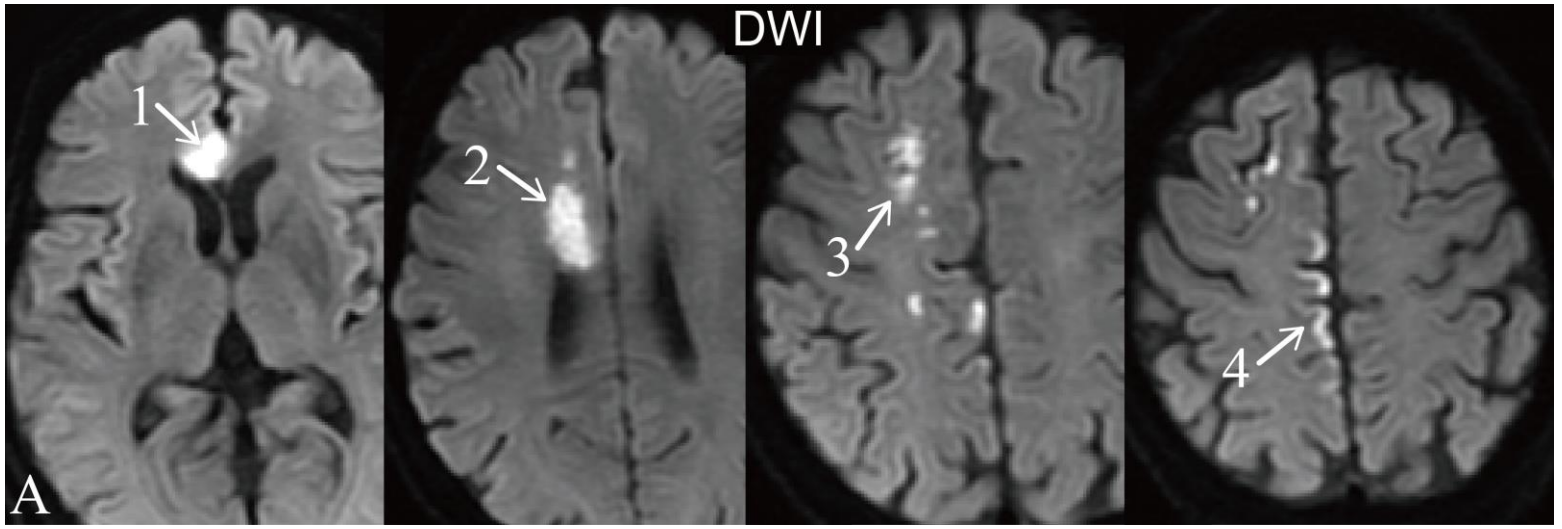




Intracranial artery atherosclerosis:

(thrombosis and hypoperfusion)





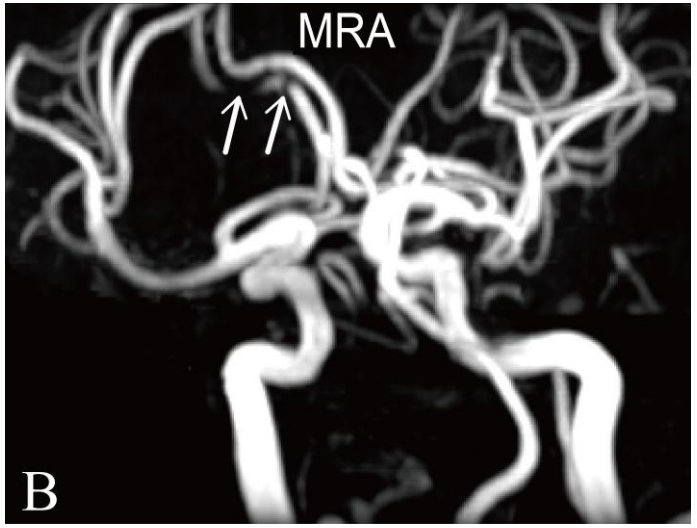


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圖5-17

女/60，ACA stenosis and infarction

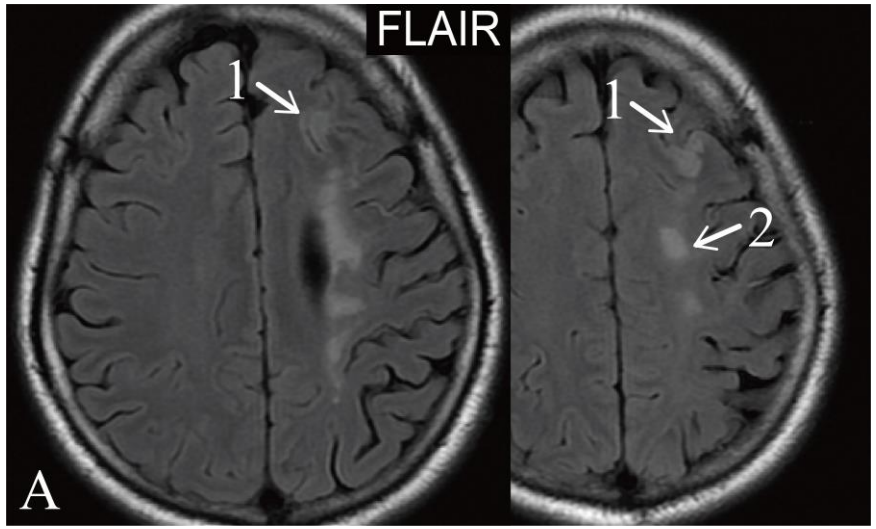
高血壓，高血糖(hyperglycemia)患者，突然發生左側肢體無力，truncal ataxia。

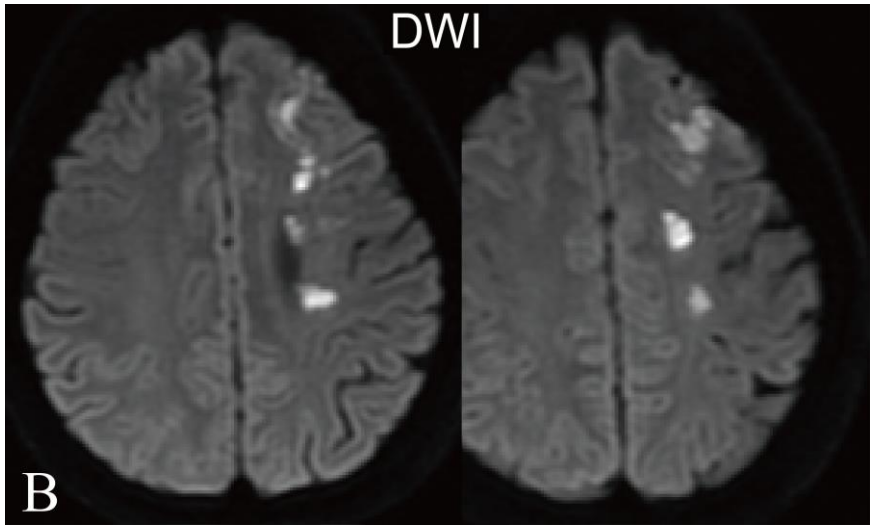
第三天之MRI

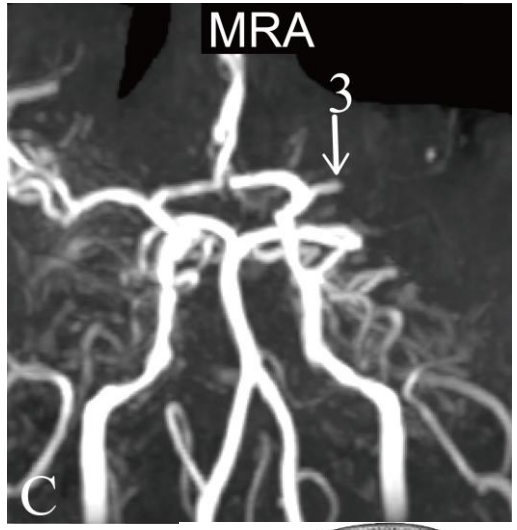
(A) DWI，可見genu of corpus callosum右側(1)，及右frontal lobe內側(2)有片狀及念珠狀(3) diffusion restriction的cytotoxic edema，深層cortex也有(4)，表示這是右ACA灌溉區之急性梗塞。

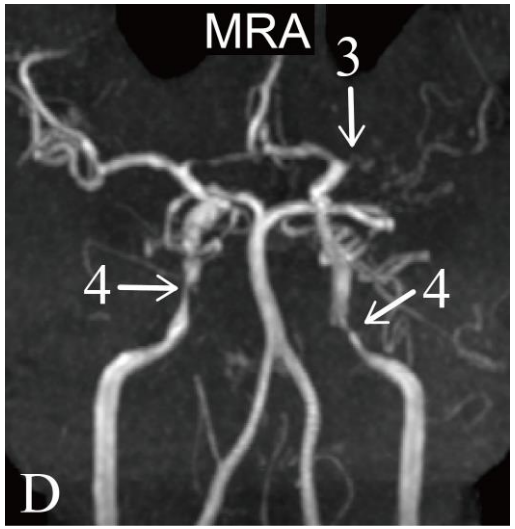
(B) MRA可見右ACA有嚴重狹窄(arrows)，是嚴重atherosclerosis，所以這是ACA引起之hemodynamic impairment的border zone infarction。

Intracranial artery atherosclerosis:
(hypoperfusion)

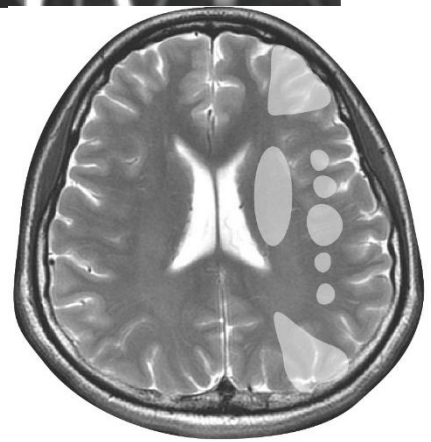




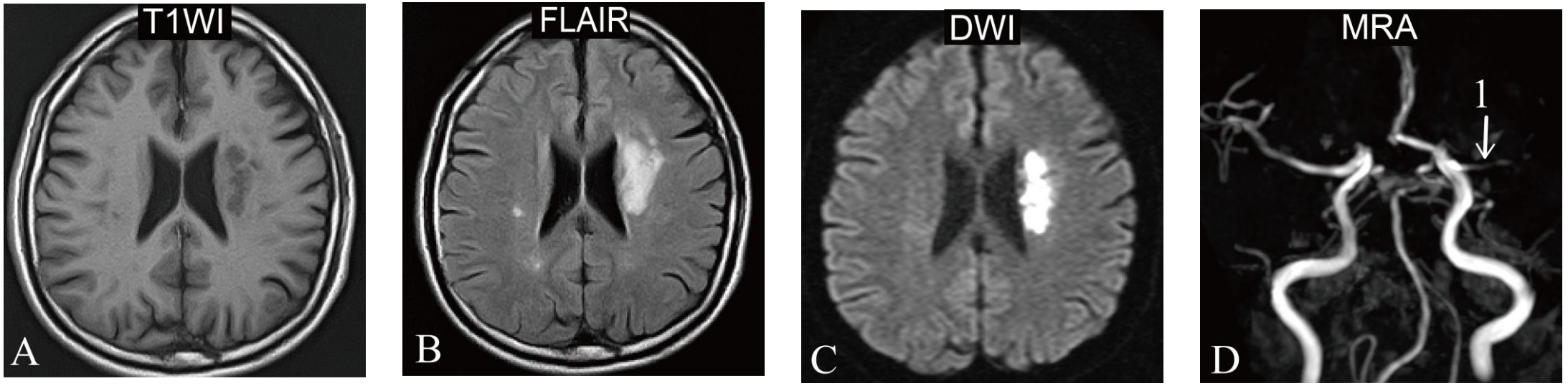




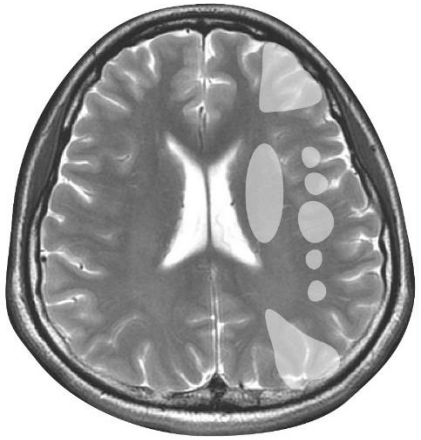
女/39，MCA border zone infarctions
糖尿病已12年，沒妥善控制，又有高血脂、高血壓。發生右側肢體無力，第3天做MRI。
(A) FLAIR可見左側MCA與ACA間分水嶺(watershed area)區域(1)及corona radiata(2)有多個高訊號病灶。
(B) DWI，這些病灶都是diffusion-restriction，所以都是急性梗塞引起的cytotoxic edema。
這是皮質性邊界(cortical border zone)(1)合併皮質下(subcortical)(2)的念珠狀梗塞(rosary-like infarctions)。
(C) MRA證實是MCA硬化、阻塞(steno-occlusion)(3)。
(D) 三年後之MRA，除MCA之外，更可見雙側ICA也硬化狹窄(4)。



Intracranial artery atherosclerosis:
(hypoperfusion)



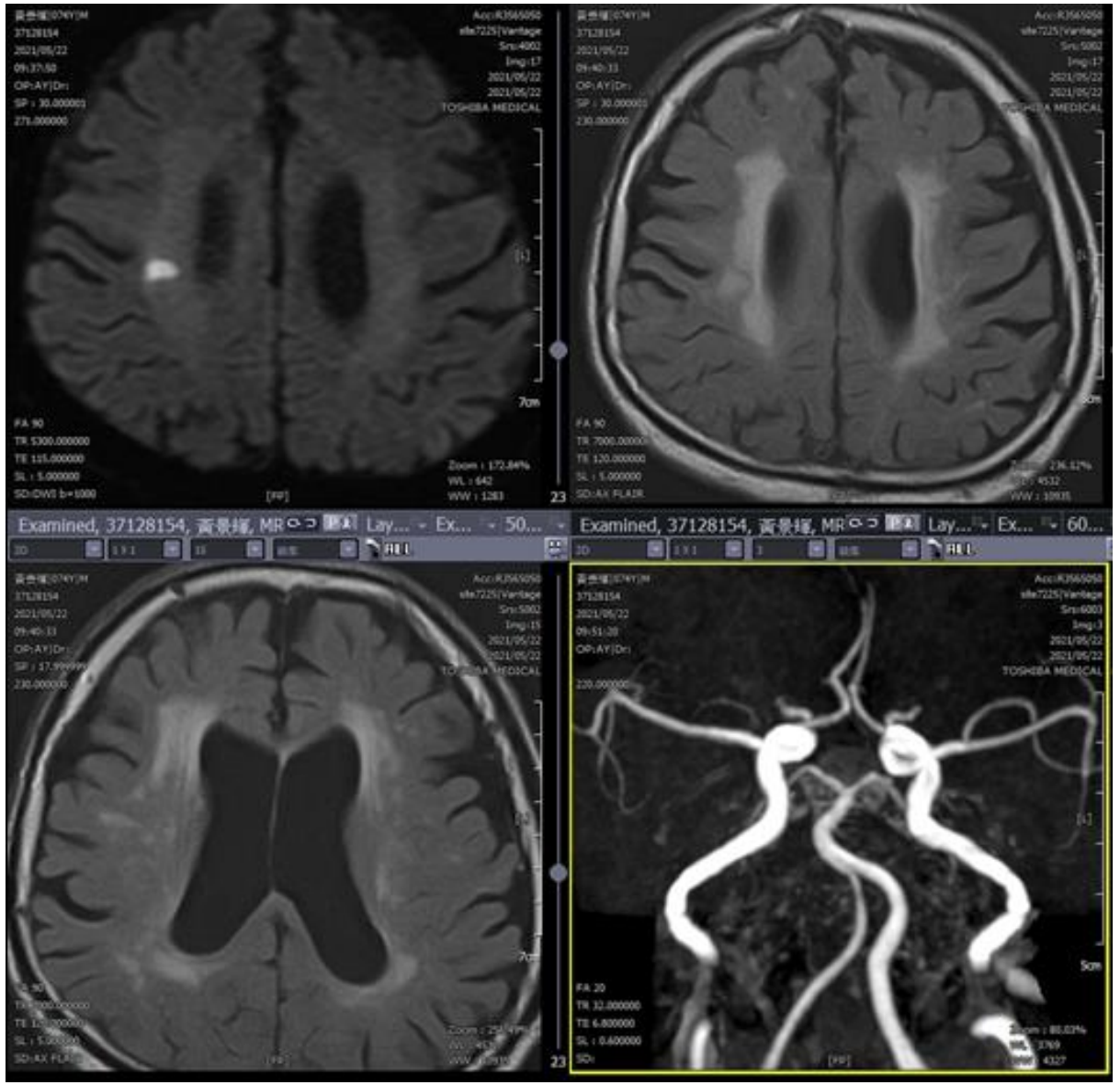
男/57，internal border zone infarction, confluent pattern
高血壓、酗酒者，突然發生右側肢體無力，講話困難(dysarthria) 已4天。
(A-C) MRI可見左側放射冠(corona radiata)有急性梗塞腦水腫，在T1WI稍暗，FLAIR白，DWI更白，是diffusion restriction。
(D) MRA顯示左MCA嚴重狹窄且阻塞(steno-occlusion)。
這是典型的internal border zone infarction，confluent type，由於MCA steno-occlusion導致血流動力不足(hemodynamic impairment)所引起的。



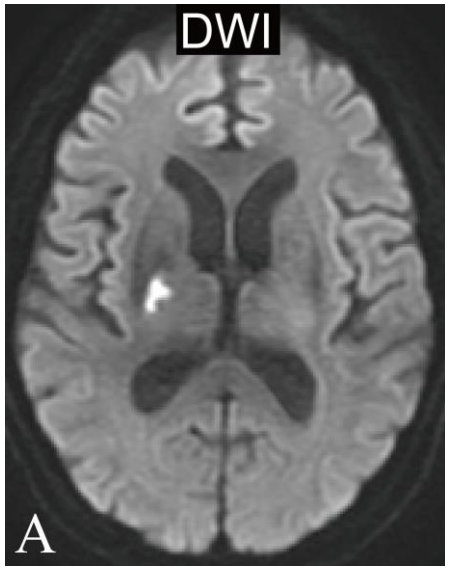
Small vessel atherosclerosis

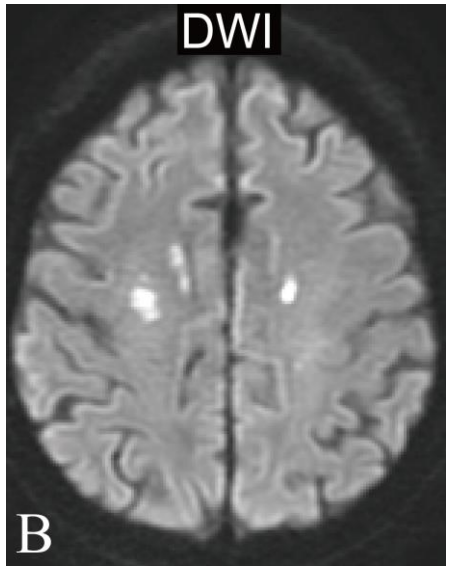
(lacunar infarction due to hyaline atherosclerosis)

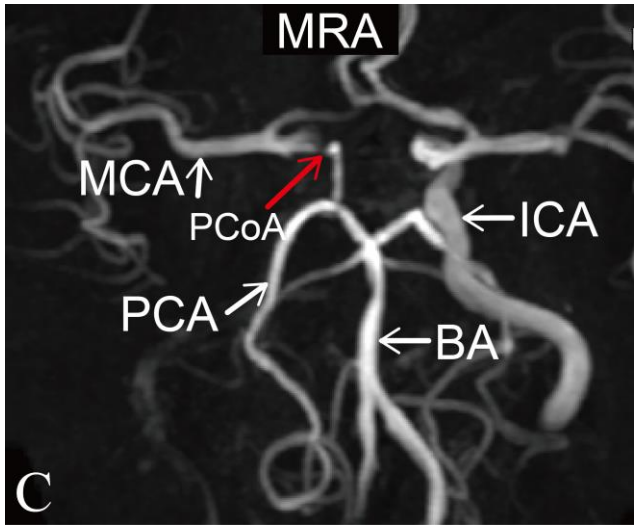
M74
Left hand weakness for 9 days.
Chronic hypertension without control.
No DM,　no hyperlipidemia.
2021,5,22 MRI: acute lacunar infarction in right corona radiata,
PVH, SAH, no microbleed.
MRA: No abnormality of larger vessels.
So, this is a typical small vessel diseases caused by chronic hypertension.

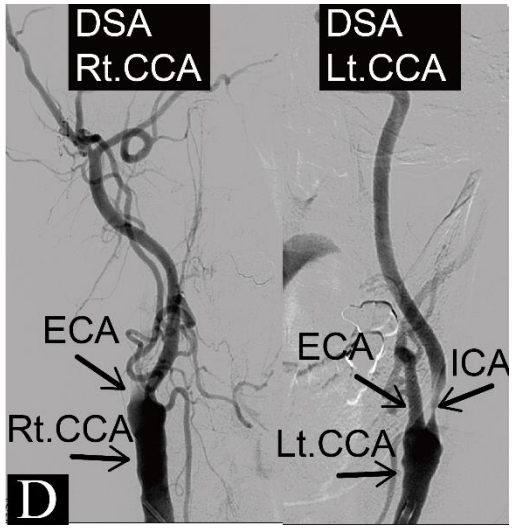


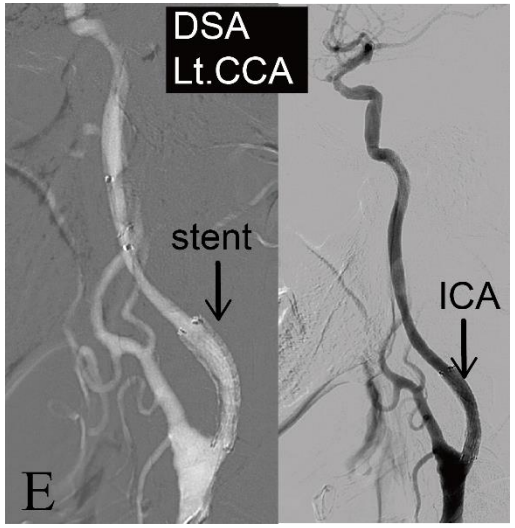
Lacunar infarction caused by ICA atherosclerosis











男/73，ICA狭窄、阻塞、急性 lacunar infarction

高血壓、糖尿病、心律不整的患者，突然發生左側肢體無力。

(A) DWI：右側putamen有一小病灶，呈現diffusion restriction，表示是急性梗塞。

(B)更高切面，雙側corona radiata，另有數個diffusion restriction之小點，代表一種hemodynamic insufficiency，這通常是因ICA或MCA嚴重狹窄所引起。

(C) MRA可見右側ICA沒顯影，表示完全阻塞。但右側MCA顯影很好，因為有來自PCA的血流經PCoA (red arrow)供應。 BA: basilar art.

(D)DSA可見右側ICA沒顯影，表示完全阻塞，同時又發現左側ICA在bifurcation上嚴重狹窄。 ECA: external carotid artery, CCA: common carotid artery.

(E) 病患接受左側ICA放置支架(arrow)手術， 可見左側ICA狹窄處變寬了。

Merritt's Neurology: Acute Ischemic Stroke

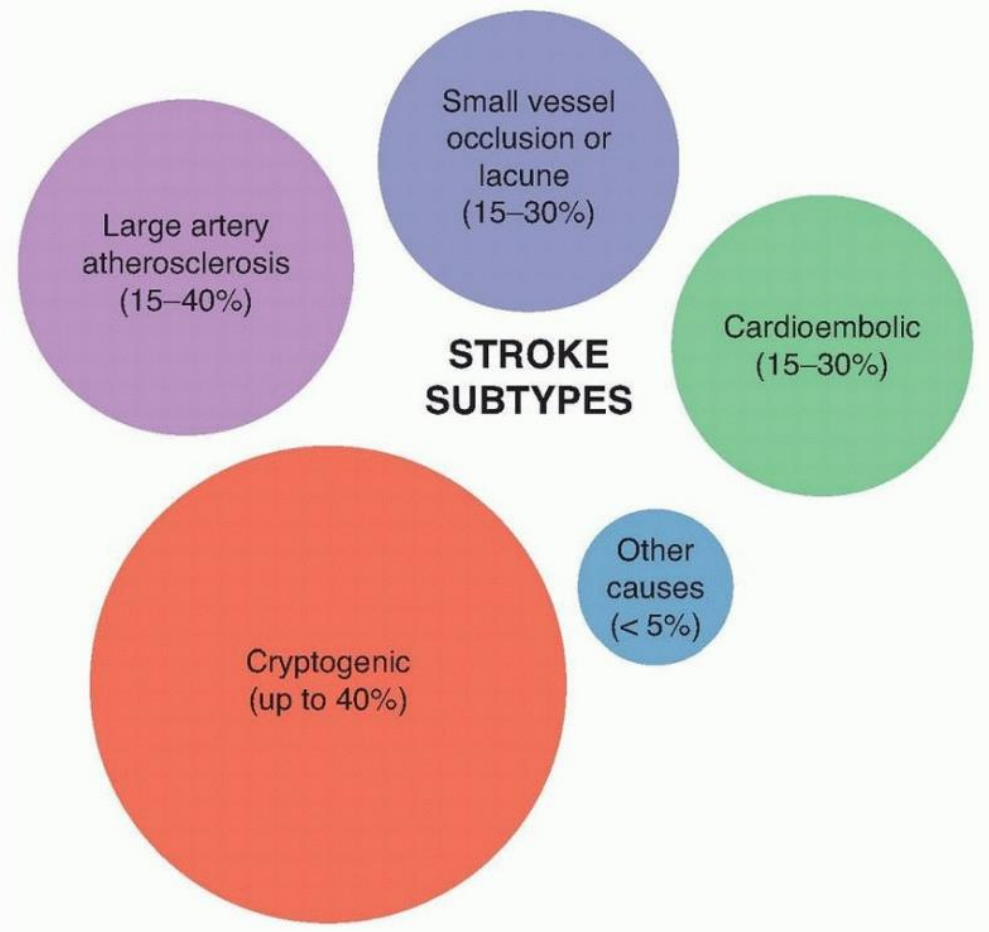


FIGURE 35.4 Stroke subtypes. This figure shows the TOAST classification criteria for ischemic stroke and the estimated relative distribution of stroke within each category.

Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification criteria is the most widely accepted ischemic stroke classification system and includes the following five subtypes:
large artery atherosclerosis (15% to 40%),
cardioembolic (15% to 30%),
small-vessel occlusion or "lacunar" (15% to 30%),
cryptogenic (up to 40%),
"other" cause

如何查?

large artery atherosclerosis:
MRA, CTA, DSA, Doppler of neck vessels.

Cardioembolic:
EKG, cardiac echo…

small-vessel occlusion:
MRI or CT of small vessel diseases