Imaging Anatomy of the Basal Perforating Arteries: Extent and Location of Cerebral Infarcts on Multiplanar MR Images

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Non-invasive demonstration of the basal perforating arteries remains difficult, although they are clinically important vessels.
Outline

1. Anatomy of basal perforators and infarct distribution:
   A. Striate arteries
   B. Anterior choroidal artery
   C. Thalamic arteries
   D. Arterial supply of corona radiata

2. Delineation of the perforators by 3-T MRI
1. **Anatomy of basal perforators and infarct distribution:**
   - A. Striate arteries
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2. **Delineation of the perforators by 3-T MRI**
Diagram of the basal perforating arteries

The perforators may be divided into 3 groups

(Adapted from Aitken HF, 1928)
Basal perforators of the cerebrum

A. Striate arteries
   - Medial striate arteries (MSA) from ACA
   - Lenticulostriate arteries (LSA) from MCA
   - Perforators from ACoA

B. Anterior choroidal artery (AChA) group
   - Perforators from AChA (AChA-p)
   - Perforators from internal carotid artery (ICA-p)

C. Thalamic arteries
   - Thalamotuberal arteries (TTA)
   - Thalamoperforate arteries (TPA)
   - Thalamogeniculate arteries (TGA)
   - Medial posterior choroidal artery (MPChA)
   - Lateral posterior choroidal artery (LPChA)
A. On coronal microangiograms, the MSAs, arising from the A1 segment and the recurrent artery of Heubner (RAH), supply the antero-inferior basal ganglia.

B. On slightly more posterior section, the LSAs arise from the M1 segment of the MCA and pass the putamen, internal capsule, and eventually reach the caudate nucleus along the lateral ventricle, thus supplying a larger postero-superior basal ganglia.
The **MSAs** extend anterosuperiorly toward the frontal horn, while the **LSAs** assume the appearance of a fan with its pivot on the anterior perforated substance.
On axial microangiograms, the MSAs are typically distributed in the anteroinferior basal ganglia extending toward the lower frontal horn.

The LSAs are distributed to a larger posterior superior striatum and the internal capsule to reach the paraventricular region superiorly.
Clinical case with MSA infarct
Medial striate arteries
The infarct is just posterolateral to the inferior end of the frontal horn of the lateral ventricle (→).

Compare the extent of the infarct with the MSA distribution on microangiogram.
LSA infarct
Lenticulostriate arteries

skip
ACoA-p infarct
Perforators from ACoA: subcallosal artery
After surgery for anterior communicating artery (ACoA) aneurysm, Amnesia has been reported (Gade A, Surg Neurol, 1982)

- The complication occurred much more frequently in trapping cases than in neck ligation ones,
- Accordingly, Gade et al. speculated the symptom might be related to the involvement of the perforators from the anterior communicating artery.
Serizawa, et al. divided ACoA perforators into 3 groups

(Serizawa T, et al. Neurosurgery, 1997)

AC: Anterior commissure
CCr: Rostrum of corpus callosum
HpTh: Anterior hypothalamus
POA: Parolfactory area
PTG: Paraterminal gyrus
SbA: Subcallosal area
SeP: Septum pellucidum
3 groups of ACoA perforators
(Serizawa T, et al. Neurosurgery, 1997)

- **Subcallosal artery**
  - A single large branch (av. 0.5 mm)
  - Arise from posterior/posterosuperior aspect of the ACoA
  - Analogous to MACC (median artery of the corpus callosum) and Azygos ACA, but does not go beyond callosal genu
  - **Supplies:**
    - Septum pellucidum, Paraterminal gyrus, Subcallosal area
    - Anterior commissure, Column of fornix, Lamina terminalis
    - Rostrum & genu of corpus callosum

- **Hypothalamic branch**
  - Av. number: 3.2 (av. 0.19 mm)

- **Chiasmatic branch**
  - Tiny branches (av. 0.1 mm)
A clinical example with amnesia developed after surgery for ACoA aneurysm, 39 year-old male

- Subarachnoid hemorrhage due to ruptured ACoA aneurysm
- Surgery
  - No neurological deficit after surgery
  - Postop. angiography disclosed small remaining of aneurysmal lumen
- Re-operation, which caused postoperative amnesia
- Admitted to our hospital 3 months later
The posterior end of septum pellucidum, i.e., column of fornix shows central hypointensity, indicating tissue damage
The inferior end of septum pellucidum, i.e., column of fornix shows central hypointensity
Amnesia due to basal forebrain involvement

- The amnesia may be caused by involvement of column of fornix, which is supplied by subcallosal artery, a perforator of ACoA

  - Fornix is a constituent of Papez circuit:

    Hippocampus → **fornix** → mammillary → thalamus → posterior cingulate

    ![Diagram](attachment:image.png)

    parahippocampal gyrus

Bilateral column of fornix lesions may be responsible for “this amnesia”.
Basal perforators of the cerebrum

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Basal perforators of the cerebrum

- (A) Striate arteries
- (B) Anterior choroidal artery (AChA)
- (C) **Thalamic arteries**
  - Thalamotuberal arteries (TTA): from PCoA
  - Thalamoperforate arteries (TPA): from P1
  - Thalamogeniculate arteries (TGA): from P2-3
  - Medial posterior choroidal artery (MPChA)
  - Lateral posterior choroidal artery (LPChA)
Thalamic arteries: perforators from PCoA and PCA

TTA: Thalamotuberal arteries from PCoA

TPA: Thalamoperforate arteries from P1

TGA: Thalamogeniculate arteries from P2-P3

MPChA: Medial posterior choroidal arteries

LPChA: Lateral posterior choroidal arteries
On the paramedian sagittal section of the brain,

The TTAs are seen to enter the tuber cinereum anterior to the mammillary (M), and the TPAs enter at the posterior perforated substance posterior to the mammillary (M).
**Contiguous sagittal microangiograms (1cm thick)**

**A.** Paramedian sagittal microangiogram shows the TTAs, which enter the tuber cinereum, ascend in hypothalamus, and extend to the anterior thalamus. The TPAs traverse posterior perforated substance just posterior to M and are distributed within the central thalamus.

**B.** On more lateral sagittal microangiogram, the TGAs are seen to enter the brain at the geniculate bodies, and course superoanteriorly to supply postero-lateral thalamus.
Coronal contiguous microangiograms (1cm thick)

- A. Coronal microangiogram through crural PCA (↑) shows that the TPA ascends along the third ventricular wall, then diverge superolaterally into thalamus.
- B. On microangiogram through ambient PCA, the TGAs are seen to enter brain in between medial and lateral geniculate bodies and forms a large capillary blush in lateral thalamus.
- Medial and lateral narrow blushes are dorsally formed by medial (MPChA) and lateral (LPChA) posterior choroidal arteries, respectively.
Axial microangiograms show the **TTA** in the hypothalamus and anterior thalamus, the **TPA** in the medio-central part of thalamus along the third ventricular wall, the **TGA** in the lateral posterior thalamus.

- Medial and lateral posterior choroidal arteries (**MPChA** & **LPChA**) are also seen.
TTA infarct
Thalamotuberal arteries
TPA infarct
Thalamoperforate arteries
**TPA infarct:** 57-year-old woman with disorientation about locations and time.

- Axial (A), coronal (B), and sagittal (C) contrast-enhanced T1WI show enhanced lesions in both thalami (→) along the third ventricular wall.

- Note that the TPA infarction often involves **both thalami**.
TPA infarct often involves both thalami

- Bilateral lesions are explained by involvement of the artery of Percheron (1973), a normal variant.
- The dominant TPA bifurcates in the cistern and supplies thalami bilaterally
TGA infarct
Thalamogeniculate arteries
TGA infarct: 65-year-old woman with Dejerine-Roussy syndrome (right hypesthesia, right hemiparesis, and left cerebellar ataxia)

- T2WIs reveal an infarct in posterolateral part of thalamus.
- This infarct may cause classical thalamic syndrome = Dejerine-Roussy syndrome
TGA infarct

- VAG shows stenosis of right ambient PCA (→), and indicates ischemia in the distribution of TGA.
- Compare infarct with capillary blush of TGA on microangiogram.
1. Anatomy of basal perforators and infarct distribution:
   A. Striate arteries
   B. Anterior choroidal artery
   C. Thalamic arteries
   D. Arterial supply of pyramidal tract

2. Delineation of the perforators by 3-T MRI
The posterior limb of the internal capsule is supplied by the AChA inferiorly, while more superiorly by the LSA.
Vascular supply of the pyramidal tract

- Projecting from the cortex down to the brainstem, the pyramidal tract passes through the corona radiata and internal capsule.

- The tract is fed by medullary arteries from M4 and M3 segments, superiorly.

- Next, by long insular arteries from M2 segment at the corona radiata,

- More inferiorly at the superior internal capsule, by the LSAs from M1 segment.
Coronal & axial microangiograms

Coronal image:
- Orange arrows: Medullary arteries (M3 & M4)
- Pink arrow: Insular arteries (M2)

Axial image:
- Orange arrows: LSAs
Arterial supply of the pyramidal tract

< From the upper side >

(1) **Medullary arteries** (M4 & M3): Centrum semiovale & corona radiata

(2) **Long insular arteries** from the M2: Corona radiata

(3) **LSAs**: Upper part of the internal capsule

(4) **AChA**: Lower part of the internal capsule
How about clinical relevance of medullary and long insular arteries?
Glioblastoma in right opercular region (1)

- Contrast-enhanced T1WI (3D-SPGR) shows an enhancing tumor in right opercular region straddling the central sulcus (→), which was excised and turned out to be glioblastoma.

- At surgery, meticulous care was paid to preserve the cortical arteries including central sulcus artery, thereby trying to avoid injury to the pyramidal tract.
 However, the patient developed left hemiplegia, postoperatively.

Postoperative MR images show an infarct adjacent to the removal cavity (↓).
· Coronal DWI with motion probing gradient in AP direction indicates that the right pyramidal tract is involved (↓).

· This is apparently caused by damage to medullary arteries (▲) and long insular arteries (▲) from the MCA.

· Thus, we should recognize that resection of insulo-opercular gliomas can cause a corona radiata infarct with injury to the pyramidal tract.

(Kumabe T, Takahashi S, et al. J Neurosurg. 2007)
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Normal cases
Paging of contrast-enhanced coronal SPGR shows a series of perforators in the order from anterior to posterior.
Coronal SPGR with contrast media in normal cases

(1) from anterior

(2)

(3)

(4)

LSA

TPA

TGA
Sagittal SPGR also shows a series of perforators in the order from lateral to medial.
Sagittal contrast-enhanced SPGR in normal cases
Tumor cases
Non-enhancing tumor in insula-basal ganglia region in a 32-year-old male

Gd-T1WI show a non-enhancing tumor centered in left insula and basal ganglia, which revealed to be anaplastic ganglioglioma.

Gd-T1WI
Non-enhancing tumor in insula-basal ganglia region

- The movie of contrast-enhanced 3D-SPGR shows the courses of several LSAs (arrows) in relation to the tumor mass.
- The vessels are medially displaced by the tumor that is mainly fed by fine arteries from the insular MCA vessels (M2).

(Courtesy of Prof. Kumabe, Sendai)
Anaplastic ganglioglioma

(Courtesy of Prof. Kumabe, Sendai)

• With preoperative recognition of the course of the LSAs, they were well preserved at surgery.

• Postop. DWI show that the tumor was totally removed without developing a new lesion adjacent to the removal cavity.
Enhancing tumor in left temporal-basal ganglia in a 67-year-old male

Gd-T1WI show an enhancing tumor in left temporal-basal ganglia, which was proved to be glioblastoma.
Enhancing tumor in left temporal-basal ganglia

- **Contrast-enhanced 3D-SPGR** shows the courses of the LSAs in relation to the enhancing mass.

- The vessels are medially displaced by the tumor.

(Courtesy of Prof. Kumabe, Sendai)
Enhancing tumor in left temporal-basal ganglia
Glioblastoma: Gd-T1WI after surgery

- With preoperative recognition of the LSA course, preservation of the vessels was accomplished at surgery.

- The tumor was totally removed without developing infarction.
Normal anatomy and distribution of the basal perforators are reviewed.

Some of the perforators are observable in relation to pathologies using a 3T-MR system.

Treatment planning should be based on knowledge of vascular anatomy and preoperative recognition of relationship between vessels and a lesion.