Management of Acute Stroke & Understanding Diagnostic Imaging

Acute Stroke Best Practices Workshop
“Advancing Best Practices in Stroke Care”
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Faculty/Presenter Disclosure
Slide 1

• Faculty: Ayman Hassan
• Relationships with commercial interests:
  – Grants/Research Support: site PI for Astra Zeneca SOCRATIS, BIOGEN IDEC ESTEEM, BAYER NAVIGATE.
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Objectives

• Describe the types of stroke
• Brief overview of cerebral circulation
• Brief overview of neuroanatomy
• Explain diagnostic imaging pertaining to stroke
• Provide an overview of Intracerebral hemorrhage (ICH)
• Provide an overview Ischemic Stroke
• Describe the various clinical stroke presentations based on anatomy
Every year, patients with stroke spend more than 639,000 days in acute care in Canadian hospitals and 4.5 million days in residential care facilities (CSN, 2011b).

Stroke costs the Canadian economy $3.6 billion a year in physician services, hospital costs, lost wages, and decreased productivity (2000 statistic) (PHAC, 2009).

For every minute delay in treating a stroke, the average patient loses 1.9 million brain cells, 13.8 billion synapses, and 12 km of axonal fibers (Saver, 2006).

Each hour in which treatment does not occur, the brain loses as many neurons as it does in almost 3.6 years of normal aging (Saver, 2006).


- Fewer Canadians are dying from stroke, thanks to advances in prevention, care and treatment… but still challenges ahead
- Today’s stroke patient is sicker with two-thirds having one or more chronic conditions, making treatment more complex
- The population is aging and stroke is age-related – most common age 70 +
- Younger patients are having strokes and this trend is expected to continue – alarming escalation among those under 70. Over the past decade, strokes in people in their 50’s have increased by 24 %, those in their 60’s by 13%
- Coordinated systems are the best way to ensure the “right resources, in the right place at the right time”.
- For every symptomatic stroke there are 9 silent strokes causing cognitive impairment “tsunami” www.ontariostrokene

Canada Stats

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Goals of Acute Ischemic Stroke Management

- reduce or minimize ischemic damage
- reduce cerebral edema
- prevent secondary complications
- determine etiology of stroke
- prevent recurrent stroke
- facilitate access to rehabilitation and community reintegration
The Ischemic Penumbra

Normal Flow 54 ml/100 gm/min
Marginal Flow 20-50 ml/100 gm/min
Critical Flow 15-20 ml/100 gm/min
Lethal Flow
10 ml/100 gm/min
Infarcted Tissue

Frontal Lobe
Parietal Lobe
Occipital Lobe
Temporal Lobe
Cerebellum
Brain Stem

Lobes of the Brain and their Function
The Human Brain
- 100 billion nerve cells (neurons)
- All in grey matter
- Highly organized into functional regions
- Prolonged processes of the neuron (axons) surrounded by myelin (insulation)
- White matter

The Brain Stem and Cerebellum

Brain Stem
- midbrain
- pons
- medulla

Cerebellum

Lobes of the Brain and their Function

Frontal Lobes
- Responsible for voluntary motor function.
- Memory for habits and motor activities.
- Executive Functions: task initiation, motivation, planning and self-monitoring.
- The ability to concentrate and attend, elaboration of thought, learning and behavior including: intelligent, abstract reasoning, problem solving, judgment, sequencing, planning, concentration.
- Controls emotional responses, expressive language, word associations and memory for habits and motor activities.

Parietal Lobes
- Location for visual attention, touch perception, goal directed voluntary movements, manipulation of objects.
- Integration of different sensory input.
- Ability to sense the position, location, orientation and movement of the body and its parts.

Occipital Lobes
- Primary visual reception area.
- Spatial organization and interpretation of visual information.
- Visual reflexes.

Cerebellum
- Regulation and coordination of voluntary movement, posture, muscle tone, balance and equilibrium.
- Control of fine motor movements.

Temporal Lobes
- Hearing ability, receptive language (Wernicke’s Area), some visual perceptions, visual memory.
- Integration of visual, auditory and somatic information.
- Sense of identity, behavior, and emotions.
- Memory (storage, retrieval of words, experiences).
Cerebral Circulation

- 4 vessels
  - 2 carotid ==> internal carotid (anterior circulation)
  - 2 vertebral ==> basilar artery (posterior circulation)
- Circle of Willis
  - connects carotids to vertebral-basilar
  - inconsistent in humans - too bad!

References:
**Definitions**

- **Ischemic stroke**
  - Clinical syndrome characterized by sudden onset of focal neurological deficits, due to a perfusion defect in a vascular territory

- **Hemorrhagic stroke**
  - Sudden onset neurological deficits secondary to intraparenchymal hemorrhage

- **Transient Ischemic Attack**
  - As above with resolution of the focal neurological deficits within 24 hours and no evidence of infarction on imaging
  - Most resolve within 1-2 hours

**Cerebrovascular Emergencies**

- **Ischemic strokes ~ 87%**
- **ICH (intracranial hemorrhage) ~ 10%**
- **SAH (Subarachnoid hemorrhage) ~ 3%**
- **TIA (Transient Ischemic Attack)**
  - ~15,000 Canadians experience a TIA / year
  - Risk of recurrent stroke following a TIA at 90 days is 10-20%

*Heart and Stroke; Go et al. Circulation 2013*

**Stroke Types & Incidence**

- **Ischemic Stroke** 88%
- **Hemorrhagic Stroke** 12%
- **Other** 0%

- **Atherosclerotic cerebrovascular disease** 20%
- **Cardiogenic embolism** 20%
- **Small vessel disease “lacunes”** 25%
- **Cryptogenic** 30%

*Albert GH et al. Chest 2004; 126 (3 Suppl): 438S–512S.
Diagnostic Tests- in Stroke Care

- Neurological Exam
- Laboratory Tests
- CT or CAT scan – Computed Tomography
- Carotid Doppler
- Echocardiogram
- MRI – Magnetic Resonance Imaging
- MRA –MR Angiography
- CTA – CT angiography
- Cardiac Rhythm monitoring

CT

- CT scans use computers and rotating X-ray machines to create images of slices, or cross-sections, of the brain.
- CT scans are a primary method to rule out hemorrhagic stroke. Ischemic stroke is not usually apparent until 6 – 12 hrs from symptom onset
- Often the first diagnostic test when a pt presents to the ED – to determine appropriate candidate for tPA
- In many cases, the involved area of the brain does not appear abnormal for the first several hours after the onset of ischemic stroke.

CT of the head

- Bone absorbs the most X-rays, so the skull appears white on the image.
- Water (in the cerebral ventricles or fluid-filled cavities in the middle of the brain) absorbs little, and appears black.
- The brain has intermediate density and appears grey.
- Most ischemic strokes are less dense (darker) (hypodense) than normal brain, whereas blood in hemorrhage is denser and looks white on CT.

CT head showing ICH Lt and small Lt Thalamic infarct
CTA Once you have diagnosed the infarction, if embolic you want to R/O carotid artery disease by performing a CTA.

CTA Preparation Implications

- Contrast media can be nephrotoxic
- Patient Prep:
  - At TBRHSC all individual need kidney function tests within 1 month prior to test (GFR)
  - Certain individuals may need additional preparation prior to the test
  - If pt has diabetes, and on Metformin (glucaphage), will need to hold medication day of procedure and two days following CTA and a repeat GFR is required prior to restarting Metformin.

MR IMAGING

- Based on behavior of hydrogen protons exposed to a magnetic field and a radio wave
- T1, T2, FLAIR, Diffusion, Gadolinium enhanced, and Angiography are specific types of Neuro imaging sequences.

MRI

- Unlike CT uses magnetic field to get pictures
- Shows more detail than CT for ischemic stroke patients
- Takes about 30 - 40 minutes, therefore not used in hyper acute stroke situation when tPA is considered
- Can show smaller ischemic strokes better than CT
- Can pick up ischemic stroke sooner than CT in hyper acute stage
- Does not show subarachnoid hemorrhage well
- High cost
- Can visualize in various modes. DWI (diffusion weighted imaging lets you know if it is a fresh/acute stroke
- Higher magnetic fields, bigger magnets, yield better results.

(http://emedicine.medscape.com/article/1155506-overview#a1)
**ANATOMY**

- Frontal lobe
- Corpus callosum
- Lateral ventricle
- Parietal lobe
- Occipital lobe
- Corona radiata

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**T1 SCAN**

Anatomic structures
- Fat = bright
- Water = hypo intense

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**T2 SCAN**

Water weighted sequence
- Water = bright
- Fat = relatively hypo intense
- Good for identifying pathology

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**MRI FINDINGS OF ACUTE STROKE**

- T1 (hypo intense)
- T2 (hyper intense)
- FLAIR (hyper intense)
- Diffusion (hyper intense)

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**VASCULAR ANATOMY**

- MCA
- ACA
- Basilar artery
- Cavernous carotid
- ECA
- ICA
- Vertebral

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**TIME OF FLIGHT MRA**

TOF-MRA
MRI / MRA contraindications

- Metallic implants
- Claustrophobia
- Pacemakers
- MR-incompatible prosthetic heart valves
- Contrast allergy
- Patient Prep: Length, noise-ear plugs, no jewelry,

30% of ischemic strokes are related to emboli from heart, can cause significant strokes with major deficits—large vessels involved

- ie AF, PFO, ASD, myoxma, endocarditis, mechanical valve, recent MI, dilated cardiomyopathy, rheumatic stenosis, valve

Carotid Doppler – assess blood flow and stenosis

Measures blood flow velocity by sound waves. Can only access proximal ICA area.

Can also look at IMT (intima medial lining thickness) and vertebral artery flow and plaque structure.

If stenosis evident, > 50% on symptomatic side, usually proceed to CTA or MRA

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- ie AF, PFO, ASD, myoxma, endocarditis, mechanical valve, recent MI, dilated cardiomyopathy, rheumatic stenosis, valve

Echocardiogram test that uses sound waves to create a moving picture of heart, assessing valves/structures/presence of clots/thrombi

TTE (transthoracic echo)

- Transducer on chest wall
- Bubble study Saline solution (salt water) is injected into the body as the cardiologist watches the heart on an ultrasound (echocardiogram) monitor. If a PFO exists, tiny air bubbles will be seen moving from the right to left side of the heart.

TEE (Transesophageal echo)

- Transducer/scope inserted in esophagus, lower end
- Better imaging in certain circumstances eg. PFO

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2994107/
Cardiac Rhythm Monitoring

ECG
Telemetry
Holter 24 or 48 hour
Loop Recorder 2 weeks
- Focus is to rule out atrial fibrillation/flutter or paroxysmal AF (5% of people over 65 have AF)
- AF most common cause of cardio-embolic stroke
- Risk for AF induced stroke increases with age
  - 1.5% risk at age 50 and 24% risk at age 80

Hemorrhagic Stroke

Hemorrhagic Strokes

- Intracerebral hemorrhage (ICH)
  - Bleeding within the parenchyma of the brain
- Intraventricular hemorrhage (IVH)
  - Bleeding into the ventricular system
- Epidural hemorrhage
  - Bleeding into the epidural space between the dura and the skull
- Subdural hemorrhage (SDH)
  - Bleeding into the subdural space (between the dura and the arachnoid layers)
- Subarachnoid hemorrhage (SAH)
  - Bleeding into the subarachnoid space (between the arachnoid and pia matter)

ICH

- Presentation:
  - Increased ICP
  - Headache
  - Nausea, vomiting
  - Decreased LOC
  - Focal neurologic deficits depend on location and may progress as the hematoma expands
  - Seizure
ICH

- Prognosis is dependent
  - Volume
    - \( \frac{A \times B \times C}{2} \)
    - \( C \) = # of slices x slice thickness
  - Location

- “Spot Sign”
  - Active extravasation

ICH – Acute Treatment

- Correct the INR if patient is on Warfarin
  - FFP
  - Vitamin K 10-20 mg IV - Class I, Level C
  - PCC – Prothrombin Complex Concentrate - Class IIa, Level B
    - Faster and less side effects
    - Octaplex - Factors II, VII, IX, and X and Proteins C and S
    - Factor VIIa is not enough - Class III, Level C

- Patients on NOACs – Limited data

ICH

- >1/3 of patients will experience ~33% growth of their initial bleed within 24 hours
  - 26% of patients will have 33% growth in 1st hour
  - 12% of patients will have 33% growth in 1-20 hours
  - Within a few hours, can no longer talk to them...

- What can we do?
  - Stop bleeding
  - BP control
  - Transfer to an ICU with Neuro-ICU trained MDs and RNs
  - Glycemic control
  - Consult neurosurgery

ICH – Acute Treatment

- Patients who are not coagulopathic
  - Studies have been done looking at FVIIa
    - Class III, Level A – Not safe…so not a good idea
    - Pilot level trials ongoing considering patients who have active bleeding – using the “Spot sign”

- Correct thrombocytopenia
  - Class I, Level C

- Patients on antiplatelet agents
  - Class IIb, Level B
**ICH – Acute Treatment**

- **Blood Pressure**
  - New evidence (INTERACT-2, NEJM, 2013)
  - For SBP 150-220, Acutely lowering to a SBP <140mmHg was safe and associated with better outcomes based on mRS
  - Class IIa, Level B

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**Case #1**

- 78 y/o R.H male, c/o of headache while driving and wife noticed that he was drifting over and crossing the midline. She drove him to hospital and en-route he became weak on Lt. Side and lethargic.
- PMH: HTN, CLL/BM transplant, Prostate CA, Basal cell CA, E.Tremors, Celiac, repeated Shingles, pneumonia, ch bronchitis.
- O/E: BP 217/112, stuporous, Lt. facial droop, Lt arm>leg weakness.
Follow Up CT Head 2 days later

Ischemic Stroke

Atherothrombosis

- sudden (unpredictable) plaque disruption
- (rupture or erosion)
- platelet activation
- thrombus formation

Atherosclerosis - Thromboembolism

Aggregation of platelets and fibrin on roughened surface. Platelet-fibrin emboli may occur

Atherothrombotic Ischemic Stroke - Major Risk Factors

- Hypertension
- Diabetes
- Dyslipidemia
- Cigarette use
- Alcohol abuse
- Family history

Hyper Acute Ischemic Stroke

- tPA - window of time < 4 ½ hours
- Thrombectomy – window of time < 6 hrs
“Time is Brain”

NINDS Recommendations for Timeline of Care:
- ED physician sees patient within 10 mins
- Stroke physician notified within 15 mins
- CT scan is completed within 25 mins
- CT interpretation is obtained within 45 mins
- IV rtPA should be initiated within 60 mins

Some centers in Europe are door to needle in 25 mins

Strategies to increase speed of treatment:
- Activate stroke team prior to CT scan
- Glucose only lab to worry about
- Store rtPA in ED
- Mix rtPA early (once CT shows no blood)

rtPA

- Tissue plasminogen activator (abbreviated tPA) is a protein involved in the breakdown of blood clots. It is a serine protease found on endothelial cells, the cells that line the blood vessels.
- As an enzyme, it catalyzes the conversion of plasminogen to plasmin, the major enzyme responsible for clot breakdown.
- Because it works on the clotting system, tPA is used in clinical medicine to treat embolic or thrombotic stroke. Use is contraindicated in hemorrhagic stroke and head trauma.
- tPA is manufactured using recombinant biotechnology techniques. tPA created this way may be referred to as recombinant tissue plasminogen activator (rtPA).

Intravenous t-PA a.k.a. the “clot buster”

- Can be given within 4.5 hours of onset of signs of stroke.
rtPA < 3hours exclusion criteria:

- Stroke or significant head trauma within 3 months
- Major surgery or serious trauma within 14 days
- Gastrointestinal and urinary hemorrhage within 21 days
- Arterial puncture at a noncompressible site within 7 days
- History of intracranial hemorrhage
- Intracranial neoplasm, arteriovenous malformation, or aneurysm
- Symptoms of subarachnoid hemorrhage
- Active internal bleeding
- Pretreatment blood pressure with systolic >185 or diastolic >110
- Clear and large hypodensity on CT scan
- Current bleeding diathesis including
  - INR>1.7
  - Heparin within 48 hours resulting in abnormal PTT
  - Platelets <100,000/mm3
  - Direct thrombin or factor Xa inhibitor (NOAC) use within 48 hours

Low numbers of Stroke Patients receiving TpA

- 'Wake up' stroke
- Arrive at hospital too late
- Major surgery within 2 weeks
- On blood thinners (elevated PTT/INR)
- Low platelet count
- Too high blood pressure
- Too low to too high blood sugar
- Symptoms improving

New Acute Stroke Therapy
Stent Retrievers

New studies - halted early due to overwhelming success

MERC  PENUMBRA
SOLITAIRE  TREVO
Comparisons of endovasc study design

<table>
<thead>
<tr>
<th>Design</th>
<th>MR CLEAN</th>
<th>EXTEND IA</th>
<th>SWIFT PTIME</th>
<th>ESCAPE</th>
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<td>Center</td>
<td>Netherlands</td>
<td>Australia</td>
<td>US/Europe</td>
<td>Global/Canada</td>
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<td>Patient #</td>
<td>500</td>
<td>70</td>
<td>196</td>
<td>316</td>
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<td>Inclusion/Selection</td>
<td>Age&gt;18 NIHSS&gt;2 Onew+Rise Confirmed LVO + extracranial ICA lesions</td>
<td>Age&lt;18 NIHSS Any Onew+Rise Confirmed LVO 100% IV-tPA Mismatch on CTP with core&lt;75cc</td>
<td>Age&lt;18 NIHSS 0-28 Onew+Rise Confirmed LVO 100% IV-tPA ASPECT&gt;5 or Core&lt;50cc or Penumbra&gt;15 cc</td>
<td>Age&gt;18 NIHSS Any Onew+Rise Confirmed LVO ASPECT&gt;5 and mod-good collateral + extracranial ICA lesions</td>
</tr>
<tr>
<td>Intervention</td>
<td>+/- IV-tPA (89%) + IAT (81.5% stent retrievers)</td>
<td>IV-tPA + Solitaire</td>
<td>IV-tPA + Solitaire</td>
<td>+/- IV-tPA (72.7%)</td>
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Stent Retrieval Pilot study at TBRHSC - summary
- 4 mega RCT support new strategy for reducing stroke impact by stent retriever
- 6 month pilot in 2015 at TBRHSC to see if feasible to manage here.
- Early CT angiogram (CTA) to see if stroke patient appropriate to have treatment by stent retriever
- On call stroke doctor contacts neurosurgeon
- Time window 6 hours

https://www.youtube.com/watch?v=uG9eDdOEC4U
Case # 2

- Rt. Handed 65 yrs old woman.
- While feeding her dog developed sudden dizziness, nausea and vomiting associated with neck pain on Rt side.
- Clinical exam at ED was consistent with BPPV and CT head was negative for acute intracranial pathology, she was subsequently discharged home and MRI head was booked as outpatient.

PH:
- HTN
- Dyslipidemia
- CAD

O/E:
- Rt. Horizontal gaze nystagmus
- Rt. Arm hypotonia and ataxia
- Unsteady gait with tendency to fall to the Rt. Side

ECG showed recent onset A.Fib with rapid ventricular response, heart rate 160/min.
Case # 3

- Rt. handed 62 yrs white man,
- 8 attacks of curtain coming down over his vision on the Rt. Eye lasting for 10 min. over the last year.
- 9 months ago his speech slurred and his Lt. hand was weak for 5 min.
- 7 months prior to ED he awakened with Rt. Frontal headache, neck pain and Lt. arm heaviness and hand weakness.
- He came to the hospital because his Lt. hand remained weak.

Past history
- Smoked cigarettes 1 1/2 PPD for 35 years
- Angina/CABG 3 yrs before.
- Slight, well-controlled HTN.
- Cervical disc disease

Family history
- Father had stroke and died at 69 yrs

Examination
- BP 130/85, pulse regular, no bruits, Lt hand marked weakness, no coordination or sensory disturbance.
What is the most likely diagnosis?

- A- Cervical disc with Rt radiculopathy?
- B- Occlusive disease of the Rt. MCA?
- C- Occlusive disease of the Rt. ICA?
- D- Occlusive disease of the VB system?
- E- Occlusive disease of the Rt. ACA?
Case # 3

- He had a successful Rt. Carotid endarterectomy and during follow up in SPC he was found to have marked difference (> 20 mm Hg) between the 2 arms systolic B.P.
Case # 4

- 63 yrs old Rt. Handed white man, previously healthy, presented to ER with a sudden onset aphasia after 75 min of onset.
- Past history
  - Hyperlipidemia
  - Drinking 3 beer/ 1 glass of wine daily
- Examination
  - BP135/90
  - Mixed aphasia more receptive

What is the most likely diagnosis?

- A- Occlusive disease of the Lt. ACA?
- B- Occlusive disease of the Lt. MCA?
- C- Occlusive disease of the Lt. ICA?
- D- Occlusive disease of the VB system?

Case # 4

- He received tPA with marked improvement of his speech over 4 weeks.
Case # 4

- Blood pressure target is < 140/90 unless DM <130/80 with high grade stenosis blood pressure should be on the upper limit of target.
- Watershed infarction is indicative of a large artery disease.

Case # 5

- 49 yrs Rt handed woman, At 01:00 Rt leg-arm weakness and numbness.
- P.H:
  - DM
  - Dyslipidemia
  - Hypothyroidism
  - MVR (mechanical valve)
  - A.Fib (warfarin D/C 5 days before and started lovenox in preparation for cardiac angiography)
- O/E:
  - Rt facial droop
  - Slurred speech
  - Rt arm 3/5 weakness
  - Rt leg 0/5 weakness and hypoesthesia

What is the most likely diagnosis?

- A- Occlusive disease of the Lt. ACA?
- B- Occlusive disease of the Lt. MCA?
- C- Occlusive disease of the Lt. ICA?
- D- Occlusive disease of the VB system?
Optimal Stroke Management With tPA: tPA Target Times

- rapid coordinated emergency response facilitates early diagnosis and treatment
- door-to-triage 1 minute
- door-to-stroke team notification 15 minute
- stroke team-to-bedside 30 minute*
- door-to-CT scan 25 minute
- door-to-needle 60 minute

*(occurring concurrently)