Imaging Decisions in Vascular Disease

Dr. Dylan Blacquiere MD MSc FRCPC
Emergency Medicine Grand Rounds
May 10, 2016
Relevant Disclosures

- Grants/Research Support: Government of New Brunswick
- Speaker Bureau/Honoraria: None
- Consulting Fees: None

- I am not a radiologist
Objectives

• To discuss the decision making process around neuroimaging in the emergency department in neurovascular conditions
  • Acute ischemic stroke
  • Subarachnoid hemorrhage
  • Intracerebral hemorrhage

• To determine how that imaging is used to make appropriate clinical decisions
Case One

• It’s your first hour on shift in the ED. Right away you are called to see a 68 year old man who had a sudden witnessed collapse in a coffee shop, and was found to have right sided weakness of the face and arm with speech deficits
  • BP 176/91, pulse irregular
  • Dense right sided hemiplegia with expressive speech deficits
  • Glucose 6.8
  • Known history of HTN, dyslipidemia; on ASA and perindopril
Canadian Stroke Best Practice Recommendations: Hyperacute Stroke Care Guidelines, Update 2015

Canadian Stroke Best Practices

• All patients with suspected stroke should have:
  • **Immediate** noncontrast brain imaging (A)
  • **Vascular** imaging with CTA, including *intracranial and extracranial* arteries (A)

• Advanced imaging such as CTP can be considered if available, but **should not delay management** (B)

• Additional imaging such as MRI and MRA can be considered, but **should not delay management** (C)

Thick and thin section NCCT Protocol

Slice thickness: 5.0 mm
Slice thickness: 2.5 mm
Slice thickness: 1.2 mm

Courtesy A. Demchuk
Hyperdense Thrombus Length and recanalization

Stroke 2011 epub

Courtesy A. Demchuk
ASPECTS

- Non-contrast scan
- Score 0-10
  - 0 – complete wipeout
  - 10 – no early ischemic changes
- 8-10 – “good scan”
- 0-7 – “fair scan” or “bad scan”
  - Less benefit to tPA
  - Higher risk
<table>
<thead>
<tr>
<th>Scan Quality</th>
<th>NCCT</th>
<th>ASPECTS Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good scan</td>
<td>![Images of CT scans]</td>
<td>8-10</td>
</tr>
<tr>
<td>Fair scan</td>
<td>![Images of CT scans]</td>
<td>5-7</td>
</tr>
<tr>
<td>Poor scan</td>
<td>![Images of CT scans]</td>
<td>0-4</td>
</tr>
</tbody>
</table>

Courtesy A. Demchuk
NCCT/CTA now standard of care and should be performed sequentially while on CT table

Courtesy A. Demchuk
4.3 Endovascular therapy

i. Endovascular therapy should be offered within a coordinated system of care including agreements with EMS; access to rapid neurovascular (brain and vascular) imaging; coordination between the ED, the stroke team and radiology; local expertise in neurointervention; and access to a stroke unit for ongoing management [Evidence Level A].

ii. Endovascular therapy is indicated in patients based upon imaging selection with noncontrast CT head and CTA (including extracranial and intracranial arteries) [Evidence Level A]. See Appendix S4 for Inclusion Criteria for endovascular therapy.

iii. Eligible patients who can be treated within six-hours (i.e. whose groin can be punctured within six-hours of symptom onset) should receive endovascular therapy [Evidence Level A].
“Neurons over nephrons” in major stroke

Courtesy A. Demchuk
Intravenous Contrast Material Exposure Is Not an Independent Risk Factor for Dialysis or Mortality¹

“CIN” called into question

Propensity Score–adjusted Outcomes

<table>
<thead>
<tr>
<th>Data Set and Outcome</th>
<th>Contrast Group</th>
<th>Noncontrast Group</th>
<th>ORs and HRs*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire matched data set</td>
<td>10,673</td>
<td>10,673</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>AKI</td>
<td>515 (4.8)</td>
<td>544 (5.1)</td>
<td>0.94 (0.83, 1.07)¹</td>
<td>.38</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>25 (0.2)</td>
<td>27 (0.3)</td>
<td>0.96 (0.54, 1.60)¹</td>
<td>.89</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>850 (8.0)</td>
<td>875 (8.2)</td>
<td>0.97 (0.87, 1.06)²</td>
<td>.45</td>
</tr>
<tr>
<td>AKI risk groups⁵</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-risk group</td>
<td>7273</td>
<td>7273</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>7 (0.1)</td>
<td>8 (0.1)</td>
<td>0.88 (0.32, 2.41)¹</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>417 (5.7)</td>
<td>426 (5.9)</td>
<td>0.95 (0.83, 1.09)³</td>
<td>.44</td>
</tr>
<tr>
<td>Medium-risk group</td>
<td>2442</td>
<td>2442</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>7 (0.3)</td>
<td>7 (0.3)</td>
<td>1.00 (0.35, 2.86)¹</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>303 (12.4)</td>
<td>314 (12.9)</td>
<td>0.97 (0.83, 1.14)²</td>
<td>.64</td>
</tr>
<tr>
<td>High-risk group</td>
<td>958</td>
<td>958</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>11 (1.1)</td>
<td>12 (1.3)</td>
<td>0.92 (0.40, 2.09)¹</td>
<td>.84</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>130 (13.6)</td>
<td>135 (14.1)</td>
<td>0.93 (0.73, 1.18)³</td>
<td>.56</td>
</tr>
</tbody>
</table>

Statistics

<table>
<thead>
<tr>
<th>Data Set and Outcome</th>
<th>ORs and HRs*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire matched data set</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>AKI</td>
<td>0.94 (0.83, 1.07)¹</td>
<td>.38</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>0.96 (0.54, 1.60)¹</td>
<td>.89</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>0.97 (0.87, 1.06)²</td>
<td>.45</td>
</tr>
<tr>
<td>AKI risk groups⁵</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-risk group</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>0.88 (0.32, 2.41)¹</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>0.95 (0.83, 1.09)³</td>
<td>.44</td>
</tr>
<tr>
<td>Medium-risk group</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>1.00 (0.35, 2.86)¹</td>
<td>.79</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>0.97 (0.83, 1.14)²</td>
<td>.64</td>
</tr>
<tr>
<td>High-risk group</td>
<td>. . .</td>
<td>. . .</td>
</tr>
<tr>
<td>30-d dialysis</td>
<td>0.92 (0.40, 2.09)¹</td>
<td>.84</td>
</tr>
<tr>
<td>30-d mortality</td>
<td>0.93 (0.73, 1.18)³</td>
<td>.56</td>
</tr>
</tbody>
</table>

Courtesy A. Demchuk
CTA Utility in Clinical Practice

Clot: Occlusion site

Collaterals

Catheter access

Courtesy A. Demchuk
<table>
<thead>
<tr>
<th>Time from onset</th>
<th>iv tPA “sweet spot”</th>
<th>iv tPA modest net benefit</th>
<th>Conservative tx avoid tPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 90 min</td>
<td>90-180 min</td>
<td>180-270 min</td>
<td>&gt;270 min</td>
</tr>
<tr>
<td>all ages</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>normal</th>
<th>high</th>
<th>very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-10 11-21</td>
<td>&lt;5</td>
<td>&gt;21</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NIHSS</th>
<th>6-10 11-21</th>
<th>&lt;5</th>
<th>&gt;21</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>high</td>
<td>very high</td>
<td></td>
</tr>
<tr>
<td>6-10 11-21</td>
<td>&lt;5</td>
<td>&gt;21</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other intangibles</th>
<th>Asian</th>
<th>ASA+clopidogrel</th>
<th>INR&gt;1.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>none</td>
<td>few</td>
<td>severe</td>
</tr>
<tr>
<td>Leukoaraiosis/ microbleeds</td>
<td>Asian</td>
<td>ASA+clopidogrel</td>
<td>INR&gt;1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NCCT EIC/ DWI volume</th>
<th>ASPECTS 8-10</th>
<th>ASPECTS 5-7</th>
<th>ASPECTS 3-4</th>
<th>ASPECTS 0-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>&lt;18 cc</td>
<td>&gt;80 cc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occlusion location</th>
<th>MCAo - distal</th>
<th>no occlusion</th>
<th>ICAo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombus characteristics</td>
<td>Short thrombus/forward flow</td>
<td>Long/large</td>
<td></td>
</tr>
<tr>
<td>Severe ischemia</td>
<td>No regions</td>
<td>Large region(s)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occlusion location</th>
<th>MCAo - distal</th>
<th>no occlusion</th>
<th>ICAo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe ischemia</td>
<td>No regions</td>
<td>Large region(s)</td>
<td></td>
</tr>
</tbody>
</table>
Mechanical thrombectomy Ideal If

Carotid Occlusion

Proximal M1 MCA Occlusion

Courtesy A. Demchuk
**BASELINE CTA CEREBRAL COLLATERAL FLOW IS ASSOCIATED WITH**

Subgroup Analysis
According to Baseline NCCT/CTA Characteristics

<table>
<thead>
<tr>
<th>Example Criteria</th>
<th>Endovascular Tx</th>
<th>Medical Tx</th>
<th>Adjusted OR (95% CI) for mRS 0-2</th>
<th>Adjusted common OR (95% CI) (shift analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mRS 0-2</td>
<td>Total</td>
<td>mRS 0-2</td>
<td>Total</td>
</tr>
<tr>
<td>Collateral grade</td>
<td>post-hoc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 absent</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>1 poor</td>
<td>11</td>
<td>72</td>
<td>11</td>
<td>64</td>
</tr>
<tr>
<td>2 moderate</td>
<td>30</td>
<td>88</td>
<td>21</td>
<td>110</td>
</tr>
<tr>
<td>3 good</td>
<td>34</td>
<td>62</td>
<td>18</td>
<td>71</td>
</tr>
</tbody>
</table>

P-value of interaction with treatment effect on primary outcome for collateral score: 0.038!

Patients with abundant CCF showed a clear benefit of IAT. The effect of IAT was reduced in patients with lower quality of CCF, and disappeared with absent CCF.

Courtesy A. Demchuk
ESCAPE Imaging Selection Criteria:
Good scan, proximal occlusion, mod/good collaterals

aspectsinstroke.com

NCCT ASPECTS 6-10

CTA: ICA T or M1 occl

Single phase CTA: mod/good collaterals

or

1st 2nd 3rd phase

Multiphase CTA: mod/good collaterals

Courtesy A. Demchuk
Collateral Assisted ASPECTS

If ultraearly scan; lots of motion; old cortical infarcts; severe atrophy; severe leukoaraiosis.

Quick NCCT ASPECTS determination

Read CTA collaterals

Reread NCCT ASPECTS

Courtesy A. Demchuk
The growth rate of early DWI lesions is highly variable and associated with penumbral salvage and clinical outcomes following endovascular reperfusion.


---

**Initial Growth Rate in 65 Patients with Known Onset**

**Part 1 Analysis**

- Median Initial DWI Growth Rate: 3 ml/hr
- Range of Initial Growth Rates: 0-117 ml/hr
- **0.1-100 ml/hr**

---

*Courtesy A. Demchuk*
Best Practice Guidelines

• Patients should be assessed using the **ASPECTS score** looking for a **small-to-moderate** infarct core (ASPECTS 6 or higher) (B)

• **Thrombolysis**
  • If ASPECTS is less than 6 (large core), decision to treat should be made using **best clinical judgement** (B)

• **Endovascular**
  • There should be a **proximal occlusion** in the **anterior circulation** (A)
  • Strongly recommended to have **moderate-to-good** collaterals on CTA, or **perfusion-mismatch** on CTP (B)

ABCD2I

- Pooled analysis of >4500 patients
- Presence of infarction (old or new) on CT or MRI showed increased risk of recurrent stroke
- Independent association with stroke risk, regardless of ABCD2 score
  - Giles et al. Stroke 2010; 41: 1907
CATCH

- Prospective study of TIA/minor stroke
- All had acute CT/CTA
- CT/CTA positive metric: acute infarction OR occlusion/>50% stenosis of extracranial/intracranial vessel in relevant distribution
- Higher rates of recurrent stroke, 90-day disability
  - Coutts et al. Stroke 2012;43:1013
CATCH

Coutts et al. Stroke 2012;43:1013
Best Practice Guidelines

• Patients presenting within **forty-eight hours** of onset with **motor or speech symptoms** should be seen the same day in an **emergency department** with access to **advanced stroke care** (C)
  • Urgent **neuroimaging**, including **noninvasive vascular imaging**, should be completed without delay (B)

• All patients being evaluated for TIA or minor stroke should have **neuroimaging of the brain** and **noninvasive vascular imaging of the carotid arteries** (B)
  • **CTA** at time of initial CT is **most efficient**, though alternatives may be used (C)
  • Allows for more **comprehensive evaluation** of vasculature (B)
  • **Intracranial and extracranial** imaging should be performed if CTA/MRA done (C)

Case Two

• On a roll now, you are called to see a 37 year old woman presenting with a severe headache.
  • She describes it as the worst headache of her life; came on suddenly while grocery shopping three hours before
  • Never happened before, no history of migraine or other significant headaches
• Currently appears uncomfortable, with neck stiffness, light sensitivity and fatigue
• Vitals and examination otherwise normal, except for blood pressure
  • 182/96 with normal heart rate
  • GCS 15
• No focal neurological deficits
Subarachnoid Hemorrhage

• 7% of strokes, with a pediatric risk as well
• Commonly due to aneurysmal rupture
• High mortality
  • 40% within 30 days
• Complicated by metabolic abnormalities, vasospasm
Canadian Stroke Best Practices

• Patients with suspected aneurysmal SAH should:
  • Be seen without delay (B)
  • If SAH confirmed, have urgent neurosurgical consultation (B)
  • Be treated in centres with expertise in aneurysmal management (C)

• All patients with suspected SAH should have neuroimaging immediately on arrival in the Emergency Department (B)

Ottawa SAH Rule

- Perry et al. (2013)
  - 2131 patients presenting with acute non-traumatic headache
    - Reached maximal intensity within 1 hour
    - GCS 15, onset within 14 days
  - 132 (6.6%) diagnosed with SAH
  - Particular clinical features associated with likelihood of positive findings

Perry et al. JAMA 2013; 310: 1248-55
Ottawa SAH Rule

Box 2. The Ottawa SAH Rule
For alert patients older than 15 y with new severe nontraumatic headache reaching maximum intensity within 1 h

Not for patients with new neurologic deficits, previous aneurysms, SAH, brain tumors, or history of recurrent headaches (≥3 episodes over the course of ≥6 mo)

Investigate if ≥1 high-risk variables present:

1. Age ≥40 y
2. Neck pain or stiffness
3. Witnessed loss of consciousness
4. Onset during exertion
5. Thunderclap headache (instantly peaking pain)
6. Limited neck flexion on examination
SAH indicates subarachnoid hemorrhage.

Perry et al. JAMA 2013; 310: 1248-55
How Sensitive Is CT?

• Cortnum et al. (2010)
  • CT alone able to diagnose 295/296 patients with SAH
  • Done within one week of symptoms
  • Cases confirmed with lumbar puncture

• Sensitivity from days 1-5 – 100%
• Overall sensitivity 99.7% (98.1 - 99.9%)

How Sensitive Is CT?

• Perry et al. (2011)
  • 3132 patients in 11 emergency departments
  • Presenting with non-traumatic acute headache, or syncope with headache
  • All had CT scan done
    • 30.4% - within six hours
    • 49% - had LP after negative CT
  • Accuracy of CT alone for SAH; compared to CT, LP or angiographic conformation

Perry et al. BMJ 2011; 343: d4277
### Table 3  Sensitivity of computed tomography for subarachnoid haemorrhage in patients with acute headache stratified by timing of scan

<table>
<thead>
<tr>
<th>Time from headache onset to scan</th>
<th>No of patients</th>
<th>% Sensitivity (95% CI)</th>
<th>% Specificity (95% CI)</th>
<th>Likelihood ratio (95% CI)</th>
<th>Predictive value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>All patients</td>
<td>3132</td>
<td>92.9 (89.0 to 95.5)</td>
<td>100 (99.9 to 100)</td>
<td>Infinity</td>
<td>0.07 (0.05 to 0.11)</td>
</tr>
<tr>
<td>≤6 hours</td>
<td>953</td>
<td>100 (97.0 to 100.0)</td>
<td>100 (99.5 to 100)</td>
<td>Infinity</td>
<td>0.00 (0.00 to 0.02)</td>
</tr>
<tr>
<td>&gt;6 hours</td>
<td>2179</td>
<td>85.7 (78.3 to 90.9)</td>
<td>100 (99.8 to 100)</td>
<td>Infinity</td>
<td>0.14 (0.14 to 0.17)</td>
</tr>
</tbody>
</table>
CT Imaging and Lumbar Puncture

• If scan is
  • Within six hours of onset,
  • Done on a third generation CT scanner or higher, and
  • Is read as normal by a neuroradiologist,

• Then a lumbar puncture is not required (B).

• If high index of suspicion, and neuroradiologist not available, then a lumbar puncture should be performed (C)

CT Imaging and Lumbar Puncture

• If scan is
  • **Beyond** six hours of onset,
  • **Not** done on a third generation CT scanner or higher,
  • **Cannot be read** by a neuroradiologist, **or**
  • The patient has an **altered level of consciousness**

• Then a lumbar puncture **should be performed** (C).

• Xanthochromia may be more sensitive after 12h, but waiting may not be **practical** or **appropriate** (B)

Case Two

- On a roll now, you are called to see a 37 year old woman presenting with a severe headache.
  - She describes it as the worst headache of her life; came on suddenly while grocery shopping three hours before
  - Never happened before, no history of migraine or other significant headaches
- Currently appears uncomfortable, with neck stiffness, light sensitivity and fatigue
- Vitals and examination otherwise normal, except for blood pressure
  - 182/96 with normal heart rate
  - GCS 15
- No focal neurological deficits
Vascular Imaging in SAH

- Catheter angiography remains the standard of care for identification and diagnosis of aneurysm
- Reasonable to do CTA first, but if negative, not currently thought to be conclusive enough to definitively exclude an aneurysm
  - Perimesencephalic? (Interrater agreement)
  - Initial negative CT?
- Canadian Guidelines:
  - All patients should have vascular imaging
  - High-quality CTA may be useful and is appropriate, but catheter angiography remains the gold standard (B)

Illustration of a MMBE procedure in a 44-year-old woman with a ruptured right middle cerebral artery (MCA) aneurysm.

A 77-year-old woman with SAH and a false-positive-aneurysm finding on CTA. A, Axial CTA-MMBE image shows near complete bone removal as only the auditory ossicles (arrowheads) are not masked.
Communication

• Severity should be communicated using a validated scale (B)

Table 3. Hunt And Hess Classification Of Subarachnoid Hemorrhage.

- **Grade 1**: Asymptomatic, or minimal headache; slight nuchal rigidity.
- **Grade 2**: Moderate to severe headache, nuchal rigidity; no neurological deficit (apart from cranial nerve palsy).
- **Grade 3**: Drowsiness, confusion, or mild focal deficit.
- **Grade 4**: Stupor, moderate to severe hemiparesis; possible early decerebrate posturing.
- **Grade 5**: Deep coma, decerebrate posturing, moribund.

Other Emergent Management

- Transfer to a **comprehensive stroke centre** (C)
- If not hypotensive, start **nimodipine** (A)
- Arrange for treatment of **aneurysm** and **hydrocephalus** (B)
  - **Evacuation** of hematoma causing mass effect (C)
- Prophylactic treatment of seizures is **not recommended** in the absence of seizures (B)
- Treatment of **hypertension**, especially if aneurysm unsecured (B)

Case Three

• 67 year old woman, previously healthy
  • Takes daily ASA (no specific indication)
  • Visited chiropractor for generalized fatigue

• During visit, abrupt onset of right facial weakness, impaired speech, confusion and right hemiplegia.
  • No history of neck manipulation
  • No treatment yet given at time of onset

• EMS called and brought to Civic as possible stroke code.
Case Three

• On arrival – SBP = 165 mm Hg

• NIHSS – 26
  • Profound decrease in LOC
  • Withdrawal to pain on left; no movement on right
  • Upgoing toe
  • Left gaze preference

• GCS – 8, rapid decline
  • Quickly intubated for airway protection
  • Transient elevation of SBP to 226 mm Hg
  • On intubation – correction to 122/65
Unenhanced CT head
63 minutes from symptom onset
ICH volume – 17.6 mm³
IVH volume – 36.6 mL

CTA Source Images
64 minutes from symptom onset
Dynamic CTA
64 minutes from symptom onset
Dynamic CTA
64 minutes from symptom onset
Bottom Line

• Significant intracerebral hemorrhage with intraventricular extension and midline shift
  • Volume 17.6 mm³ as per ABC/2 method
  • However, IVH is independent predictor of poor outcome
  • Total volume approximately 55 mL

• Spot sign observed
  • Predictions for expansion?
Some Background

• ICH mortality (1 month) – 40%
  • Death or severe disability – 75%\(^2,3\)

• Hematoma volume is associated with bad outcome\(^4\)

• Expansion in size occurs in about 40% of people\(^5,6\)
  • Further contributes to poor outcomes
  • Stopping expansion now a key goal in trials

---

2. Qureshi et al. Lancet 2009; 373:1632
5. Brott et al. Stroke 1997; 28:1
Predicting Expansion

• Spot Sign
  • “One or more foci of contrast enhancement within an acute primary parenchymal hematoma visible on the source images of CTA.”

• Likely represents extravasation of contrast from vessels
  • Surrogate for active bleeding

---

Figure 1: A sign with spot-like appearance on CTA in a patient with intracerebral haemorrhage

CTA = CT angiography. The spot sign (green arrow) measures 2.2 mm in maximal axial diameter, and has a density of 173 Hounsfield units. The spot sign is located within the haematoma, has no connection to any outside vessel, and is absent on baseline non-contrast CT, as per published criteria. ²⁶
<table>
<thead>
<tr>
<th>Primary imaging outcome</th>
<th>Spot-sign positive (n=61)</th>
<th>Spot-sign negative (n=167)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Met either 6 mL or 33% growth criteria</td>
<td>37 (60.7%)</td>
<td>36 (21.6%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component and secondary imaging outcomes</th>
<th>Spot-sign positive (n=61)</th>
<th>Spot-sign negative (n=167)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute ICH growth (mL)</td>
<td>8.6 (-9.3 to 121.7)</td>
<td>0.4 (-11.7 to 98.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Relative ICH growth (%)</td>
<td>37.7 (-22.7 to 941.0)</td>
<td>5.0 (-100 to 361.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Absolute IVH growth (mL)</td>
<td>0.6 (-12.5 to 78.3)</td>
<td>0 (-20.8 to 47.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Absolute total growth (mL)</td>
<td>12.7 (-15.5 to 200.0)</td>
<td>0.3 (-22.4 to 98.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met 6 mL growth criteria</td>
<td>34 (55.7%)</td>
<td>23 (13.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met 12.5 mL growth criteria</td>
<td>28 (45.9%)</td>
<td>12 (7.2%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met 33% growth criteria</td>
<td>33 (54.1%)</td>
<td>31 (18.6%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Met either 12.5 mL or 33% growth criteria</td>
<td>34 (55.7%)</td>
<td>32 (19.2%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary clinical outcomes</th>
<th>Spot-sign positive (n=61)</th>
<th>Spot-sign negative (n=167)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-point worsening in NIHSS score at 24 h</td>
<td>17/53 (32.1%)</td>
<td>19/139 (13.7%)</td>
<td>0.006</td>
</tr>
<tr>
<td>mRS score at 90 days</td>
<td>5 (0-6)</td>
<td>3 (0-6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mortality at 3 months*</td>
<td>23/53 (43.4%)</td>
<td>31/158 (19.6%)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Data are n/N (%) or median (range). ICH=intracerebral haemorrhage. IVH=intraventricular haemorrhage. NIHSS=National Institutes of Health stroke scale. mRS=modified Rankin scale. *Adjustment for age and baseline Glasgow coma scale score does not change these proportions.
### Table 3: Predictors of the primary outcome

<table>
<thead>
<tr>
<th>Univariable (selected variables)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;80 years*</td>
<td>1.2 (0.8-1.9)</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.1 (0.7-1.7)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.0 (0.6-1.6)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.0 (0.6-1.6)</td>
</tr>
<tr>
<td>Antiplatelet use</td>
<td>1.2 (0.7-2.1)</td>
</tr>
<tr>
<td>Anticoagulant use</td>
<td>2.8 (2.0-3.9)</td>
</tr>
<tr>
<td>Systolic blood pressure &gt;200*</td>
<td>0.6 (0.3-1.2)</td>
</tr>
<tr>
<td>NIHSS score ≥18*</td>
<td>1.7 (1.1-2.5)</td>
</tr>
<tr>
<td>Onset-to-CTA time &lt;90 min</td>
<td>1.9 (1.2-2.7)</td>
</tr>
<tr>
<td>CTA spot-sign positive</td>
<td>2.8 (2.0-4.0)</td>
</tr>
</tbody>
</table>

**Multivariable model†**

| CTA spot-sign positive           | 2.3 (1.6-3.1)  |

RR = relative risk. NIHSS = National Institutes of Health stroke scale. CTA = CT angiography. *Dichotomised at the population 75th percentile. †Interaction term—anticoagulation use by onset-to-CTA time <90 min, p=0.006.
PREDICT

- Spot-sign positive patients had:
  - Larger hematomas (19.9 mL vs. 10 mL)
  - More expansion (8.6 mL vs. 0.4 ml)
  - Higher relative risk of expansion (2.3; CI 1.6-3.1)

- Positive predictive value – 61%
- Negative predictive value – 78%
- Sensitivity – 51%
- Specificity – 85%

<table>
<thead>
<tr>
<th>Primary Outcome</th>
<th>Hematoma Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study design</td>
<td>Prospective</td>
</tr>
<tr>
<td>No. of patients</td>
<td>39</td>
</tr>
<tr>
<td>No. of spot-positive patients (%)</td>
<td>13 (33)</td>
</tr>
<tr>
<td>Time window</td>
<td>&lt;3 h from symptom onset</td>
</tr>
<tr>
<td>Hematoma expansion definition</td>
<td>&gt;30% or &gt;6 mL increase from baseline ICH volume</td>
</tr>
<tr>
<td>Expansion (%)</td>
<td>11 (28)</td>
</tr>
<tr>
<td>Point estimate multivariate analysis (95% CI)</td>
<td>LR 8.5 (2.9–25)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.91</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.89</td>
</tr>
<tr>
<td>PPV</td>
<td>0.77</td>
</tr>
<tr>
<td>NPV</td>
<td>0.96</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.90</td>
</tr>
</tbody>
</table>

ICH indicates intracerebral hemorrhage; 95% CI, 95% confidence interval; LR, likelihood ratio; OR, odds ratio; n/a, not available; RR, relative risk; PPV, positive predictive value; NPV, negative predictive value; CT, computed tomography.
What Limits This?

• Technology dependent

• Time dependent
  • Later from symptom onset means fewer spots

• Site dependent
Chakraborty et al. British Journal of Radiology 2009; 83:e216
Clinical Applications

- Tells us who is at risk for expansion of hematoma from primary ICH, and by extension, is at risk of a poorer outcome.

- Being examined in secondary ICH.

- Target for enrollment in therapeutic trials for ICH.
Dowlatshahi et al. Lancet 2012; epub Sept. 20
Non-Contrast Signs

• Margin irregularity
• Density heterogeneity
  • DH associated with growth of hematoma at 24h\textsuperscript{3,4}

• Fluid levels
  • Present in patients with underlying coagulopathy; possible predictor of expansion\textsuperscript{5}

\textsuperscript{3} Barras et al. Stroke 2009; 40: 1325-31
\textsuperscript{4} Fujii et al. Stroke 1998; 29: 1160-6
\textsuperscript{5} Pfleger et al. AJNR 1994; 15: 217-23
Comparisons

<table>
<thead>
<tr>
<th>Value</th>
<th>Spot Sign (PREDICT)</th>
<th>Fluid Level</th>
<th>Density Heterogeneity (Grade 4,5)</th>
<th>Margin Irregularity (Grade 4,5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>51% (39-63%)</td>
<td>15% (8-23%)</td>
<td>44% (34%-54%)</td>
<td>69% (59-78%)</td>
</tr>
<tr>
<td>Specificity</td>
<td>85% (78-90%)</td>
<td>94% (91-97%)</td>
<td>72% (66-78%)</td>
<td>46% (40-53%)</td>
</tr>
<tr>
<td>PPV</td>
<td>61% (47-73%)</td>
<td>52% (25-34%)</td>
<td>40% (31-49%)</td>
<td>35% (28-42%)</td>
</tr>
<tr>
<td>NPV</td>
<td>78% (71-84%)</td>
<td>73% (68-77%)</td>
<td>76% (70-81%)</td>
<td>78% (71-85%)</td>
</tr>
</tbody>
</table>
Canadian Stroke Best Practices

• Patients with intracerebral hemorrhage should:
  • Have **immediate** neuroimaging to confirm diagnosis, location and extent (A)
  • If ICH confirmed, **CTA or MRA** is recommended to rule out an underlying structural cause (B)

• All patients should be assessed using **NIHSS or GCS** to communicate severity; this will also assist in predicting outcomes (B)

• Blood pressure monitoring is important; though target is uncertain, there is safety evidence to suggest a **target of 140 mm Hg** systolic (B)

Objectives

• To discuss the decision making process around neuroimaging in the emergency department in neurovascular conditions
  • Acute ischemic stroke
  • Subarachnoid hemorrhage
  • Intracerebral hemorrhage

• To determine how that imaging is used to make appropriate clinical decisions