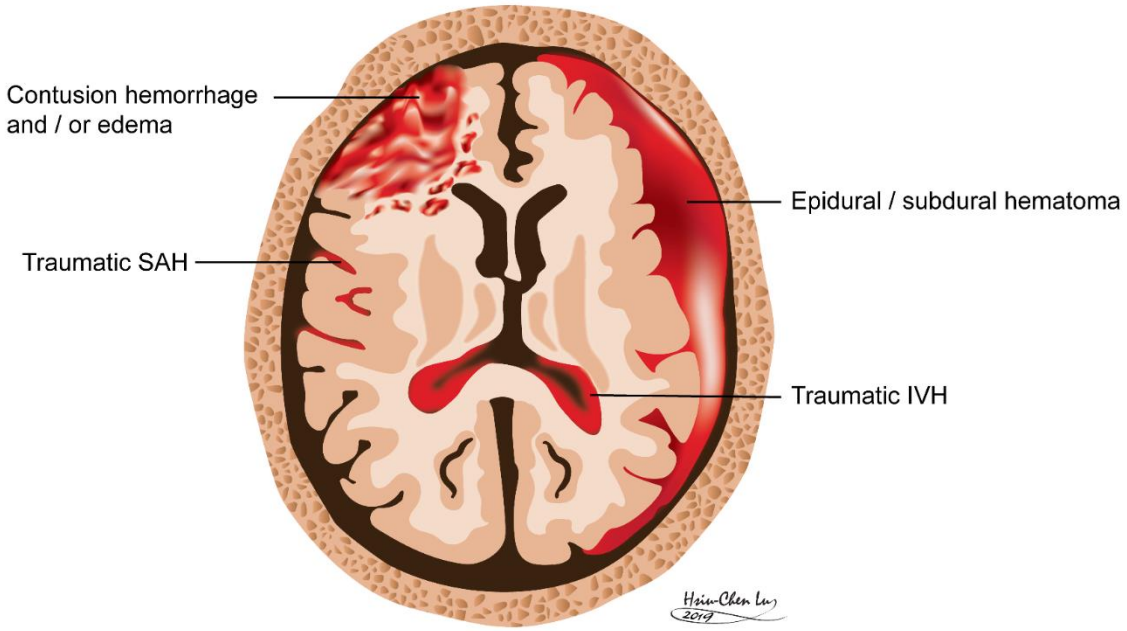
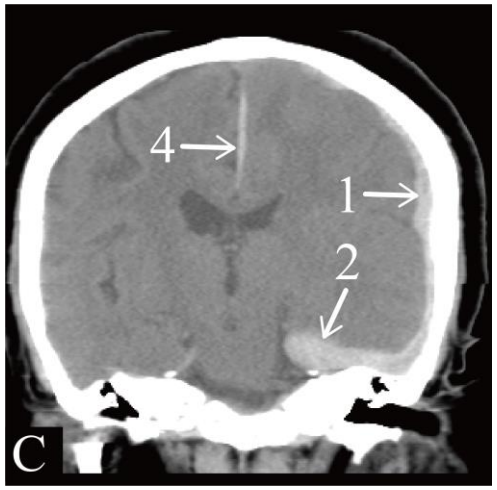
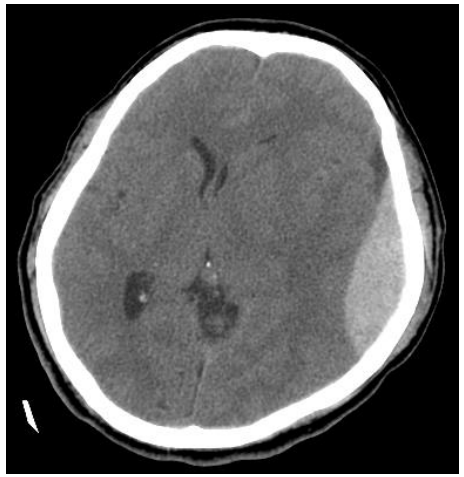
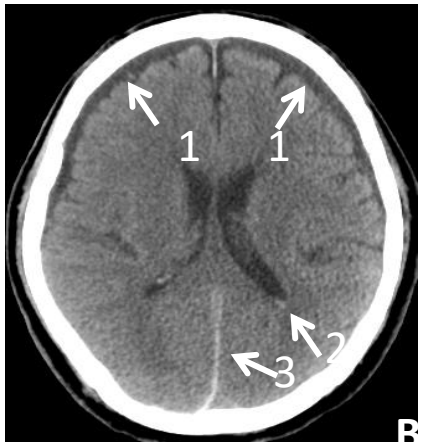
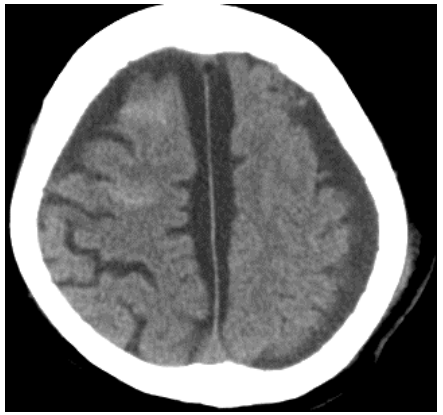
Head injury 核心知識



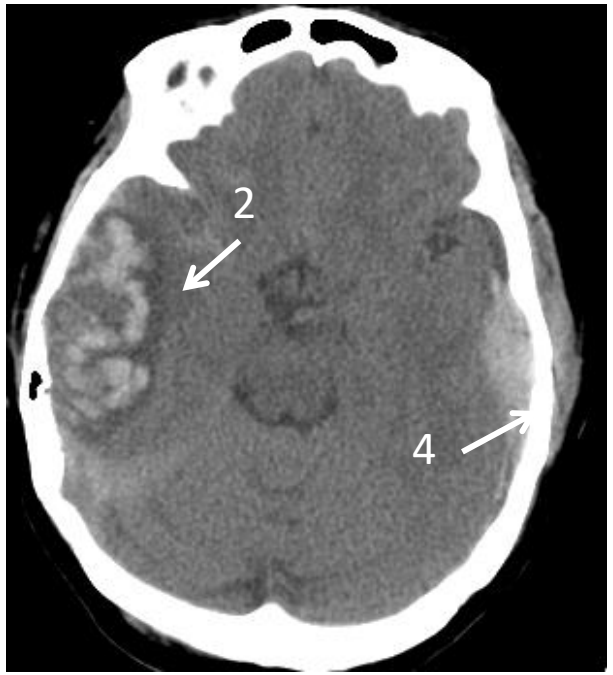


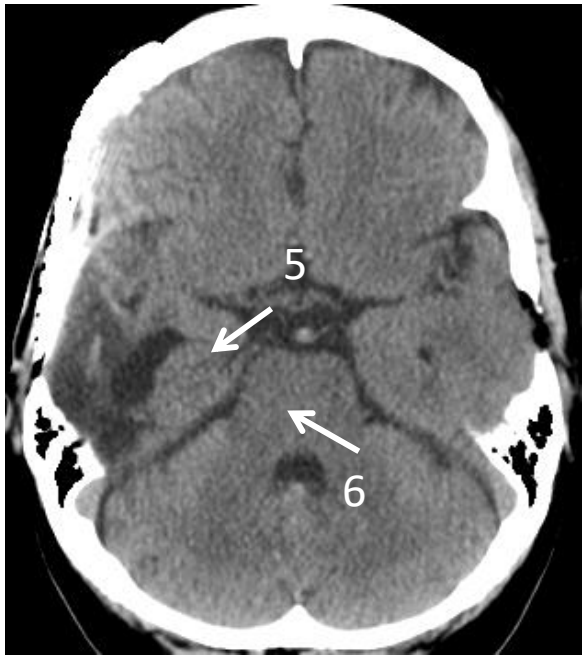






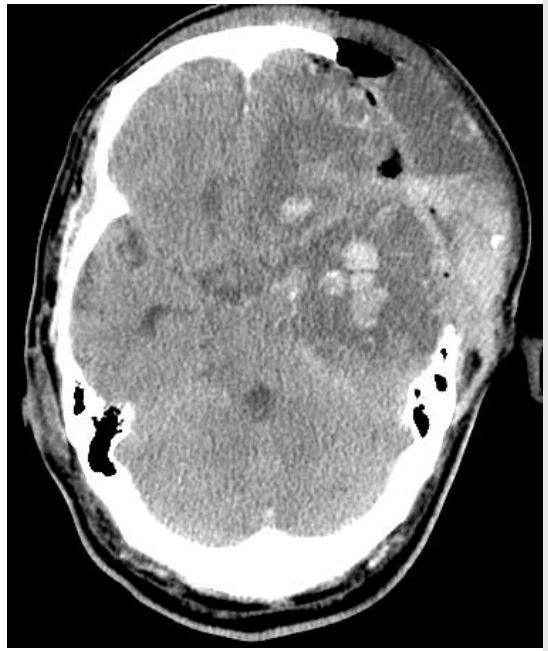
contusion hemorrhage



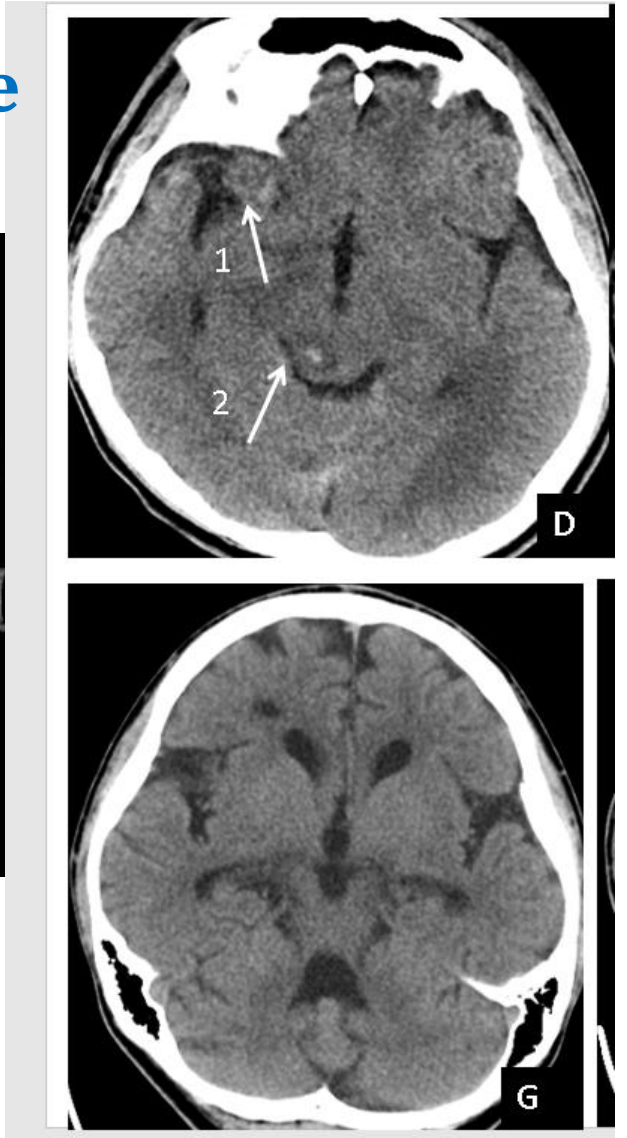


contusion hemorrhage
and edema

Delayed hemorrhage

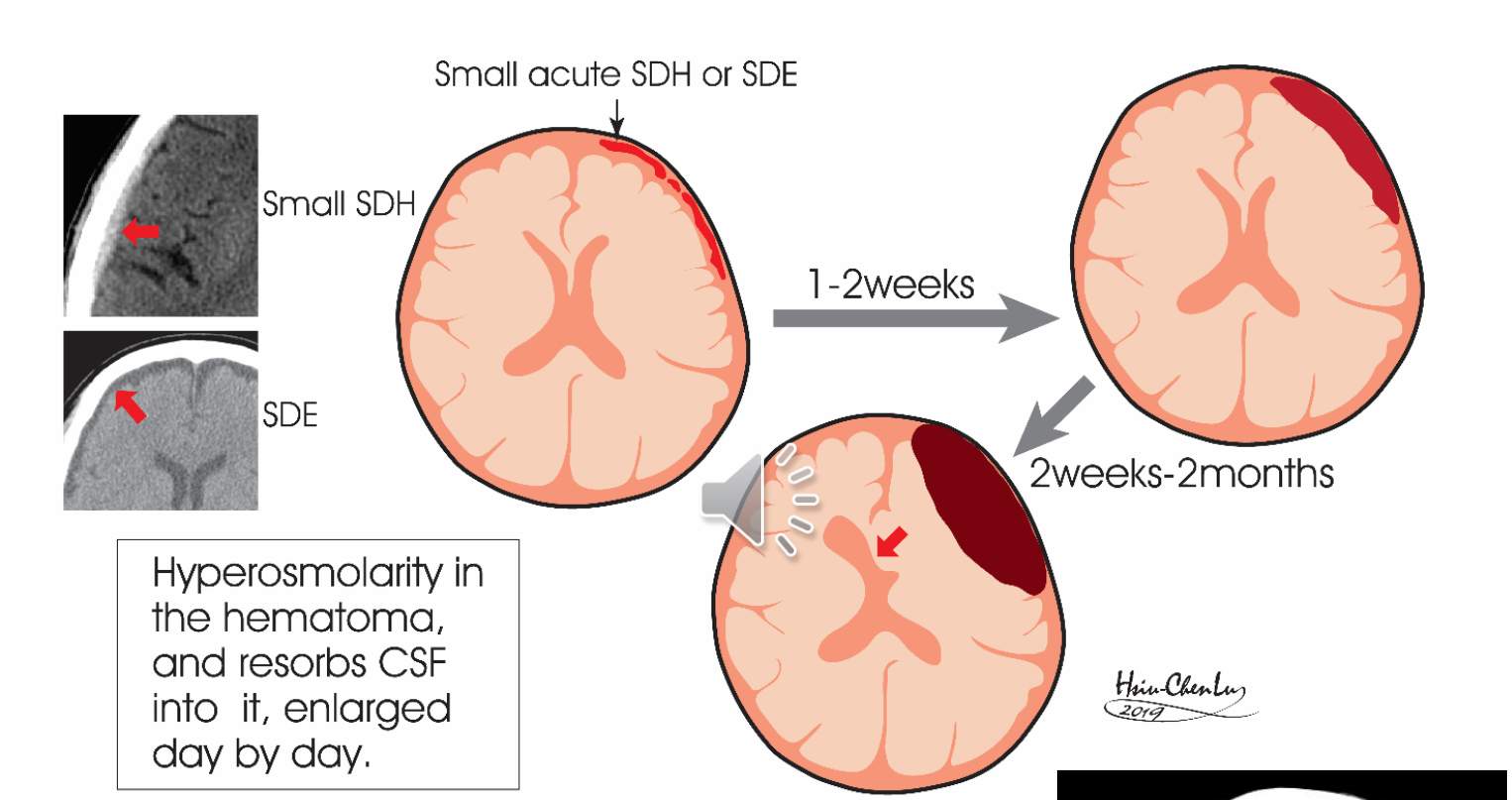


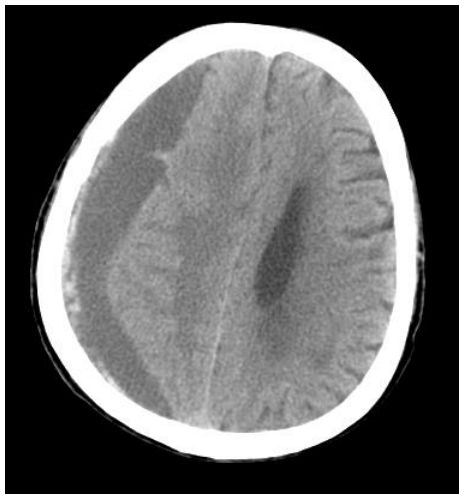
delayed contusion
hemorrhage
and edema



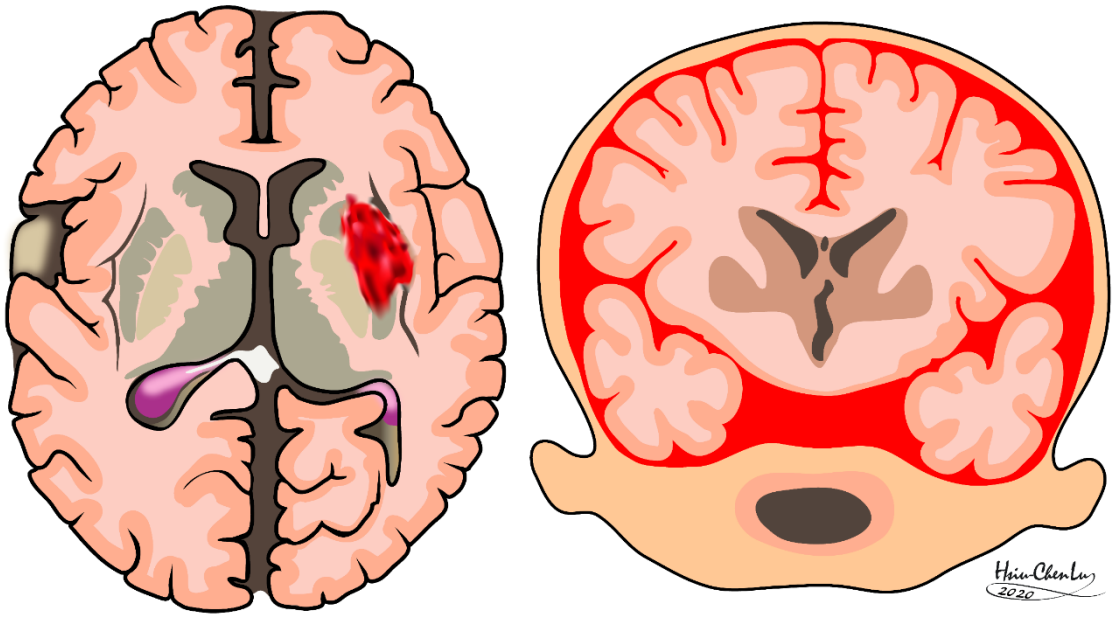
Sequela of contusion–
brain atrophy

Chronic SDH


Small acute SDH or SDE
Small SDH
SDE
1-2weeks
2weeks-2months
Hyperosmolarity in the hematoma, and resorbs CSF into it, enlarged day by day.
Hsiu-Chen Lu 2014



ICH and SAH and Ischemic infarction
核心知識



ICH SAH

Infarction

Thrombosis

Lacunar stroke (small vessel)

Large vessel thrombosis

Embolic occlusion

Artery-to-artery

Cardioembolic

出血性中風ICH的病因

ICH 最重要的是 hypertension 引起的 ICH (deep ICH)
以及 amyloid angiopathy引起的 ICH (lobar ICH)

腦內出血性(ICH)中風的病因可以分為下列幾種：

1. 高血壓性，最常見
2. 澱粉狀血管病變(amyloid angiopathy)
3. 血管疾病，如AVM、aneurysm、venous malformation、hemangioma
4. 腫瘤出血(tumor bleeding)
5. 有出血傾向的疾病，如白血病、肝功能異常、服用抗凝血劑

---WC Shen: Diagnostic Neuroradiology. Springer-Nature 2021

Causes of ICH

1. Hypertension
2. Amyloid angiopathy
3. AVM、aneurysm、cavernous hemangioma 、venous angioma
4. Dural sinus thrombosis
5. Tumor bleeding
6. Coagulopathy
7. Vasculitis
8. Cocaine or alcohol use
9. Hemorrhagic transformation of infarction

---Qureshi et al: Spontaneous ICH. NEJM, 2001

Box 72-2

Causes of Spontaneous Intracerebral Hemorrhage

Hypertension
Vascular anomaly
- Cerebral aneurysm
- Arteriovenous malformation
- Cavernous malformation

Cerebral infarction (stroke) hemorrhagic transformation
Cerebral amyloid angiopathy
Coagulopathy
- Blood diseases (hemophilia, leukemia.....)
- Uremia
- SLE
- Liver disease
- Anticoagulant therapy

Tumors
Drug abuse
Other

----Townsend: Sabiston Textbook of Surgery, 18th ed.

Deep ICH 的 出血位置(anatomic locations)

腦內出血性(ICH)中風的病因可以分為下列幾種：

1. 高血壓性，最常見
2. 澱粉狀血管病變(amyloid angiopathy)
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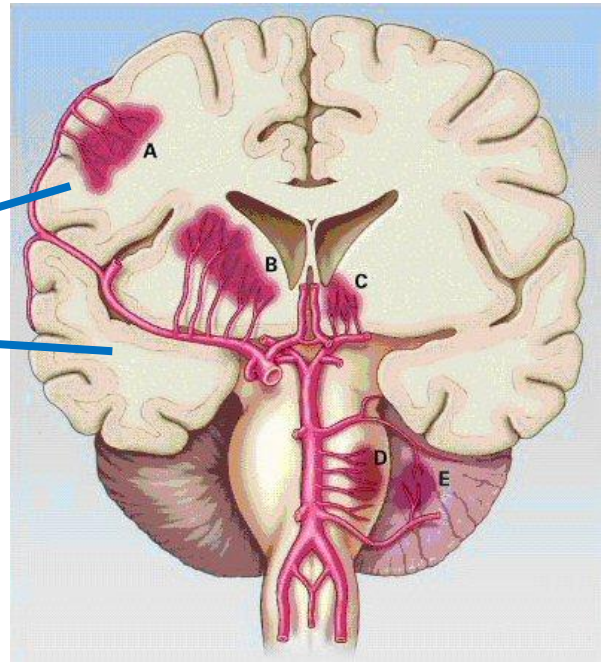
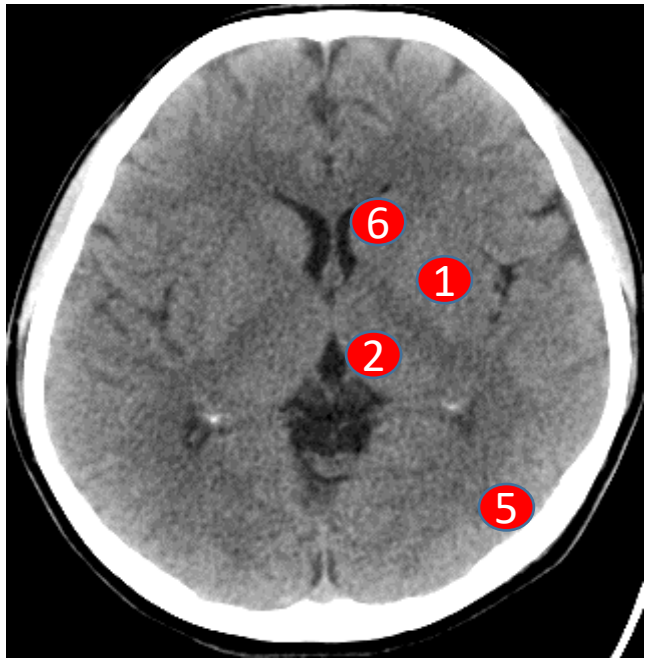
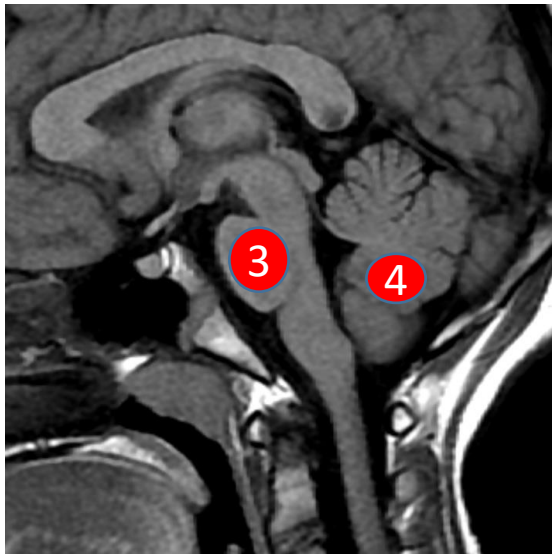
4. 腫瘤出血(tumor bleeding)
5. 有出血傾向的疾病，如白血病、肝功能異常、服用抗凝血劑

---WC Shen: Diagnostic Neuroradiology. Springer-Nature 2021





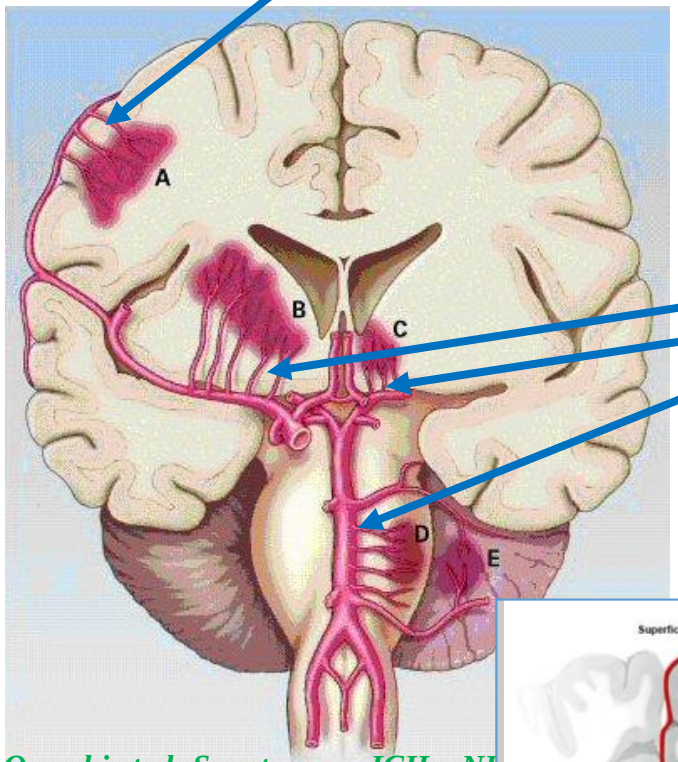


- Basal ganglion:
  putamen
  caudate nucleus
- Thalamus
- Brainstem
- Subcortical white matter of cerebellum
- Cortex of cerebrum (amyloid angiopathy)

發生率順序：1. putamen→2. thalamus→ 3. brainstem(pons) → 4. cerebellum →5. subcortex of cerebrum →6. caudate nucleus → brainstem(midbrain) → brainstem(medulla oblongata)

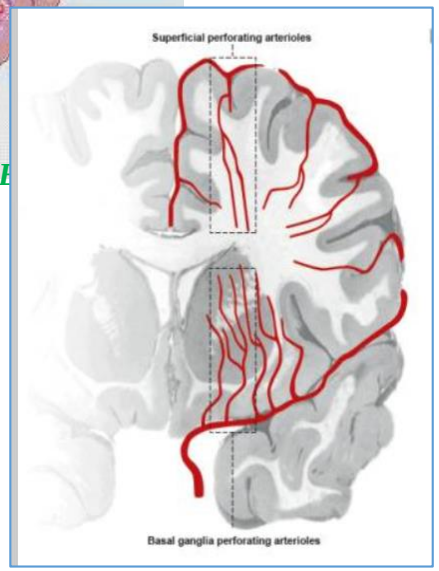
引起Deep ICH 以及 lobar ICH 出血的血管
(都是small arteries--- penetrating arteries, medullary art.)

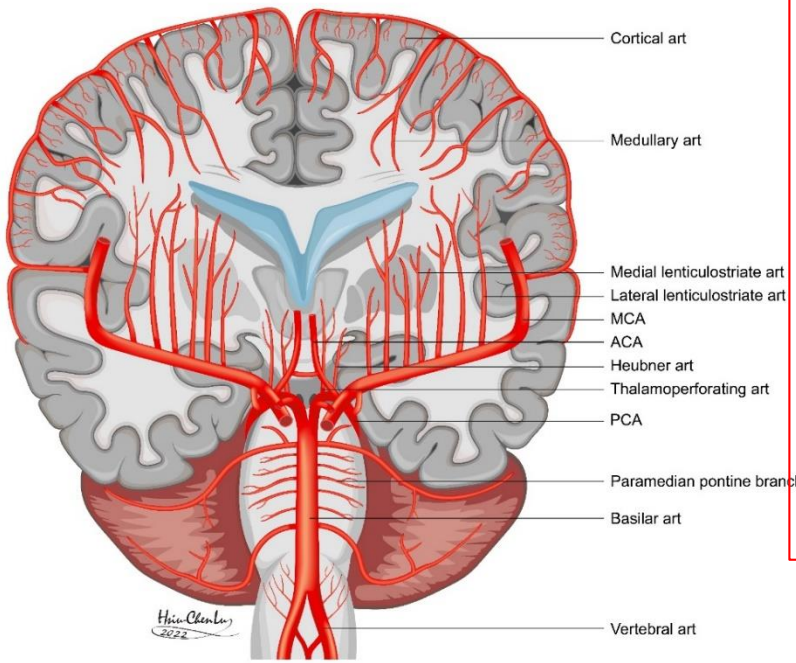
medullary arteries



penetrating arteries

---Qureshi et al: Spontaneous ICH. NE





hypertension 引起的 ICH (deep ICH):
---- penetrating arteries

以及 amyloid angiopathy引起的 ICH (lobar ICH)
--- medullary arteries

穿透小動脈(penetrating artery 或稱 perforating artery)

中腦動脈(MCA的內及外側豆狀核紋狀體動脈(medial and lateral lenticulostriate arteries)

後腦動脈(PCA)的視丘穿透動脈(thalamoperforating artery)

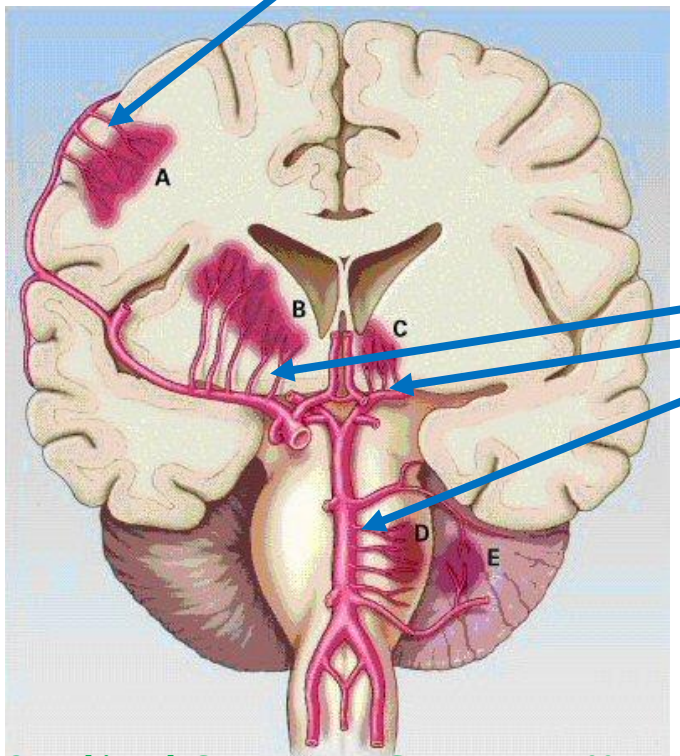
前腦動脈(ACA)的recurrent artery of Heubner.

基底動脈(basilar artery) 的正中傍分枝(paramedian branches).

另外，ACA、MCA、PCA的遠端在大腦皮質外的軟腦膜動脈(pia arteries)發出的髓動脈(medullary artery) 供應腦葉皮質下白質，包括centrum semiovale。

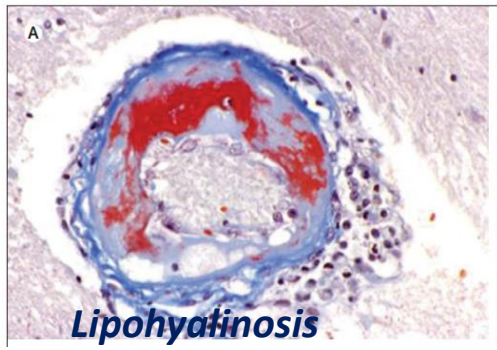
這些小血管(small arteries--- penetrating arteries, medullary art.)
為什麼會破裂出血?

稱為 **small vessel disease (SVD)**



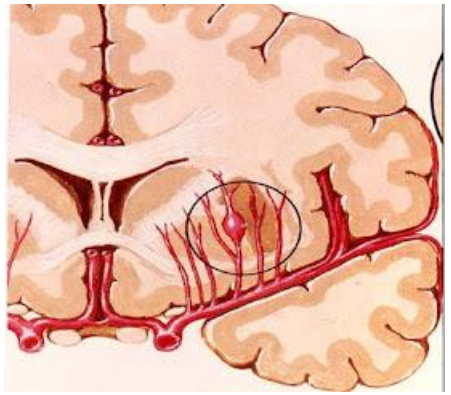
---Qureshi et al: Spontaneous ICH. NEJM, 2001

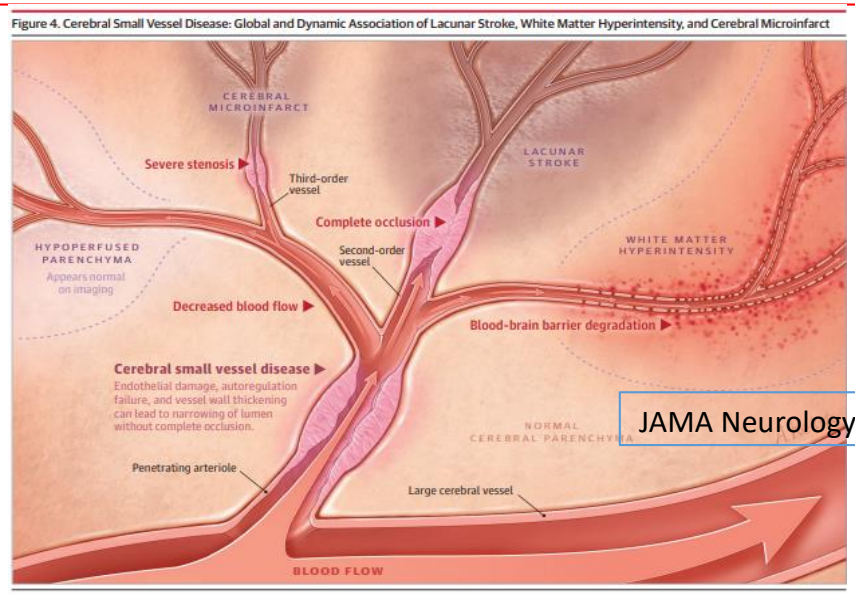
Chronic hypertension *is the most common underlying cause of primary brain parenchymal hemorrhage.* chronic hypertension.
Hypertension causes abnormalities in vessel walls:
Atherosclerosis in larger arteries;
Hyaline arteriolosclerosis in smaller vessels;
Arteriolar walls affected by hyaline change are presumably weaker than are normal vessels and are therefore more vulnerable to rupture.
In some instances chronic hypertension is associated with the development of minute aneurysms, termed ***Charcot-Bouchard microaneurysms***, which may be the site of rupture.
Robbins and Cotran Pathologic Basis of Disease, Professional Edition , 8th ed.
Cerebrovascular Diseases



Lipohyalinosis

Microaneurysm





JAMA Neurology 2018,

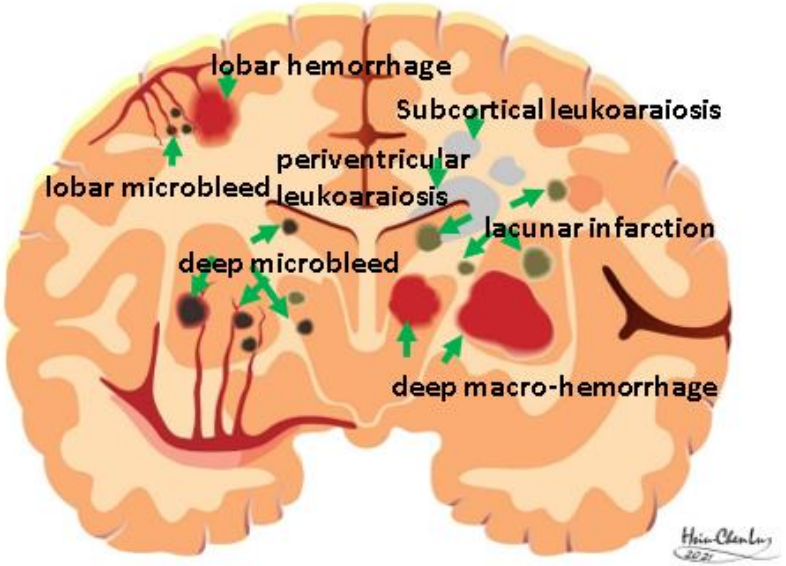
Small vessel disease (SVD) (Hyaline arteriolosclerosis in smaller vessels)
除了引起 ICH，還會引起哪些病變?

Small vessel disease (SVD) 包括:
Deep penetrating artery, chronic hypertension:
Hyaline arteriolosclerosis
Lobar penetrating artery (medullary arteries), chronic hypertension:
Amyloid angiopathy

引起
Bleeding:
ICH (intracerebral hemorrhage)---deep or lobar ICH (symptomatic)
Microbleeds (asymptomatic)

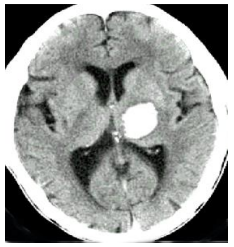
Small vessel stenosis, occlusion, ischemia:
Lacunar infarction (¼ symptomatic, ¾ asymptomatic)
White matter change (leukoaraiosis) (白質疏鬆) (asymptomatic)

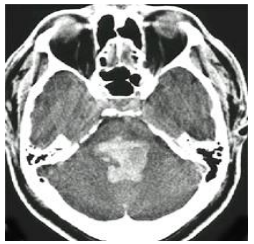
Small vessel tortuosity:
Dilated Virchow Rabin space (asymptomatic)



(慢性高血壓引起small vessel degenerative change (small vessel disease, svd)
除了會引起ICH，也會:
Lacunar infarction
Microbleed
White matter changes (leukoaraiosis) , *subcortical / periventricular*
Virchow-Robin space widening
------ ***imaging markers of svd***

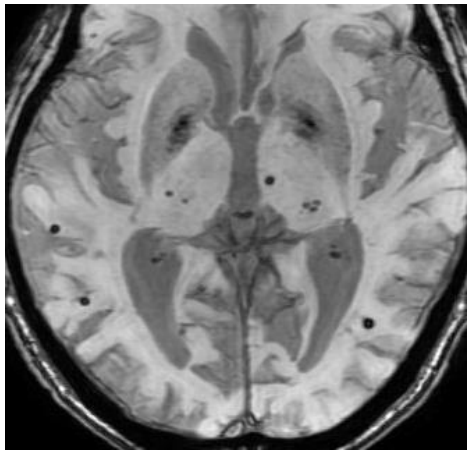
Small vessel disease (SVD) 的影像

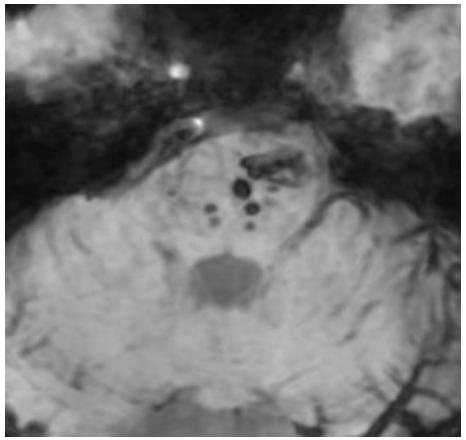




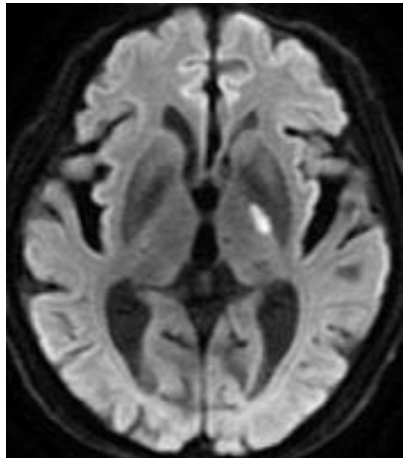
Deep ICH

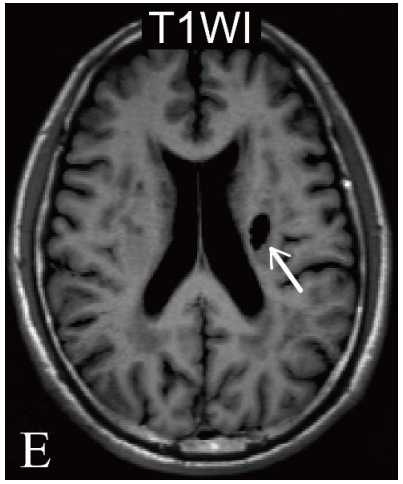
Lobar ICH



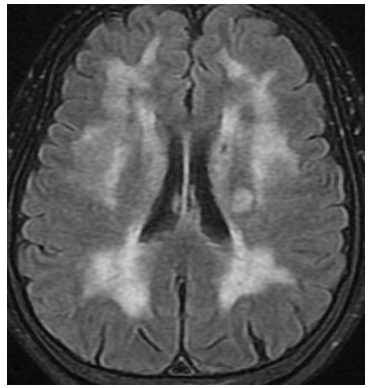


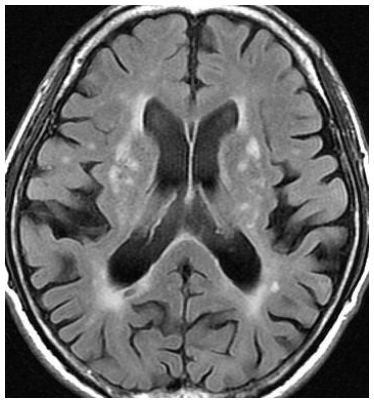
microbleeds



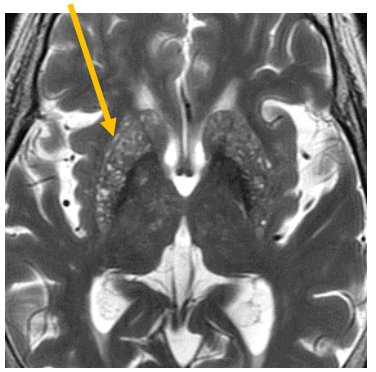


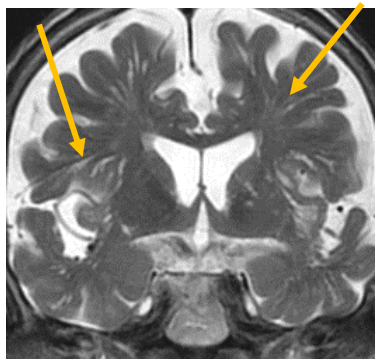
Lacunar infarction





leukoaraiosis



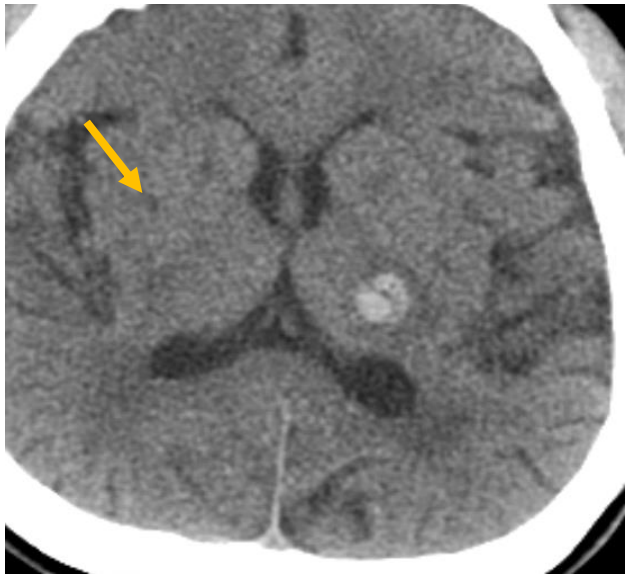


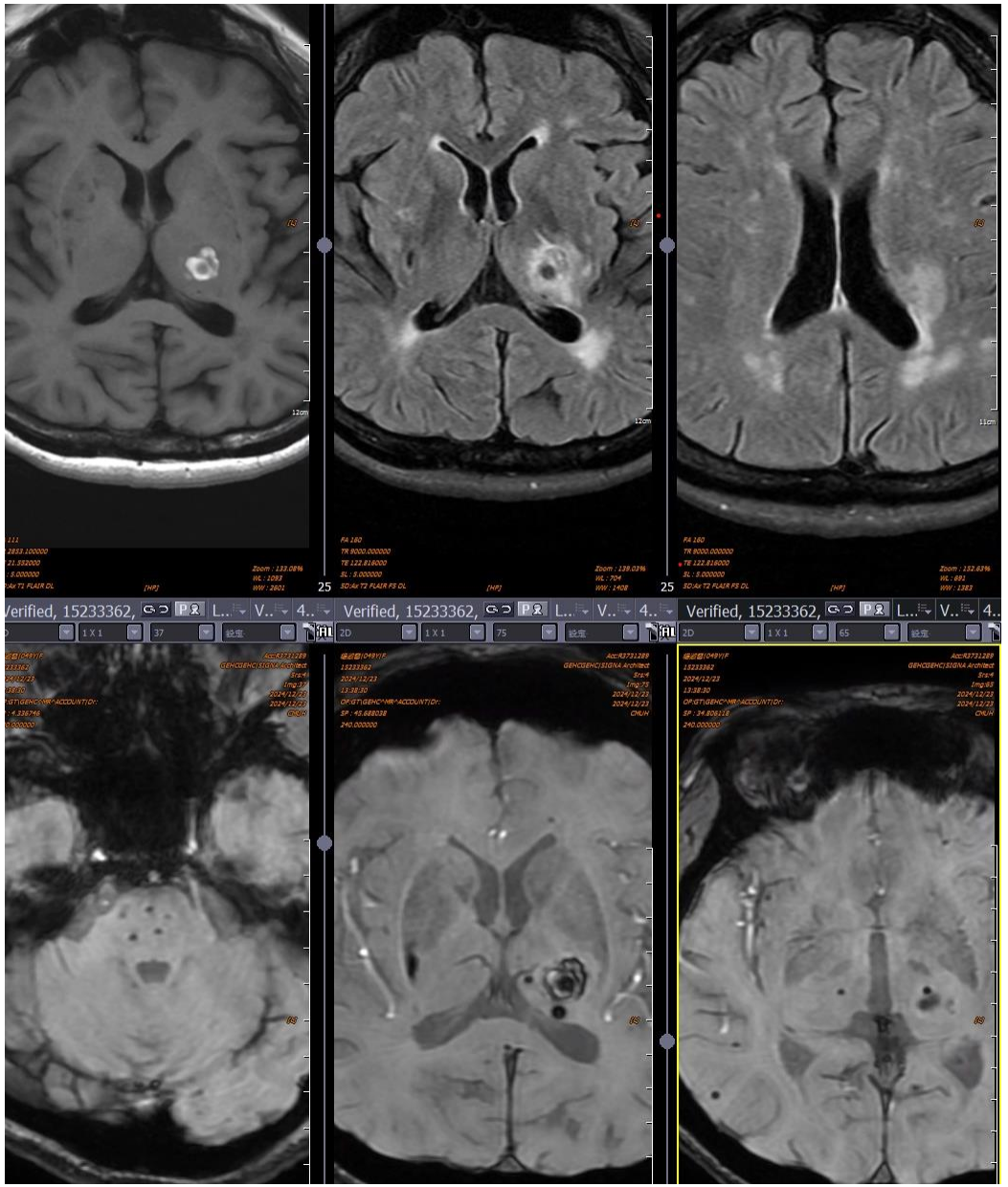
widened perivascular space

------ ***imaging markers of svd***

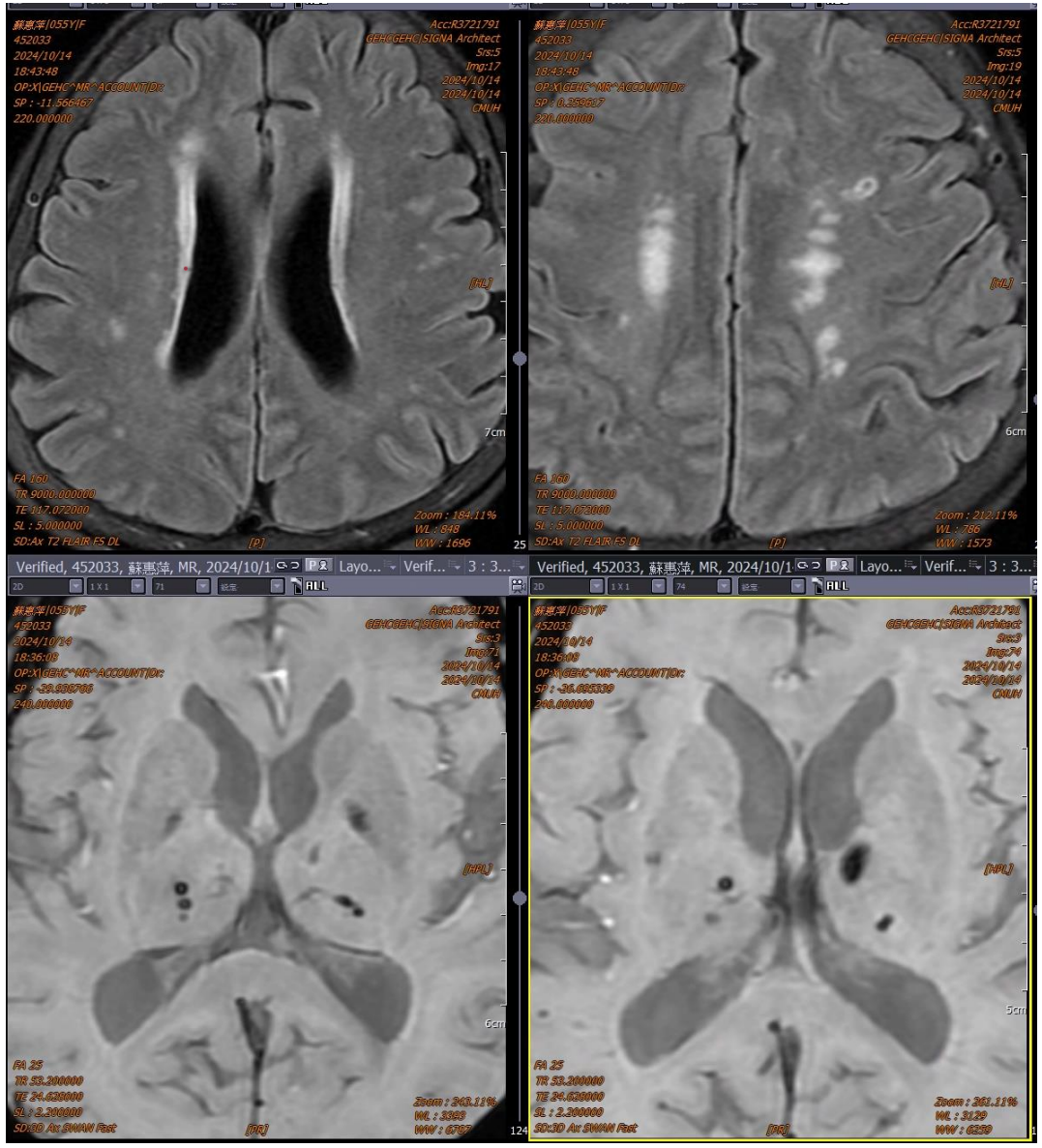
實例 1　deep ICH

F/49
Right limbs weakness
2024/12/17 CT:
Small acute hematoma in left thalamus.
Lacune in right putamen.
PVL.
2024/12/23 MRI:
Old lacunar infarct in Rt. putamen
Old ICH in Rt. Putamen.
Leukoaraiosis
Microbleeds in pons, thalamus.



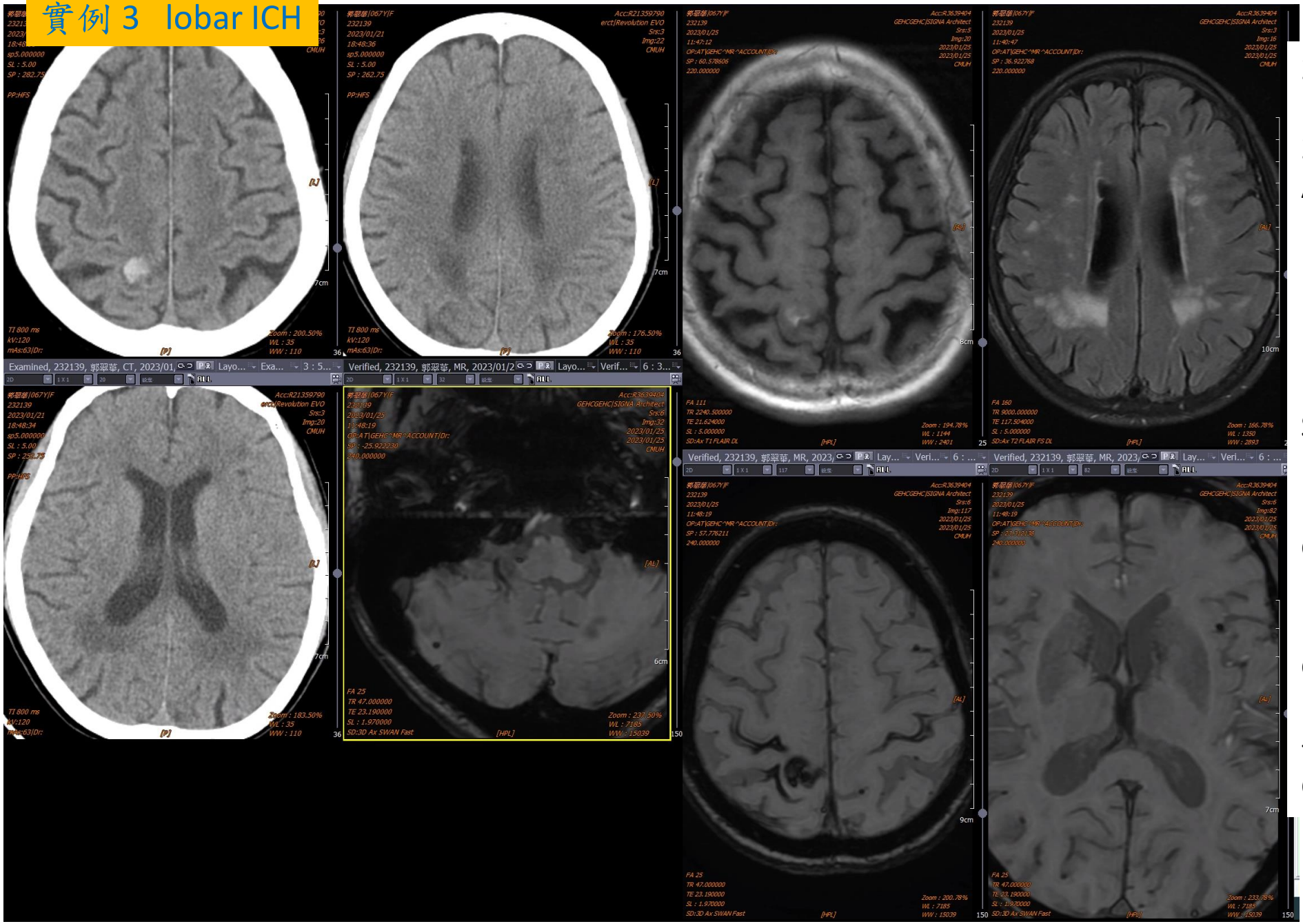


實例 2 deep ICH



F55　HTN
Sudden dizziness, vertigo.
2024/10/7 CT: left cerebellar ICH.
2024/10/14, MRI:
Leukoaraiosis,
Lacunar infarction
Microbleed
---------typical small vessel disease.

實例 3　lobar ICH



232139 F68

2023,1,21 CT:
A small acute ICH in Rt. parietal lobe
PVL

1,25 MRI:
ICH in right parietal lobe.
SAH in the sulci of bil. Parietal lobes.
Microbleeds in the right cerebellum, left external capsule, bil. F-P lobes.
Leukoaraiosis in periventricles, centrum semiovale

---- this is a case of lobar ICH due to amyloid angiopathy.

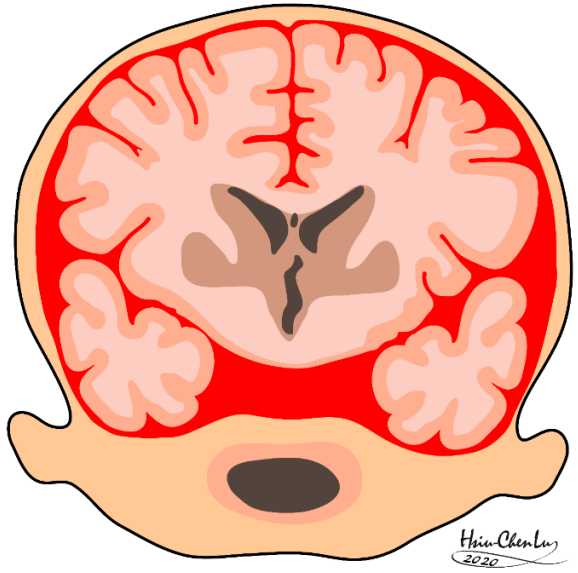
Spontaneous SAH

Spontaneous SAH 的症狀:

Spontaneous SAH是一種中風，是腦血管意外(cerebral vascular accident，CVA)的一種，臨床症狀主要是突然劇烈頭痛、頭暈、噁心、嘔吐、意識變差、脖子僵硬、畏光等meningeal sign，因此較輕微時，很類似腦膜炎(meningitis)。

SAH量大的患者意識會昏迷，甚至死亡。

因為沒有半身無力、手腳無力、嘴歪、臉麻....等等一般民眾比較熟悉的腦中風症狀，因此容易被忽視，一般人對這類中風也比較不了解。



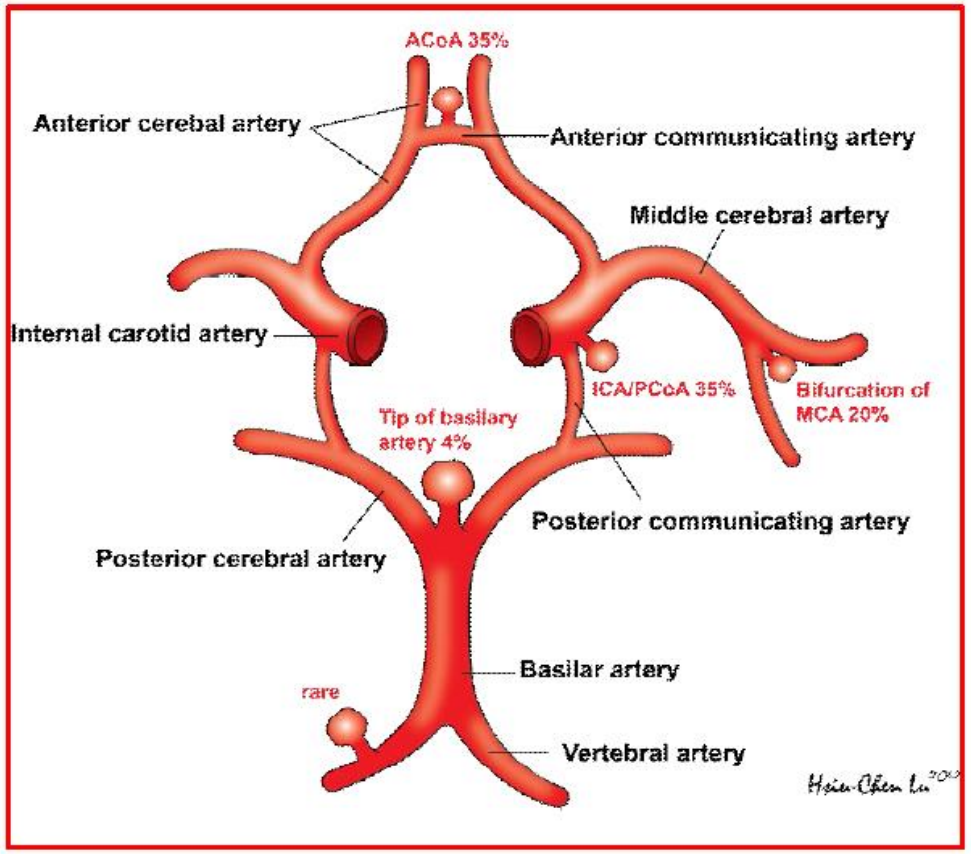
Symptoms:

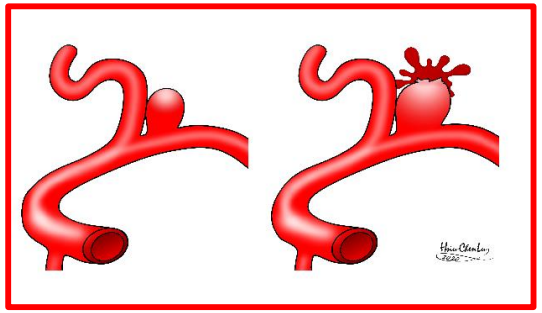
- **headache**
- **vomiting**
- **neck stiffness**
- **conscious change**

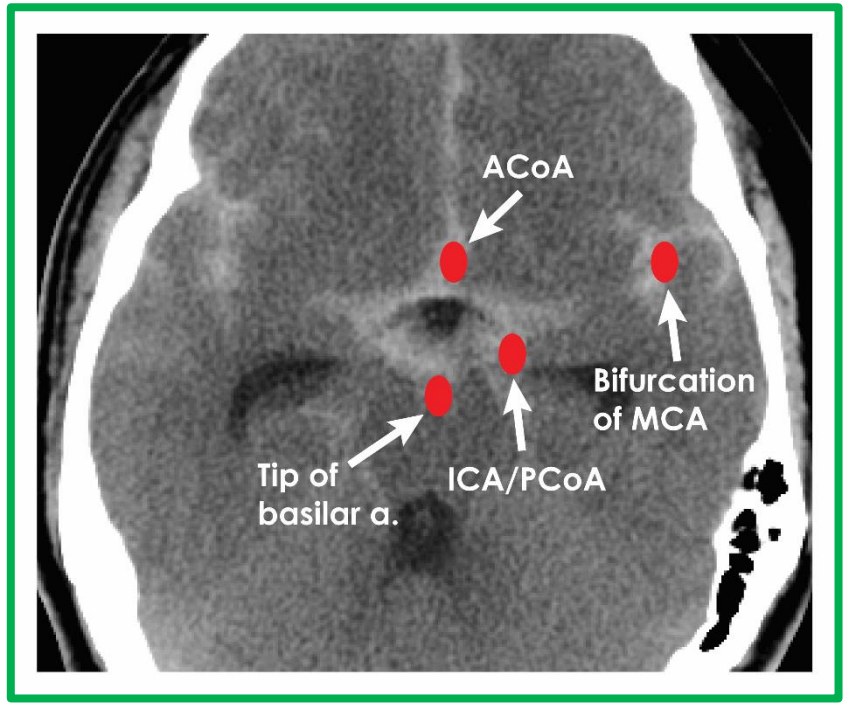
突然發生如雷擊般的瞬間頭痛。
此為最嚴重的腦出血性中風，
有將近5分之1的患者在到院前就死亡，
到院者也有3分之1因其它合併症病逝。

Spontaneous SAH 的病因

Spontaneous SAH大多數是顱內先有動脈瘤(aneurysm)生成，aneurysm破裂(rupture. 其實是leak)出血所引起。
少數是AVM引起。
有一種少見的spontaneous SAH，出血在大腦的sulci而不在basal cisterns，這類引起的原因主要是血管炎vasculitis。
約有15-20%的SAH找不到出血點，可能是顱內動脈硬化，在沒有形成aneurysm就自行裂開出血。



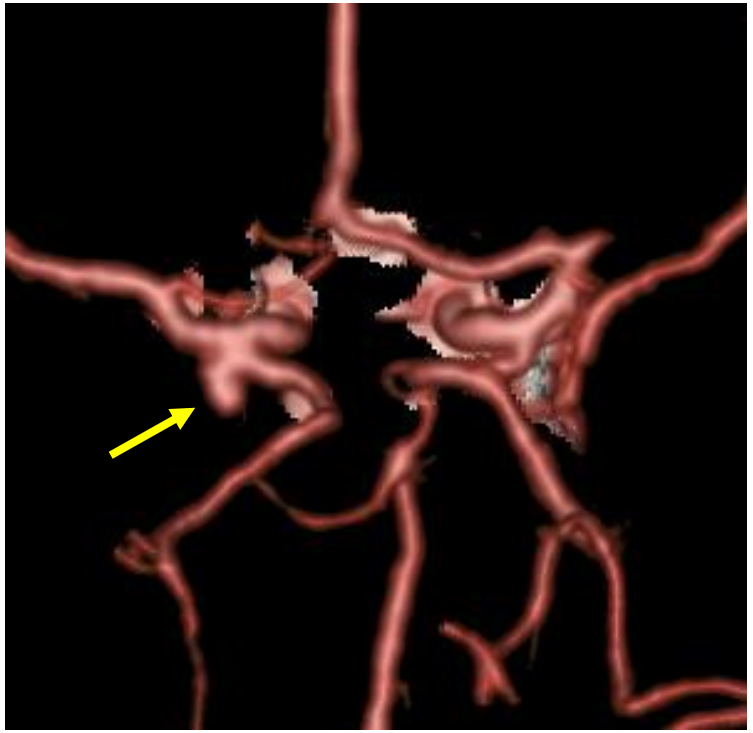




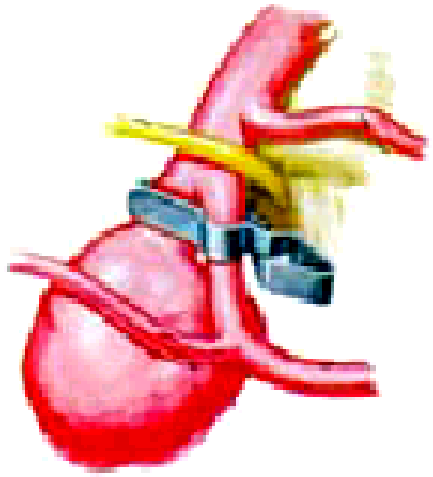
Aneurysm 出血型態:
Pure SAH (70%)
SAH + ICH (25%)
Pure ICH (5%)

找到aneurysm後的處理:

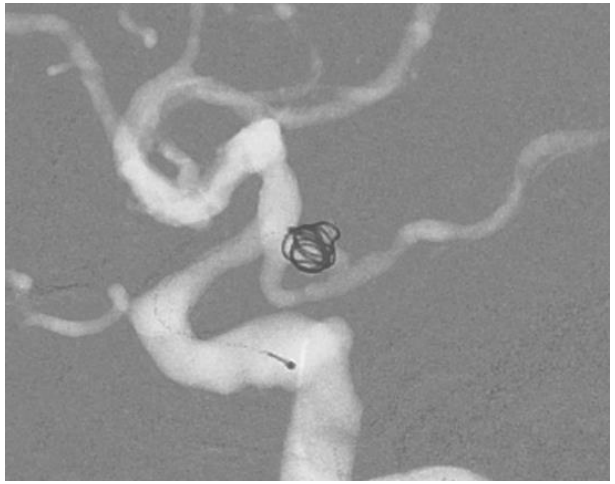
Surgical clipping
Coil embolization

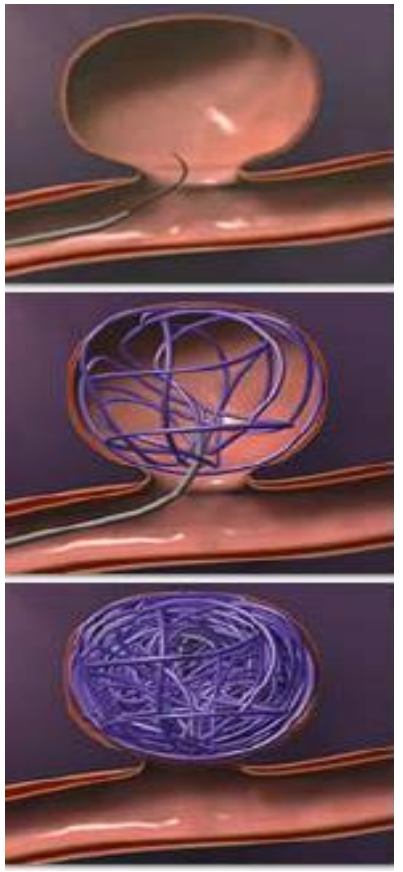


Aneurysm, Rt. ICA/PCoA



Surgical clipping





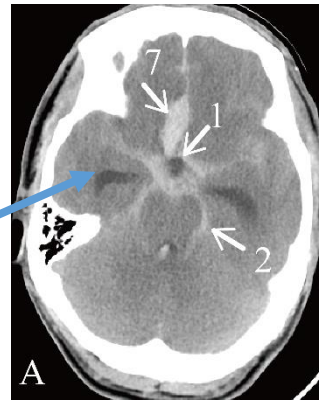
Coil embolization
via intra-arterial procedure

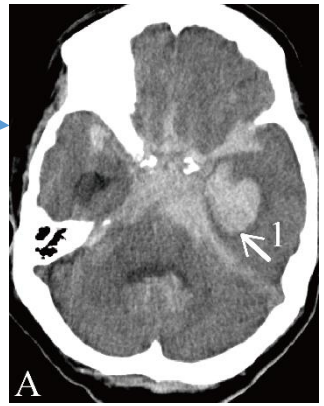
由CT出血型態臆測aneurysm 的位置:

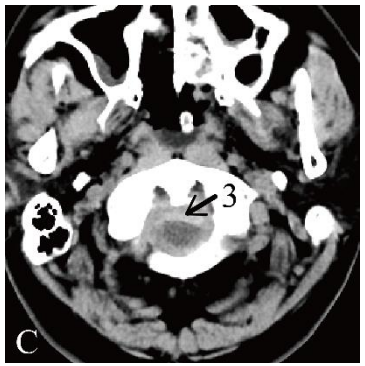
SAH如合併ICH，以CT影像就可臆測aneurysm 位置。

例如:

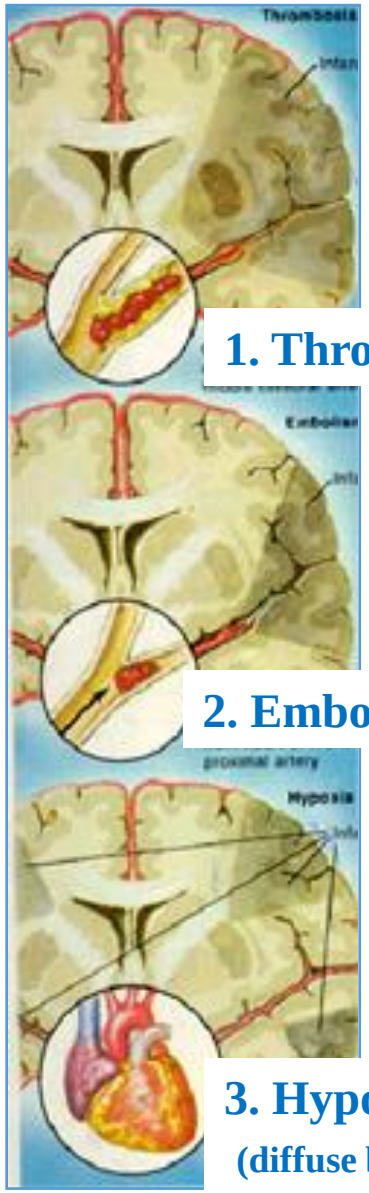
1. SAH如果合併額葉有ICH，或透明中隔(septum pellucidum)有hematoma，就可推測aneurysm在ACoA 。
2. SAH如果合併temporal lobe內側有ICH，可推測aneurysm在ICA/PCoA。
3. SAH合併Sylvian fissure內有hematoma，或temporal lobe外側有ICH，可推測aneurysm位於MCA bifurcation。
4. 其他如foramen magnum，甚至頸椎第一、二節SAH甚多，就要考慮vertebral artery的aneurysm 。







Ischemic Stroke



1. Thrombosis

2. Embolism

3. Hypoxia

(diffuse brain edema or watershed edema)

Table 364-2
Causes of Ischemic Stroke.

Thrombosis
- Lacunar stroke (small vessel)
- Large vessel thrombosis
- Dehydration

Embolic occlusion
- Artery-to-artery
  - Carotid bifurcation
  - Aortic arch
  - Arterial dissection
- Cardioembolic
  - Atrial fibrillation
  - Mural thrombus
  - Myocardial infarction
  - Dilated cardiomyopathy
- Valvular lesions
  - Mitral stenosis
  - Mechanical valve
  - Bacterial endocarditis
- Paradoxical embolus
  - Atrial septal defect
  - Patent foramen ovale

Atrial septal aneurysm

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

Ischemic Stroke
原因及機轉

Pathophysiology of ischemic stroke:

Three major mechanisms that underlie ischemic stroke:

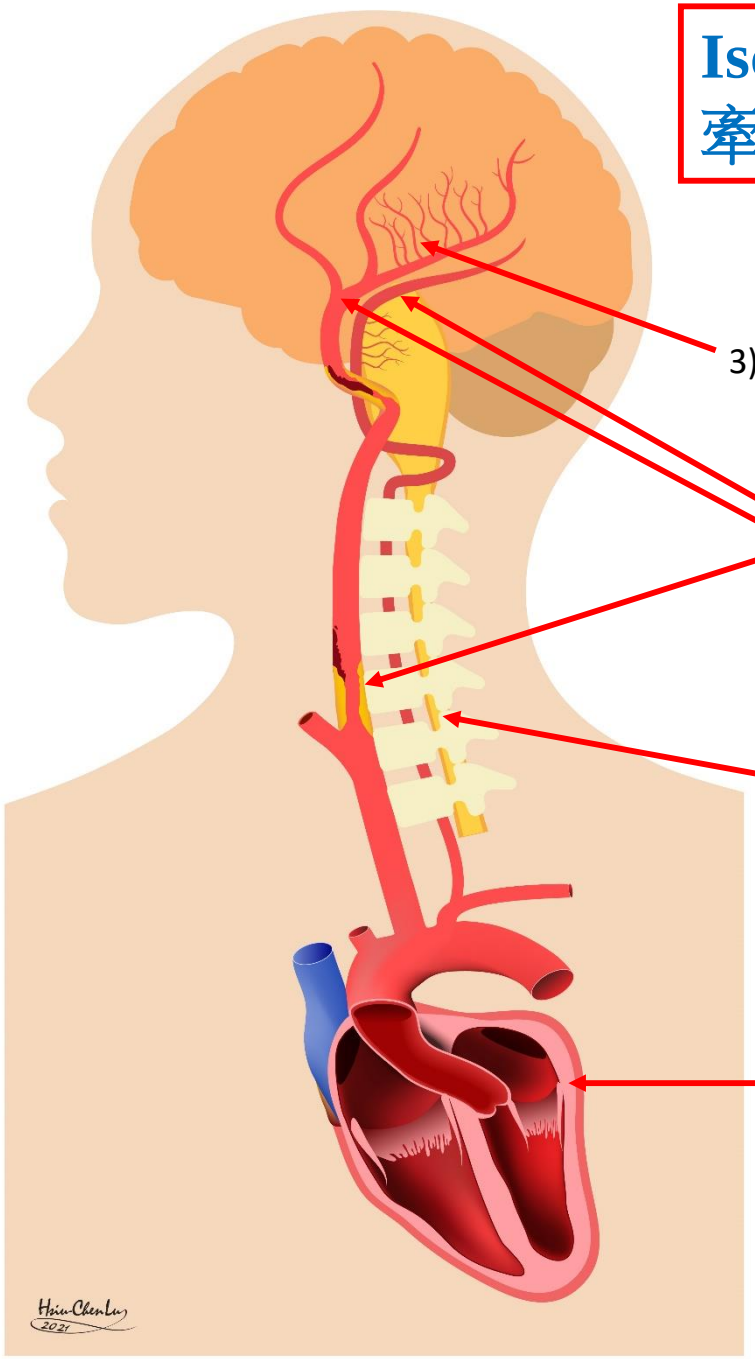
(1) occlusion of an intracranial vessel by an embolus that arises at a distant site (e.g., cardiogenic sources such as atrial fibrillation or artery-to-artery emboli from carotid atherosclerotic plaque), often affecting the large intracranial vessels;

(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.

Ischemic Stroke
牽涉到的 arteries



3) Small vessel (lacunar stroke)---

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

4) Others:
Arterial dissection

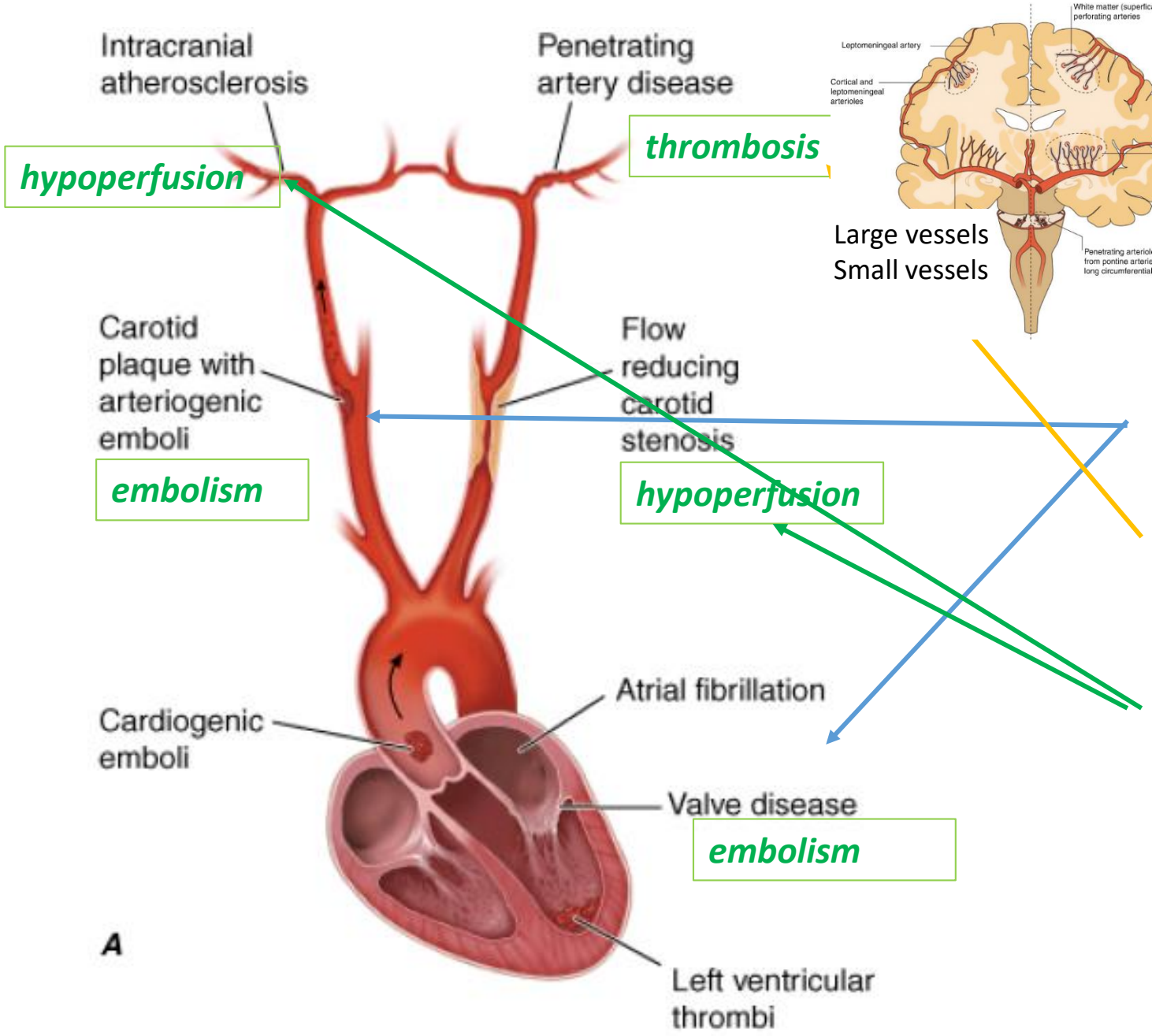
2) Cardioembolic
AF, Mural thrombosis
MI, Dilated myopathy
Valve disease
Bacterial endocarditis

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

Large arteries
Intracranial arteries
-- 本身 atherosclerosis (thrombosis, stenosis , occlusion)
-- 被堵塞 (embolism)

Extracranial arteries (thrombosis, stenosis. dissection, artery to artery embolism)
Carotid artery, vertebral artery.
Aorta
Subclavian artery

Small vessels
-- 本身 arteriosclerosis (lacunar infarction)
-- 被堵塞 (embolism)



引用 Harrison 的圖表說明
brain infarction的pathophysiology
三個mechanisms

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.

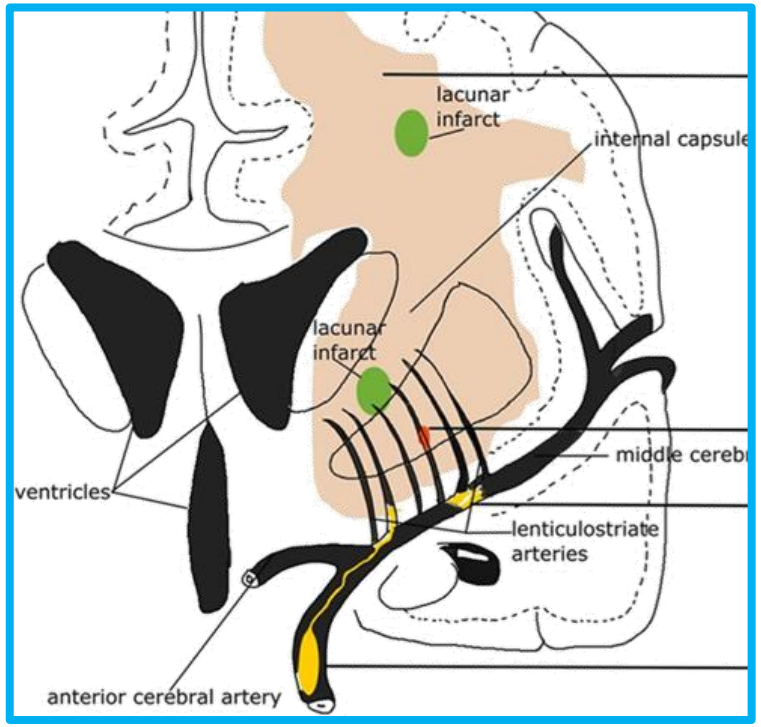
TOAST 3. Small vessel occlusion

Small artery occlusion: 3 mechanisms

A. Lipohyalinosis (small vessel mechanism)

B. Atherosclerosis of the parent artery (branched artery disease. BAD}

C. Embolization from proximal artery or heart



2022年最新版 **UpToDate** 對lacunar infarcts的病因 (etiology) 分為

(1) 高血壓引起的小血管病變 (hypertensive microangiopathy)

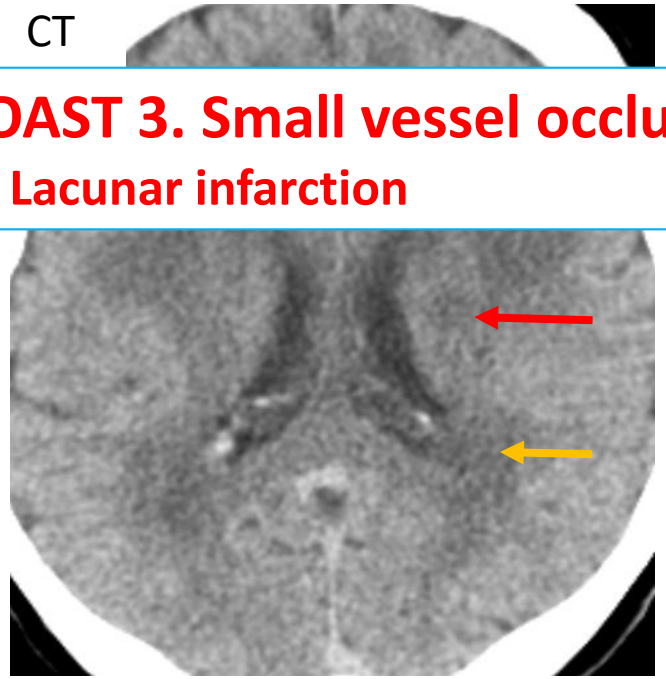
(2) 分枝動脈粥樣硬化 (branch atheromatous disease)，上游血管動脈硬化之斑塊堵住 penetrating artery 開口

(3) 栓塞 (embolism) ，來自心臟或大動脈的小血栓。

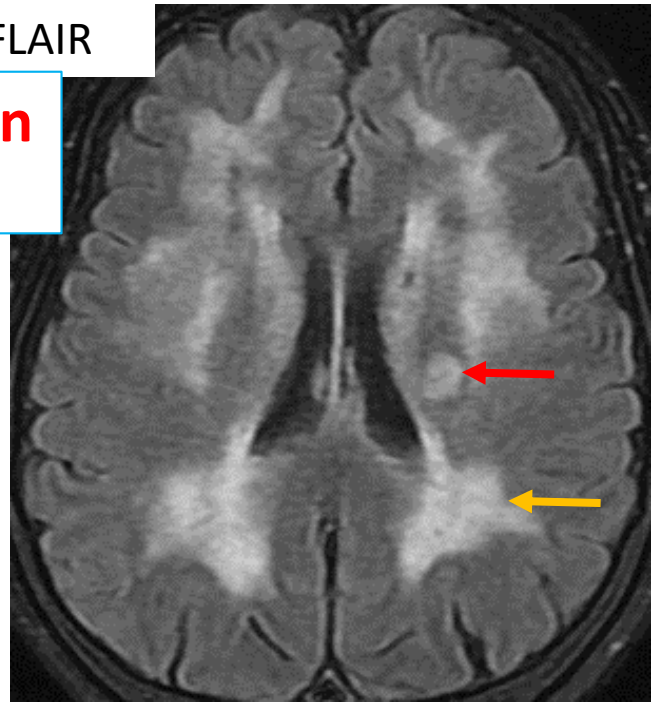
TOAST 3. Small vessel occlusion

A. Lacunar infarction

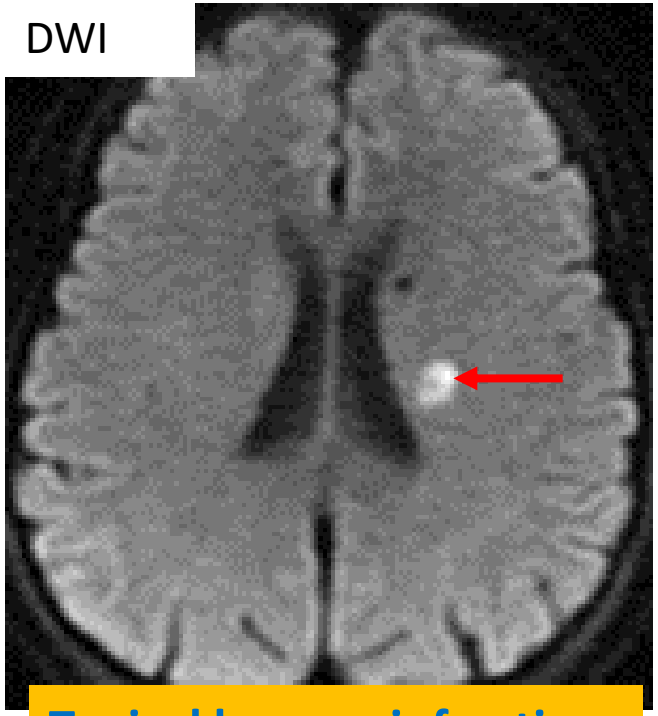
CT



FLAIR

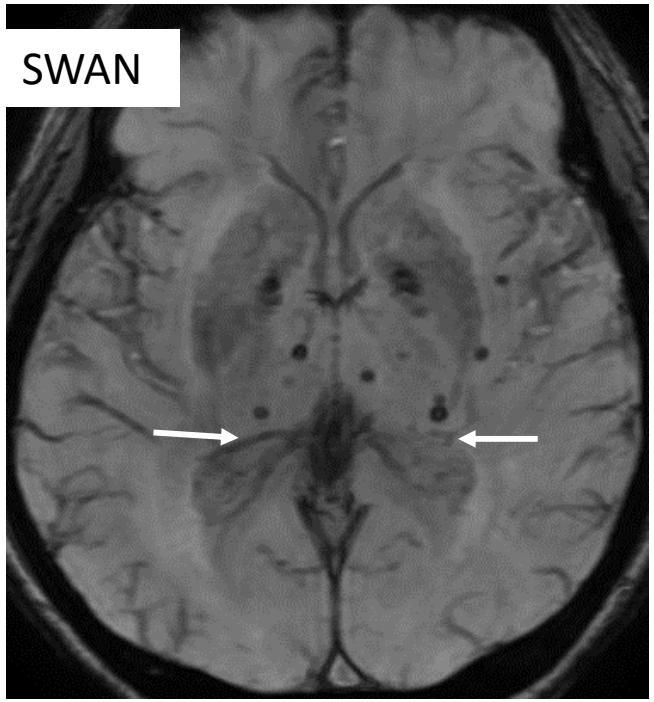


DWI

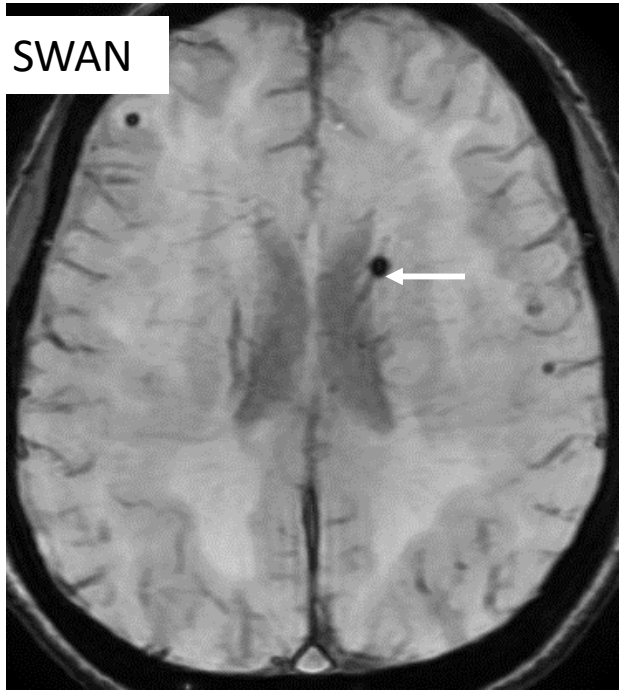


Typical lacunar infarction: Small vessel mechanism

SWAN



SWAN

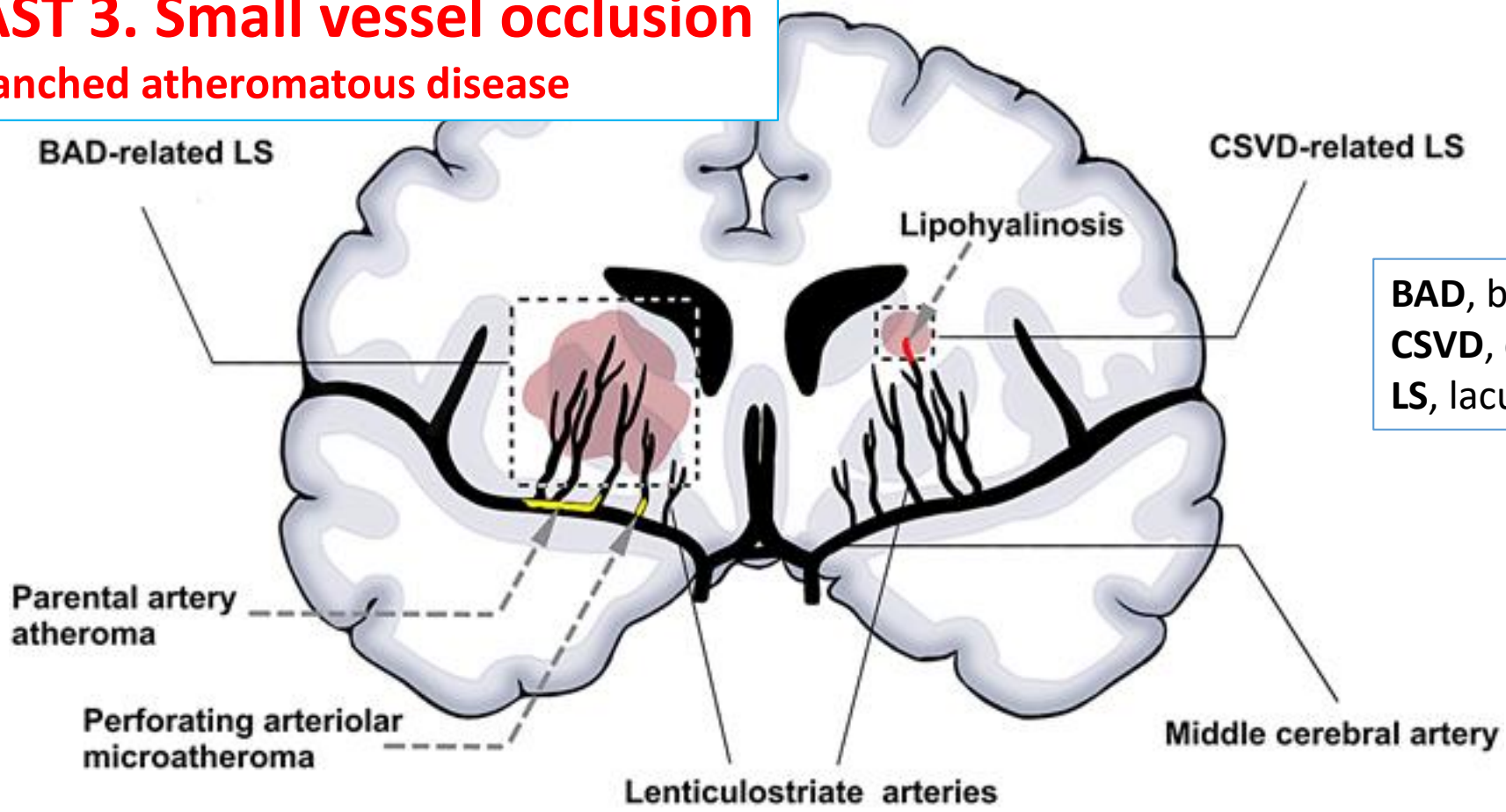


女/66歲　腦小血管疾病(small vessel diseases)與急性微小梗塞(acute lacunar infarction).

慢性高血壓病人，因右側肢體無力，疑是腦中風。

TOAST 3. Small vessel occlusion

B. Branched atheromatous disease



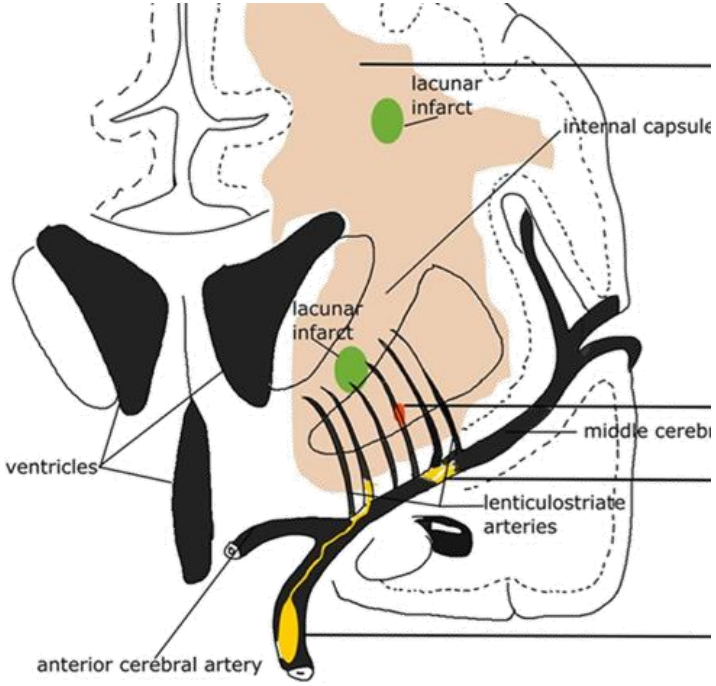
BAD, branch atheromatous disease;
CSVD, cerebral small vessel disease;
LS, lacunar stroke;

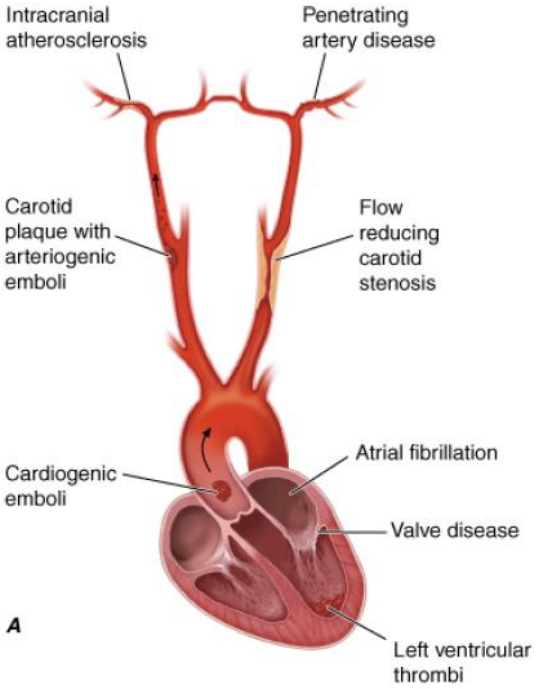
Fig. 2. Schematic diagram for mechanisms of BAD-related and CSVD-related LS in MCA territory. BAD-related LS is considered to be caused by parental artery atheroma (yellow) blocking the orifices of LSAs or microatheroma (yellow) at the proximal portion of the LSA itself. CSVD-related LS is described as lipohyalinosis (red) at the distal end of the perforating artery.

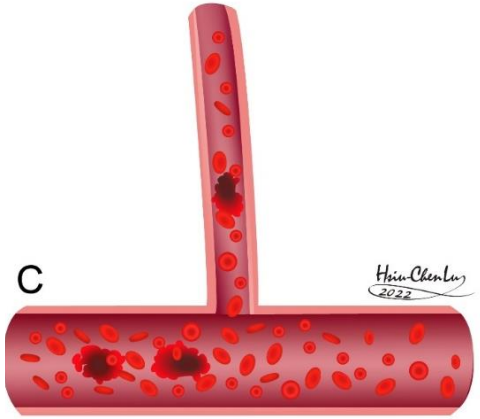
Jiang S et al: Advances in understanding the pathogenesis of lacunar stroke: from pathology and pathophysiology to neuroimaging. Cerebrovasc Dis. 2021

TOAST 3. Small vessel occlusion

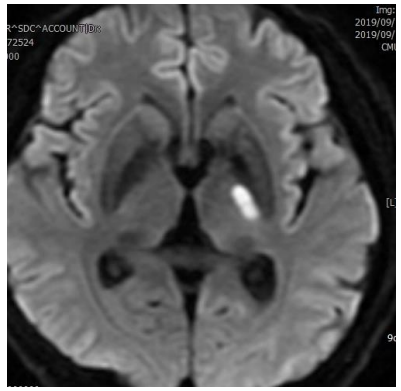
C. Embolism

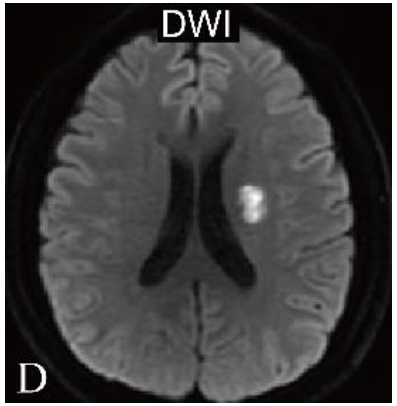






C. Embolism
Embolus from
Atheromatous plaque of parent artery
Carotid artery
Aorta
Heart





TOAST 2. Cardioembolism or cardio-aortic embolism

Embolic occlusion:

Artery-to-artery
- Carotid bifurcation
- Aortic arch

Cardioembolic
- AF
- Mural thrombosis
- MI
- Dilated myopathy
- Valve disease
- Bacterial endocarditis

Harrison, Table 370-2

Emboli 除了 from cardiac sources
另外再加 aortic sources
Artery to artery

UpToDate:

Embolism — Embolic strokes are divided into four categories :

Cardiac

Possible cardiac or aortic source based upon transthoracic and/or transesophageal echocardiographic findings

Arterial source (artery to artery embolism)

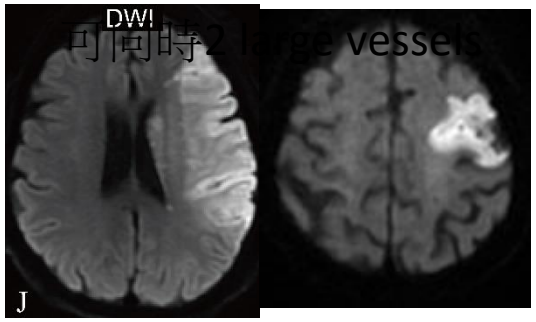
Truly unknown source in which tests for embolic sources are negative

TOAST 2. Cardioembolism

A. Large vessel occlusion-

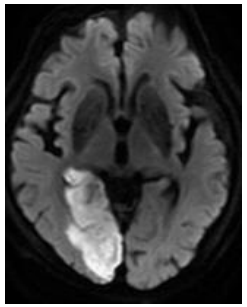
Infarction area: in whole or partial territory of a larger artery, cortex/subcortex, 很高比例combine with hemorrhagic transformation
可同時2 large vessels occlusion

CT:
Early signs of infarction

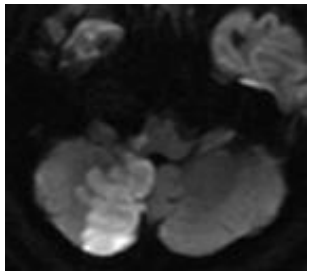


MCA infarction

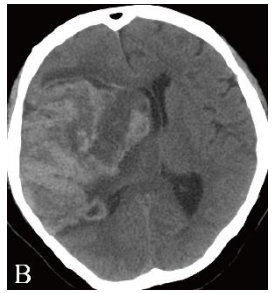
1/3 of MCA



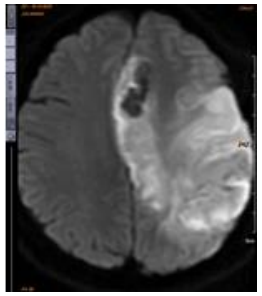
PCA infarct



PICA infarct

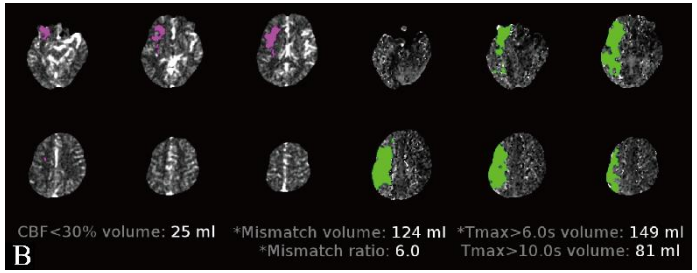


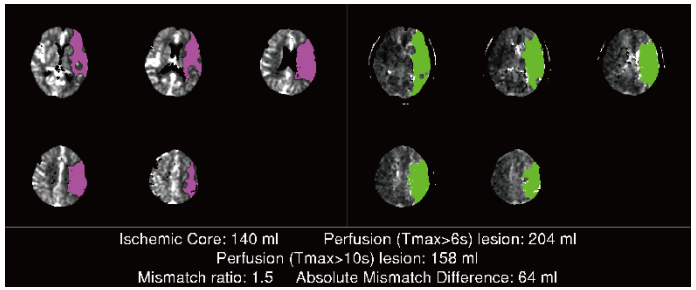
hemorrhagic transformation



ACA & MCA infarctions

CT-perfusion: core 隨著時間分分秒秒增長



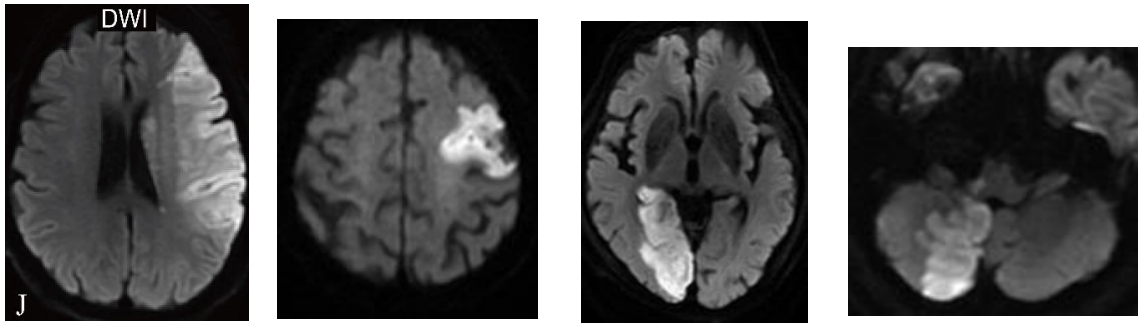


IA thrombectomy: 很快取出thrombus

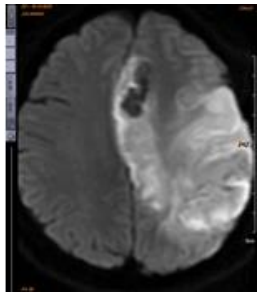
CTA, MRA, DSA: all other main arteries may be normal.

TOAST 2. Cardioembolism----小總結

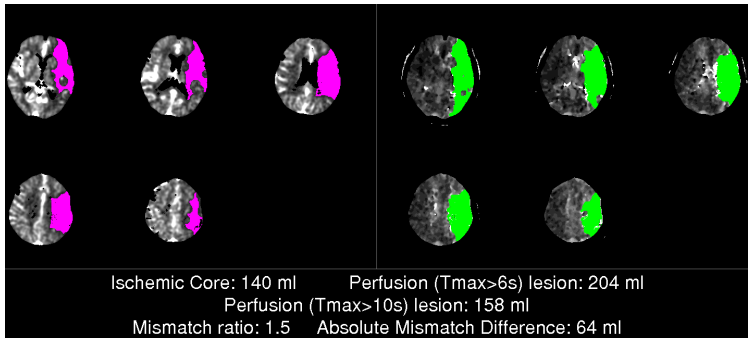
A. Large vessel occlusion- Image: in whole or partial territory of larger artery, cortex/subcortex, 很高比例combine with hemorrhagic transformation
可同時2 large vessels occlusion



Hemorrhagic transformation

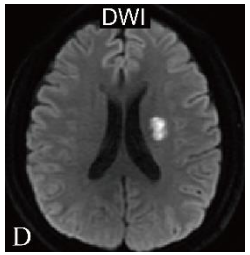


2 large vessels infarctions

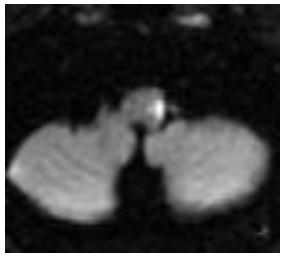


CT-perfusion: core 隨著時間分分秒秒增長

B. Small vessel occlusion– phenotype lacunar infarction

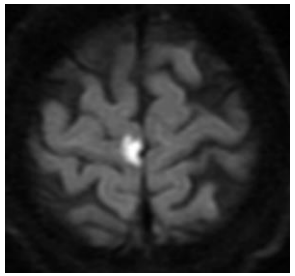


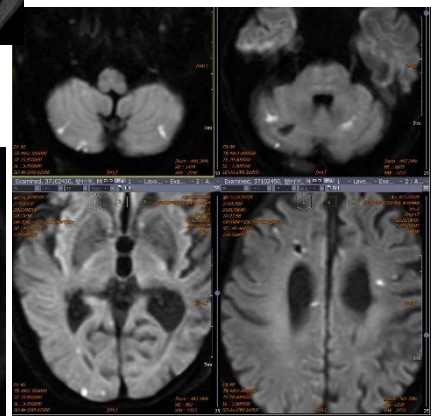
Lacunar infarct

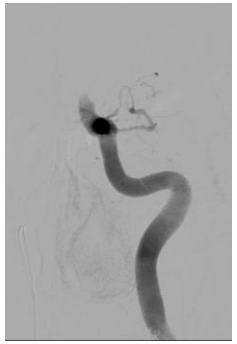


No other small vessel diseases

C. Scattered small infarctions



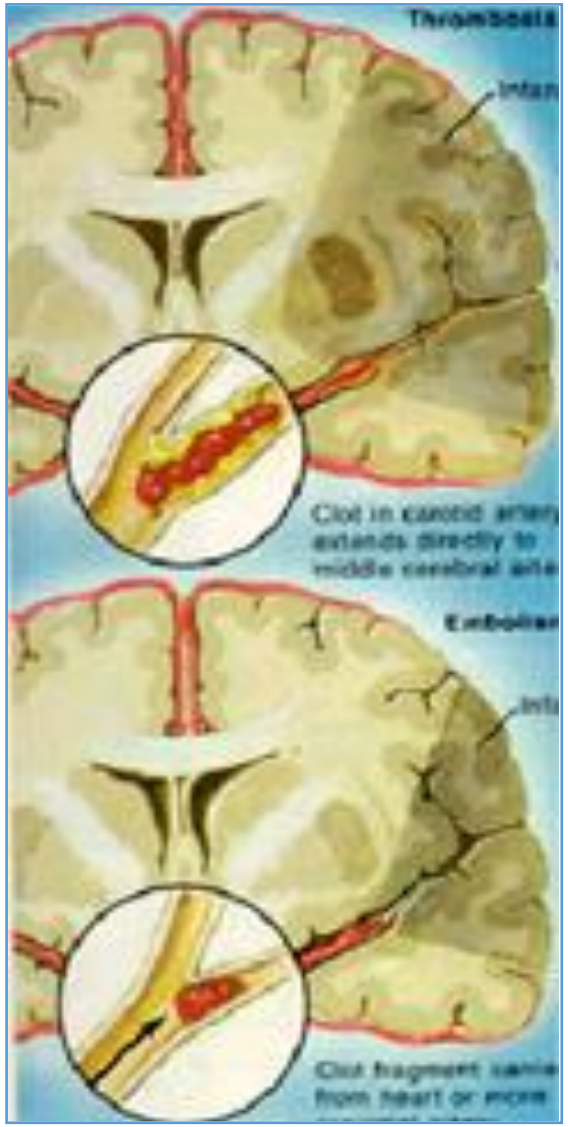


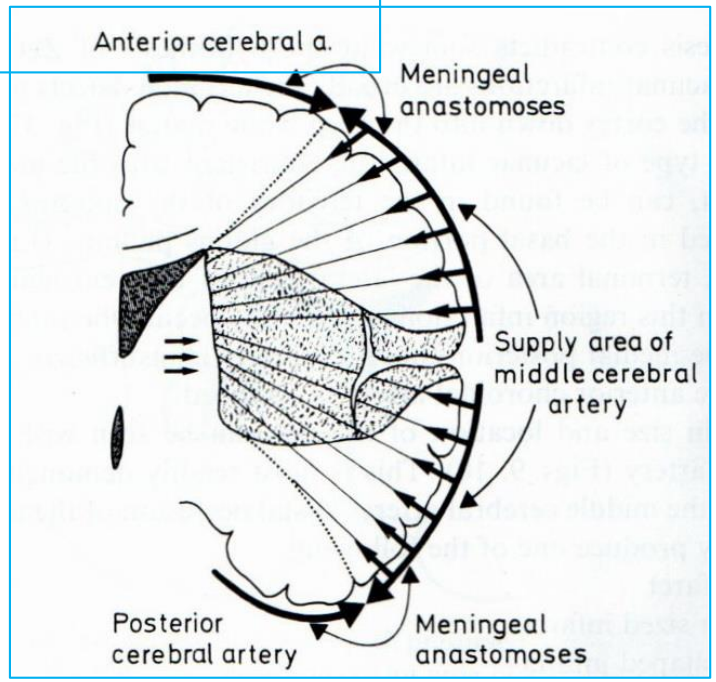


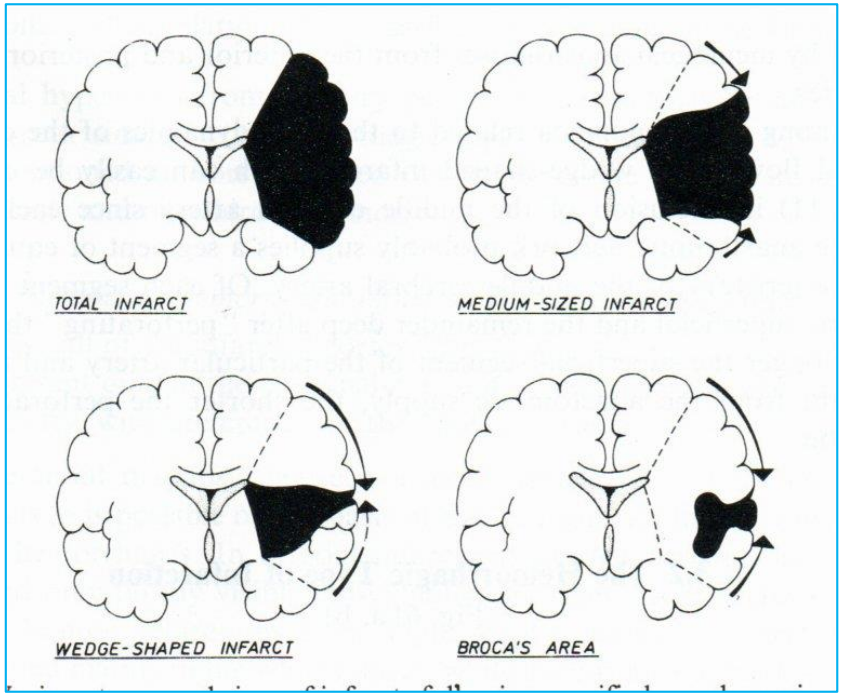
IA thrombectomy: 很快取出thrombus
CTA, MRA, DSA: all other main arteries may be normal.

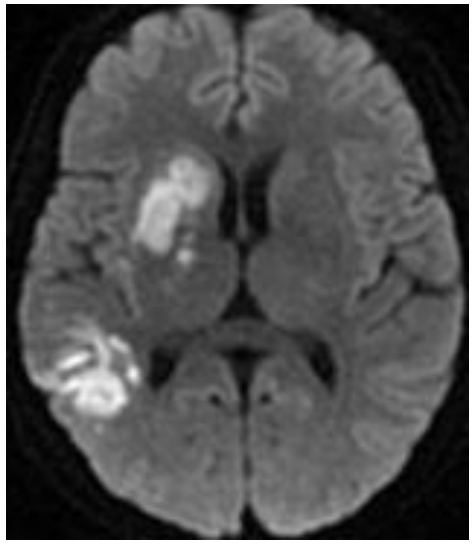
TOAST 1. Large artery atherosclerosis

A. thrombotic infarction



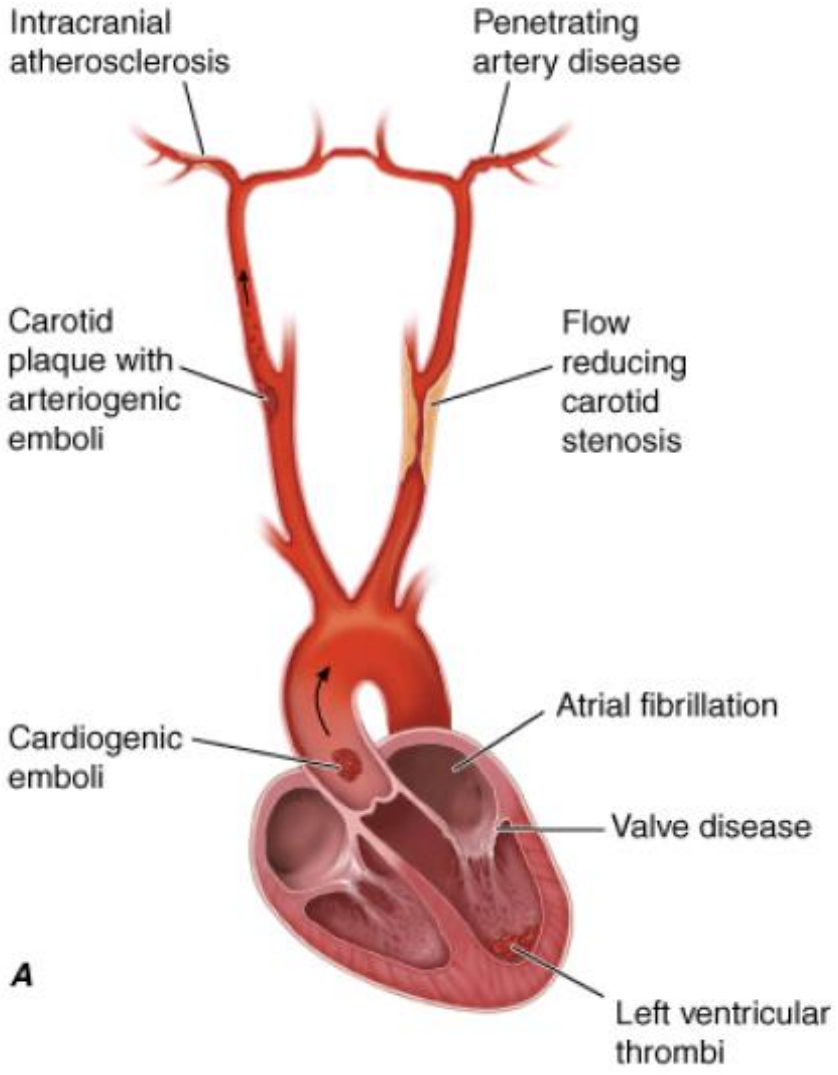






TOAST 1. Large artery atherosclerosis

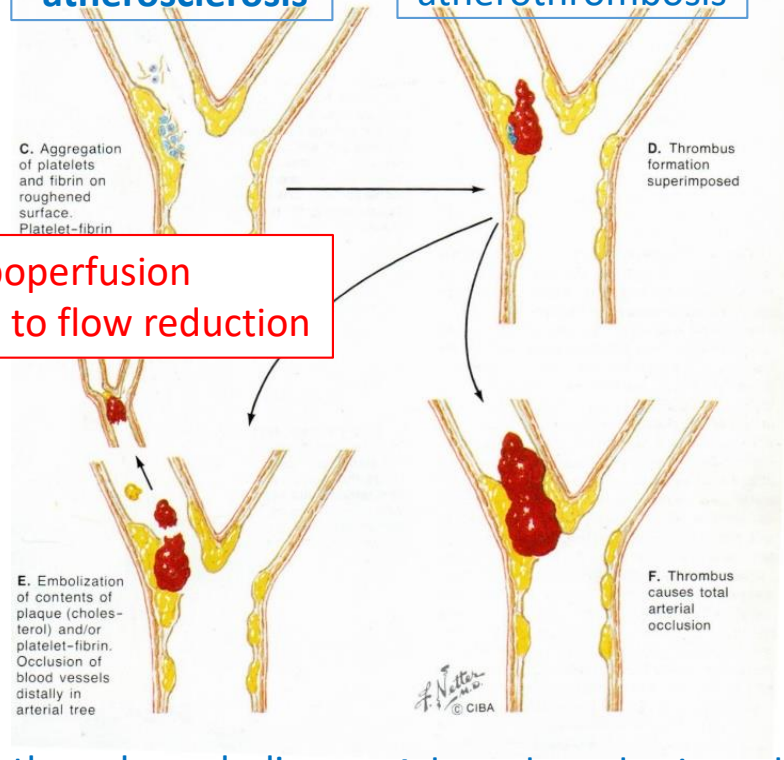
B. hypoperfusion



Harrison:

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

atherosclerosis | atherothrombosis



Hypoperfusion due to flow reduction

atherothromboembolism

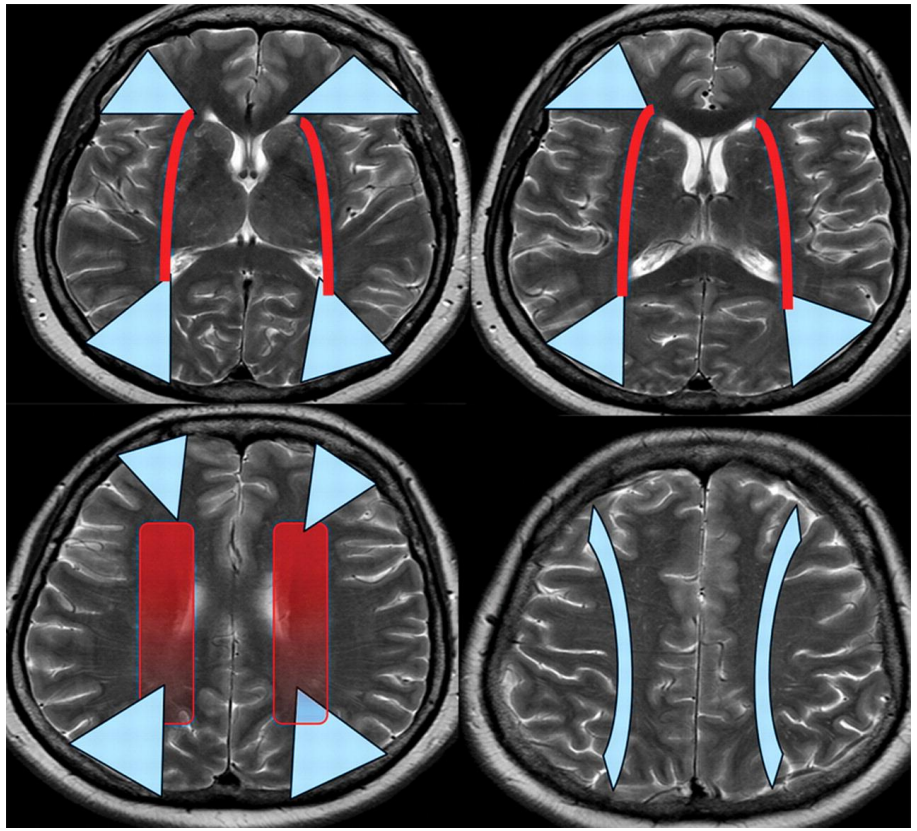
embolism

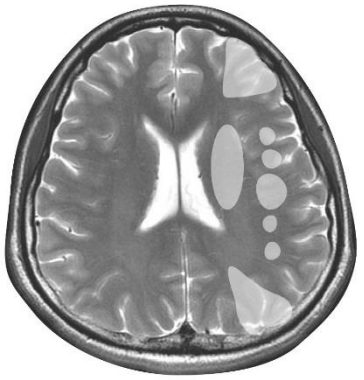
Atherothrombotic occlusion

thrombotic infarction

TOAST 1. Large artery atherosclerosis

B. hypoperfusion





Border zone infarction

一 皮質型(cortical)或外在型(external) 。皮質型的梗塞常位於ACA、MCA，或MCA、PCA之分界間，呈三角形(triangular shape)。

二 皮質下型(subcortical)或內在型(internal)。 Internal border zone infarct主要發生在半卵圓中樞(centrum semiovale)及放射冠(corona radiata) 。
皮質下型梗塞有二種形狀，
一是念珠狀(rosary-like)，一連串小梗塞
二是融合型(confluent)

三 混合型(mixed type)，皮質型及皮質下型同時存在。

Figure 1 Color overlays on axial T2-weighted magnetic resonance (MR) images of normal cerebrum show probable locations of
external (blue) and internal (red) border zone infarcts.

RSNA
RadioGraphics

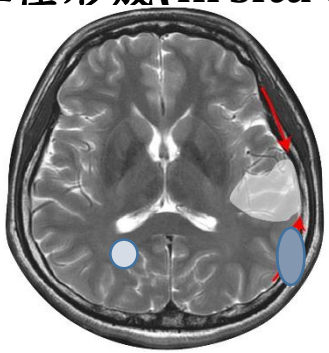
Mangla R. : Border Zone Infarcts: Pathophysiologic and Imaging Characteristics
2011 https://doi.org/10.1148/rg.315105014

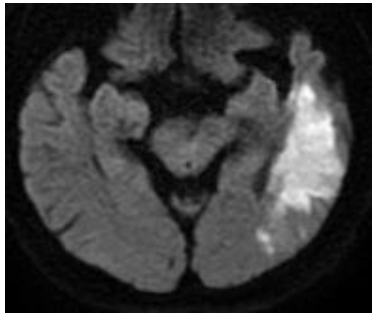
小總結:

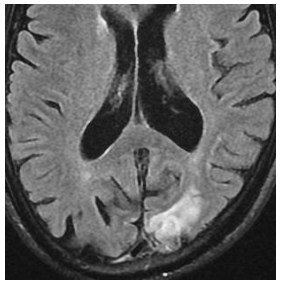
TOAST 1. Large artery atherosclerosis

顱內動脈原位血栓形成(in situ thrombosis)

Thrombosis

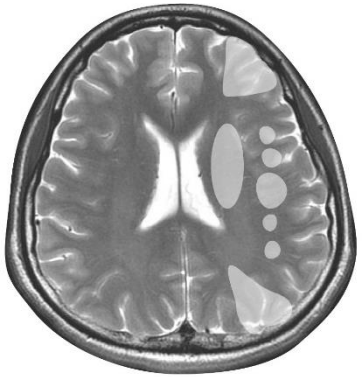


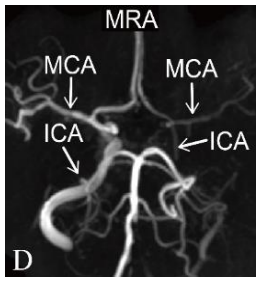


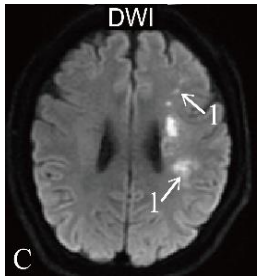


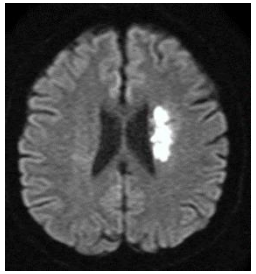
灌流不足(hypoperfusion)= watershed infarction

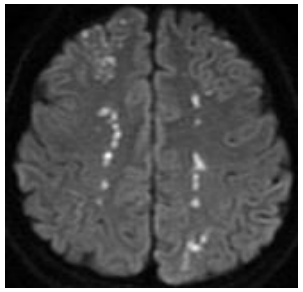
Hypoperfusion







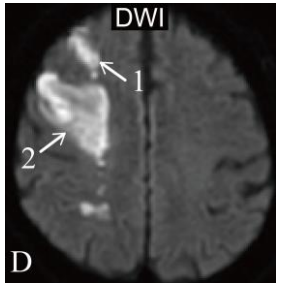




ICA atherosclerosis

動脈硬化血栓形剝落栓塞(thromboembolism)

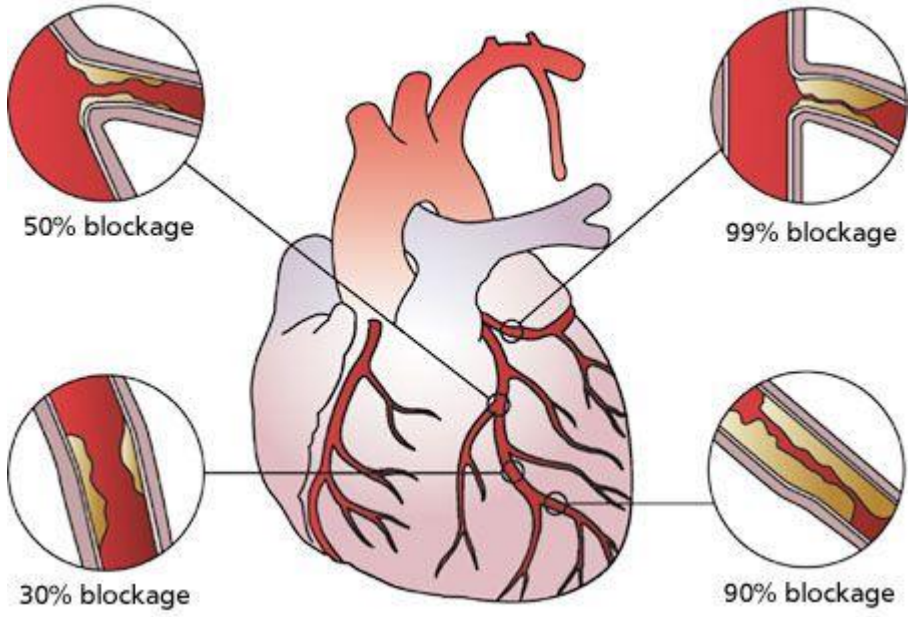
Embolism



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)