Neuroimaging for Mechanical Thrombectomy in Early- and Late-Window Ischemic Stroke:

What the On-Call Radiologist Needs to Know

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Ischemic Stroke

Reperfusion Methods

Stroke Imaging Checklist

1. Is there a small **core infarct**?
2. Is there a **large-vessel occlusion**?
3. Is there **salvageable brain**?
4. Is there **hemorrhage**?

Core Infarct
Assess with:

- Non-contrast CT
- ASPECTS
- CBF $<30\%$
- DWI

Large-Vessel Occlusion (LVO)
Assess with:

- CT Angiography
- MR Angiography

Salvageable Brain (Penumbra)
Assess with:

- Clinical Mismatch⁸
- Collateral Scoring⁹
- Perfusion: Target-Mismatch Profile¹⁰ (Tmax $>6s$ volume minus core infarct volume)

Hemorrhage
Assess with:

- Non-contrast CT
- Susceptibility Weighted Imaging (GRE)

Early-Window Assessment (≤ 6 Hours)

***Perfusion** imaging is **not required** for the evaluation of **early-window** patients.¹¹

1. Clinical Mismatch:

- High NIHSS without a large **core infarct** suggests cortical involvement, which in the **early-window** implies a large **penumbra**, therefore a **clinical mismatch** and a good ET candidate.
- Minimalist approach which may use only NCCT and CTA.
- Example provided of patient presenting 5 hours after symptom onset.

2. ASPECTS:

- **Alberta Stroke Program Early CT Score**.
- Semi-quantitative measure of **core infarct** size on NCCT and is only validated for patients with **middle cerebral artery occlusions**.
- **10-point scale** for each named region (schematized to the right).
- Subtract 1 point for each affected region; **ASPECTS ≤ 6** suggests **large core infarct** and is predictive of poor ET outcomes.¹³

3. Collateral Scoring:

- Collateral grading is based on the degree of retrograde flow from pial vasculature toward the site of occlusion.⁹
- Collateral status suggests the likelihood of **core infarct** progression (poor collaterals) or **penumbral** preservation (good collaterals).
- Derived from **CTA**, but more reflective of the **penumbra**.

4. CT or MRI Perfusion:

- Perfusion imaging is a unifying technique: the assessment of both **early-window** and **late-window** stroke is the **same**. Use of perfusion is discussed in detail below.
- Perfusion-based thrombectomy criteria:^{5,10}
 1. **Core infarct volume <70 mL.**
 2. **Proximal large vessel occlusion** (ICA, M1, or proximal M2 MCA segments).
 3. **Mismatch volume ≥ 15 mL and mismatch ratio ≥ 1.8 .**
 4. **No hemorrhage.**

✓ NCCT with **no/small core**.

• Estimate **large core** using: **ASPECTS ≤ 6** or **$>1/2$ MCA territory**

CTA with **occlusion** of the proximal M1 segment of the right MCA.

✓ **LVO**

Presenting NIHSS = 17 suggests **large penumbra** and **clinical mismatch** given **no/small core** on NCCT and **proximal LVO** on CTA

• **Cortical signs** (aphasia/neglect) and/or **NIHSS $>7-10$** most predictive of LVO.¹²

✓ NCCT with **no intracranial hemorrhage**.

C = Caudate
L = Lentiform nucleus
I = Insula
M1-M3 = Lower MCA territory
M4-M6 = Upper MCA territory

• Subtract 1 point for each region which appears acutely infarcted (hypoattenuation with loss of gray-white differentiation, early edematous change, no focal volume loss).

• No points subtracted for chronic changes (leukoariosis, encephalomalacia).

• Poor inter-observer reliability.

• Three separate patients each with **occlusions** of the proximal M1 segment of the left MCA but different **collateral grades**:

• **Poor collaterals** = more rapid **core infarct** progression.

• **Good collaterals** = slow **core infarct** progression.

Poor collaterals:
• No or minimal distal territory flow.
• Extensive pruning of the distal vasculature.

Moderate collaterals:
• Flow from the periphery into the Sylvian fissure.
• Moderate distal vascular pruning.

Good collaterals:
• Retrograde flow near to the site of occlusion.
• Minimal pruning of the distal vasculature.

NCCT CBF $<30\%$ DWI

✓ **Small Core Infarct**

CTA MRA

✓ **Proximal LVO**

CTP: Tmax $>6s$ MRP: Tmax $>6s$

✓ **Target-Mismatch Profile**

NCCT GRE

✗ **Hemorrhage Present**

***Perfusion** imaging is **necessary** for evaluation of all **late-window** patients (level 1A evidence).¹¹

Late-Window Assessment (6-24 Hours)

Practical Perfusion Imaging Primer:

Technique:

1. Deliver contrast bolus.
2. Rapid acquisition of 10-20 slices at 5mm thickness through the same slab 10 times.
3. This allows dynamic imaging of the contrast as it transits from the arterial to parenchymal to venous phases.
4. Postprocessing software to calculate **perfusion maps**.

• **CBF**: Cerebral blood flow

Volume of blood moving through a unit volume of brain per unit time (mL/100g/min).

• **CBV**: Cerebral blood volume

Volume of blood in a given unit volume of brain (mL/100g).

CBV <2 mL/100g is suggestive of **core infarct** on CT; but may decrease with any edema.

• **MTT**: Mean transit time

Average of the transit time of blood through a given brain region (sec).

Delayed in both **acute infarct** and **penumbra**; relative **MTT $>145\%$** = **tissue-at-risk**.

• **Tmax**: Time-to-maximum

Time to maximum contrast enhancement within a given voxel (sec)

Delayed in both **acute infarct** and **penumbra**; **Tmax $>6s$** = **tissue-at-risk**.

Tmax $>4s$ = benign oligemia; **Tmax $>10s$** = suggestive of poor collaterals.

Target-Mismatch Profile
✓ **Excellent ET Candidate**

Matched infarct
No **tissue-at-risk** (**penumbra**)
Poor **collaterals** (Tmax $>10s$)
✗ **No thrombectomy**

Luxury perfusion to infarct following **recanalization** by tPA
✗ **No thrombectomy**

1. CT Perfusion:

- **NCCT** or **CBF $<30\%$** used for **core infarct** estimation.
- **NCCT** less sensitive; more specific.
- **CBF $<30\%$** may overestimate **core** but reduces false negative ET exclusion.

2. MR Perfusion:

- **DWI** is the gold standard for **core infarct** assessment.
- If contrast bolus is contraindicated, **arterial spin labeling (ASL)** can be used for **perfusion** assessment.

NCCT CBF $<30\%$

✓ **Small Core Infarct**

✓ **LVO**

CTA with **Right M1 Occlusion**

Tmax ✓ **Penumbra**

CTP with right MCA territory Tmax $>6s$ delay

MRP with left MCA territory Tmax $>6s$ delay

Tmax delay pattern predicts site of LVO¹⁴

ICA M1 Sup. M2 Inf. M2

✓ **NCCT with no hemorrhage**

✓ **Target-Mismatch Profile**

CBF $<30\%$ = 5mL; Tmax $>6s$ = 156mL

Mismatch volume = 151mL

Mismatch ratio = 31.2

✓ **DWI with Small Core Infarct**

✓ **LVO**

MRA with **Left M1 Occlusion**

✓ **Target-Mismatch Profile**

DWI volume = 11mL; Tmax $>6s$ = 96mL

Mismatch volume = 85mL

Mismatch ratio = 8.7

✓ **GRE with no hemorrhage**

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