CT Brain Perfusion
in the Acute Stroke Setting

Maria Scotti
Outline

1. Stroke Basics
   ➢ What is stroke?
   ➢ Stroke facts and figures
   ➢ Treatment

2. Role of Imaging
   ➢ Role of the CT Brain Perfusion scan
   ➢ Dose considerations
   ➢ Scan protocol
   ➢ Interpreting CT Perfusion maps

3. CT Perfusion Case Studies
   ➢ Cases from Prince Of Wales Hospital
1. Stroke Basics

What is a Stroke?

Stroke occurs when the supply of blood to the brain is suddenly disrupted

www.strokefoundation.com.au
New procedure for stroke victims will save one patient a day

March 12, 2015

Harriet Alexander

Christie Pitronaci with her daughter Mia. Christie’s life was saved using a new stroke treatment. Photo: Nic Walker

Shortly after 7am on Christmas Eve, Christie Pitronaci woke up, dying.

She had no feeling on one side of her body and could not speak. She was choking.

As her husband rolled her onto her side, one of her last images was the face of their two-year-old daughter who had crawled into bed with them overnight, calling “Mummy, mummy, mummy”.

She remembers the paramedics cutting off her nightie. And then nothing.
1. Stroke Basics

Two main causes of stroke:

1. Ischaemic (Blocked artery)
   - 70% of cases
   - Embolic stroke
   - Thrombotic stroke

2. Hemorrhagic (Bleed in the brain)
   - 30% of cases
   - Subarachnoid (5%)
   - Intracerebral
1. Stroke Basics – Facts & Figures

- Stroke is one of Australia’s biggest killers and a leading cause of disability.
- 1 in 6 people will have a stroke in their lifetime
- Stroke kills more women than breast cancer and more men than prostate cancer.
- In 2012, the total financial costs of stroke in Australia were estimated to be $5 billion.

www.strokefoundation.com.au
1. Stroke Basics

The FAST test is an easy way to recognise and remember the signs of stroke:

- **Face**  Smile, is one side drooping?
- **Arms** Raise both arms, is one side weak?
- **Speech** Speak, unable to? Words jumbled, slurred?
- **Time**  Act fast dial 000. Time lost may mean brain lost

"Time is brain"
1. Stroke Basics - Treatment

- Thrombolysis
  - is a clot-busting drug
  - rt-PA (recombinant tissue plasminogen activator)
  - Can reduce the amount of damage & save lives
  - Must be given within 4.5 hours after symptoms begin *(time is brain)*
  - Complex eligibility criteria, risk of intra cranial bleeding
  - Administering is complex and done through an intravenous line in the arm
1. Stroke Basics - Treatment

**National Stroke Audit**

**Acute Services Report 2015**

**Thrombolysis**

- 2011: 7%
- 2015: 7%

Ischaemic stroke patients receiving clot busting drugs through thrombolysis

- 43%
- 56%
- 26%

Patients receiving thrombolysis within 60 minutes of hospital arrival
1. Stroke Basics - Intervention

- Interventional clot retrieval
  - Endovascular procedure performed by Interventional Neuroradiologist
  - aka Thrombectomy or Embolectomy
  - "stent on a stick" is advanced through the clot. Suction is applied then the stent is pulled back & the clot comes along with it
  - Not suitable for all pts
  - Limited access
ROLE OF IMAGING IN ISCHAEMIC STROKE

Exclude other pathologies that may mimic stroke eg tumour

Exclude Haemorrhagic stroke

CT BRAIN PERFUSION
Establish location & size of infarct core & penumbra

Help select patients that will benefit from treatment
2. Role of Imaging

Infarct Core and Penumbra

- **Infarct Core** – irreversible damage
- **Penumbra** – tissue at risk

Without treatment the infarction will expand to include penumbra
2. Role of Imaging

Rather than fuelling debates about which imaging modality is superior, CT and MR imagers should work together toward their common goal, which is to markedly increase the number of acute stroke patients who benefit from thrombolytic therapy through selection of the appropriate imaging modality.
2. Role of Imaging

The Stroke Team

Enables efficient pt care in the acute setting to expedite:

1. Initial pt examination
   - NIHSS stroke score

2. Imaging

3. Diagnosis

4. Treatment
   - Triage to Treatment < 60min
2. Role of Imaging

Non contrast CT brain

✓ Detects hemorrhagic stroke

BUT

✗ Early Ischaemic changes can be very subtle
✗ Large inter-observer variability
✗ Large size of early ischaemic change leads to poor outcome
2. Role of Imaging

- CT Perfusion enhances diagnostic sensitivity

<table>
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<tr>
<th></th>
<th>NCCT</th>
<th>NCCT + CTA</th>
<th>CTP</th>
<th>CTP vs NCCT</th>
<th>CTA vs NCCT</th>
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<tbody>
<tr>
<td>All</td>
<td>131/277</td>
<td>162/277</td>
<td>222/277</td>
<td>p&lt;0.001</td>
<td>p=0.01</td>
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<td>(47%)</td>
<td>(58%)</td>
<td>(80%)</td>
<td></td>
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<td>Mild/improving</td>
<td>22/115</td>
<td>28/115</td>
<td>73/115</td>
<td>p&lt;0.001</td>
<td>p=0.33</td>
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<td>(NIHSS ≤7)</td>
<td>(19%)</td>
<td>(24%)</td>
<td>(63%)</td>
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CTA, CT angiography; CTP, CT perfusion; NCCT, non-contrast CT; NIHSS, National Institutes of Health Stroke Scale.

Campbell BCV et al. JNNP 2012; 10.1136/jnnp-2012-303752
2. Role of Imaging

- Coverage a traditional challenge for stroke imaging

1st Generation CT Brain Perfusion

- 2 - 4cm
- 4slice
- 16slice
- 64row / 128 slice
2. Role of Imaging

- Coverage a traditional challenge for stroke imaging

- **Up to 16cm**
  - 320row/ 640slice
  - Dynamic Volume CT
  - No Table movement
  - Isophasic data
THE RADIATION BOOM
After Stroke Scans, Patients Face Serious Health Risks

By WALT BOGDANICH
Published: July 31, 2010

When Alain Reyes’s hair suddenly fell out in a freakish band circling his head, he was not the only one worried about his health. His co-workers at a shipping company avoided him, and his boss sent him home, fearing he had a contagious disease.
2. Role of Imaging – Dose considerations

Peak Skin and Eye Lens Radiation Dose From Brain Perfusion CT Based on Monte Carlo Simulation

AJR: 198, February 2012

Eye Lens Dose Reduction by Tilting the Gantry Angle

When the gantry was tilted by 15° away from the eye lens, the dose to that structure was decreased by 87%.
2. Role of Imaging – Perfusion – Scan Protocol

- Immobilise pt
- Ensure pt is in isocentre
- Consider angling gantry to decrease eye dose & increase range of brain covered
- Take tenting into account when planning scan (Exact+ off)
2. Role of Imaging
2. Role of Imaging – Perfusion – Scan Protocol

Perfusion Scan protocol – Variable scan intervals and exposure

- CT DSA Mask
- Arterial 2s sampling
- Venous 5s sampling

mA

Time

19 scans
2. Role of Imaging – Perfusion Maps - Processing

**Input Artery**
Earliest transit time
MCA or ACA

**Output Vein**
Maximum total density
Superior sagittal sinus

Time Intensity Graph

- Artery
- Vein
2. Role of Imaging – Perfusion Maps
We discuss the maps with reference to an increase or decrease.
2. Role of Imaging – Perfusion Maps
TTP – Time To Peak

- Length of time (seconds) to reach peak density/enhancement of voxels
- TTP is an **indicator of delayed flow** due to stenosis or occlusion
- Increases when abnormal

Area that is not getting enough blood
• Relative arrival time of contrast in tissue voxels

• Measured in seconds

• The information on the delay maps is similar to TTP
MTT – Mean Transit Time

- Time for blood to move through capillary vessels: Arterial to venous
- Measured in seconds
- An increase in MTT indicates a vasodilatory response to reduced flow
- Note: Toshiba use Delay insensitive algorithm – (not affected by stenosis)
CBV – Cerebral Blood Volume

- Volume flow rate through cerebral vasculature per unit time (ml/100g of brain tissue)
- Penumbra: displays normal or even increased CBV due to autoregulation
- Infarct core: CBV is reduced by 40% less than normal
Amount of blood flowing through capillaries per unit time per unit tissue
In units of ml/min/100g of brain tissue
CBF identifies areas of low blood flow (area of hypo perfusion)
Infarct core will display decreased CBF by <30%
Area that is not getting enough blood

Infarct Core

Penumbra
Salvageable tissue
CASE STUDY 1 – 82yo male

0615
Last seen well

0715
Found on floor of bathroom
Ambulance noted positive FAST
Conscious but not responsive

0756
Pt arrived in ED
Stroke Call activated
Stroke Score of 12
R side weakness

0817
CT Perfusion

21 mins
CASE STUDY 1 – 82yo male

- **0615**: Last seen well
- **0715**: Found on floor of bathroom. Ambulance noted positive FAST. Conscious but not responsive.
- **0817**: CT Perfusion. L MCA territory threatened.
- **0935**: Endovascular Thrombectomy.
What a normal LICA angiogram looks like
CASE STUDY 1 – 82yo male

AP View

before

after

Courtesy of Dr Andrew Cheung, Interventional Neuroradiologist
CASE STUDY 1 – 82yo male

Lateral View

before

after

Courtesy of Dr Andrew Cheung, Interventional Neuroradiologist
CASE STUDY 1 – 82yo male

0615
Last seen well

0715
Found on floor of bathroom
Ambulance noted positive FAST
Conscious but not responsive

0756
Pt arrived in ED
Stroke Call activated
Stroke Score of 12
R side weakness

0817
CT Perfusion
L MCA territory threatened

1030
Reperfusion achieved

0935
Endovascular Thrombectomy
CASE STUDY 1

DAY 1

DAY 2

DAY 2

DAY 5

Discharged from hospital
CASE STUDY 1 – 82yo male

- **0615**: Last seen well
- **0715**: Found on floor of bathroom
  - Ambulance noted positive FAST
  - Conscious but not responsive
- **0756**: Pt arrived in ED
  - Stroke Call activated
  - Stroke Score of 12
  - R side weakness
- **0756 + 21 mins**: PT Perfusion
  - L MCA territory threatened
- **0817**: CT Perfusion
- **0817 + 21 mins**: Reperfusion achieved
  - Endovascular Thrombectomy
- **0935**: MRI & CT
  - Small infarction
  - Good result, no hemorrhage
- **DAY 2**: Discharged from hospital
- **DAY 5**: Endovascular Thrombectomy

**“Time is brain”**
CASE STUDY 2 – 75yo male

1015
Sudden onset stroke symptoms

1100
Pt arrived in ED
Stroke Call activated
Stroke Score of 13
L sided weakness

1130
30 mins
CT Perfusion
CASE STUDY 2 – 75yo male

1015
Sudden onset stroke symptoms

1100
Pt arrived in ED
Stroke Call activated
Stroke Score of 9
L sided weakness

30 mins

1130
CT Perfusion
R posterior M2 territory threatened

1155
rt-PA infusion started

DAY 2
MRI
CASE STUDY 2 – 75yo male

Discharged from hospital
CASE STUDY 2 – 75yo male

1015
Sudden onset stroke symptoms

1100
Pt arrived in ED
Stroke Call activated
Stroke Score of 9
L sided weakness

1130
CT Perfusion
R posterior M2 territory threatened

DAY 2
MRI
Small infarction, good result

DAY 4
Discharged from hospital

1155
rt-PA infusion started

“Time is brain”
THE END

Thanks for listening