Neurological Assessment and Diagnostics

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Urgent TIA Clinic
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The neuroscience nurse:

• 2.1 Demonstrates knowledge of and performs the following neurological assessments as they relate to neurological disorders, including initial findings and appropriate developmental stages:
  • 2.1a level of consciousness
  • 2.1b mental status/cognition/perception and behaviour
  • 2.1c cranial nerves
  • 2.1d motor function
  • 2.1e sensory functions
  • 2.1f cerebellar functions
  • 2.1g vital signs
  • 2.1h pain
  • 2.1i speech and language
  • 2.1j swallowing
  • 2.1k gait
  • 2.1l reflexes
2.2 Demonstrates knowledge of common assessment measures (e.g., Glasgow Coma Scale, stroke assessment scale, spinal cord assessment scales, cognitive and functional assessments).

2.3 Demonstrates knowledge of the following diagnostic studies, provides pre- and post-procedure care and understands the implications of abnormal results:
- 2.3a imaging (e.g., X-rays, CT, CTA, MRI, MRA, angiogram, videofluoroscopy)
- 2.3b cerebrospinal fluid evaluation (e.g., lumbar puncture, ventricular sample)
- 2.3c electrophysiologic studies (e.g., EEG, EMG, evoked potentials)
- 2.3d nuclear medicine studies (e.g., SPECT scan, PET scan, shunt studies)
- 2.3e ultrasound studies (e.g., transcranial/carotid Doppler)
- 2.3f biopsy (e.g., brain, skin, muscle, nerve, hair)
- 2.3g laboratory testing (e.g., routine/therapeutic blood monitoring, urine studies, genetics)

Some General Principles

- There is no “complete” neuro assessment.
- Your observations are important. Document what you find and report changes.
- Communicate with others about specific things to watch for if you have to hand-off.
- Remember your scope of practice when reporting the results of specific tests.
- Keep practicing
- The internet is your friend. Lots of great tutorials out there!
2.1a Level of Consciousness

• Important to use the correct terminology:
  – Confusion - disorientation to person, place, time
  – Lethargy - Oriented but sluggish speech, movement, thinking
  – Obtundation - rousable, responds with 1-2 words, follows simple commands
  – Stupor - generally unresponsive except with repetitive stimuli, response with incomprehensible words
  – Coma - eyes closed, no response to body/sensory stimuli, no speech.

Glasgow Coma Scale
• E4V5M6
• Minimum 3
• Maximum 15
• 10T

Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Eye Opening</th>
<th>Verbal Response</th>
<th>Motor Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Spontaneous</td>
<td>5 Alert and Oriented</td>
<td>6 Obey commands</td>
</tr>
<tr>
<td>3 To Speech</td>
<td>4 Confused, coherent</td>
<td>5 Localizes to noxious stimuli</td>
</tr>
<tr>
<td>2 To Pain</td>
<td>3 Inappropriate</td>
<td>4 Withdraws from noxious stimuli</td>
</tr>
<tr>
<td>1 No Eye Opening</td>
<td>2 Incomprehensible</td>
<td>3 Abnormal Flexion</td>
</tr>
<tr>
<td></td>
<td>1 No Sound</td>
<td>Decorticate posturing</td>
</tr>
</tbody>
</table>

Add E + V + M /15  Score of 3-8 considered to be comatose.
Use T if intubated and unable to verbalize
2.1b Mental status/cognition/perception and behaviour

- MMSE Mini-Mental Status Examination
- MOCA Montreal Cognitive Assessment
- RLA Rancho Los Amigos Scale
- Orientation

2.1c Cranial Nerves

- 12 pairs of nerves written as CN I-XII
- I&II from cerebral hemispheres, III & IV from midbrain, V, VI, VII, VIII from the Pons, IX, X, XI, XII from the Medulla
- A Mnemonic for a new generation:
  - On, On, On, They Travelled And Found Voldemort Guarding Very Ancient Horcruxes
- Some Say Marry Money But My Brother Says Big Brains Matter Most
  - http://www.youtube.com/watch?v=PjAghPc9xAQ
  - http://www.youtube.com/watch?NR=1&v=vU8-PLsdJ-w
  - http://www.youtube.com/watch?v=8TWzS2sSYwU
Cranial Nerves

CN I Olfactory

- Use non-irritating scent
- Test each nostril separately (Foster-Kennedy Syndrome)
- Coffee or mint most common
- Anosmia- loss of olfactory sensation. Trauma, viral infections
- Hyposmia- Parkinson, Alzheimer, HIV dementia
- Hyperosmia- Migraine
- Olfactory hallucinations- Aura in temporal lobe seizures
CN II Optic

- Tests Visual Acuity –may have glasses on
- Test fields of vision –confrontation with glasses off
  - Quadrantanopia
  - Hemianopia (Bitemporal=optic chiasm)
- Pupillary light reflex
- Anisocoria – unequal pupils
- Miosis – small pupil (Horner Syndrome)
- Fundoscopy
  - http://www.youtube.com/watch?feature=player_detailpage&v=PUz2HLromXy

CN III Occulomotor

- CN III, IV and VI are tested together
  - Follow finger left, right, up and down (H) pattern
- Complaints may include diplopia or blurred vision
- CN III supplies innervation to levator palpebrae superioris (upper eyelid) medial rectus, superior rectus, inferior rectus and inferior oblique muscles of the eye.
- Upper eyelid ptosis is caused by CN II palsy
CN IV Trochlear

• Innervates the superior oblique eye muscle
• Moves eye down and toward the nose
• Vertical diplopia most common complaint
• Difficulty going down stairs

CN V Trigeminal

• Motor and Sensory
• 3 main branches written as:
  – Ophthalmic V1, Maxillary V2, Mandibular V3 (Motor + Sensory)
• Corneal reflex
• A loop of blood vessel arising near the origin of the nerve may cause severe pain (Trigeminal Neuralgia or Tic douloureux)
• Test light touch and pin prick sensation
• Test corneal reflex
CN VI Abducens

- Abducts the eye
  - innervates the lateral rectus muscle
- Dysfunction will produce diplopia

CN VII Facial

- Controls muscles of facial expression
- Taste to anterior 2/3 of tongue
- Supplies several gland including lacrimal
- Observe for:
  - Asymmetry
  - Loss of definition in facial folds
  - Inability to wrinkle forehead
  - Inability to completely close eyelid
  - Loss of taste
CN VIII Vestibulocochlear

- Nerve for hearing and balance
- Abnormal findings:
  - Hearing loss
  - Vertigo
  - Tinnitus
  - Dysequilibrium
  - Nystagmus

CN VIII Vestibulocochlear

- Test High frequency sound
  - rubbing fingers together
  - Test lateralization with eyes closed (Tuning fork)
- Rinne
  - Compare air conduction to bone conduction
- Weber
  - Lateralization to affected side
CN IX Glossopharyngeal

- Mixed sensory and motor
- Throat sensation
- Posterior 1/3 of the tongue
- Innervates the stylopharyngeal muscle (that’s it)
- Ask about swallowing
- Abnormal findings:
  - Loss of bitter and/or sour taste
  - Impaired swallowing

CN X Vagus

- Transmits information from the visceral organs to the brain (afferent)
- Has a role in heart rate, peristalsis, sweating
- Controls many muscles required for speech
- Look for:
  - Hoarse voice
  - Loss of gag reflex
  - Asymmetry of palate/uvula elevation (away from lesion)
CN XI Spinal Accessory

- Innervates the Sternocleidomastoid and trapezius muscles
- Test by having patient:
  - Shrug shoulders against resistance
  - Turn head against resistance

CN XII Hypoglossal

- Controls movement of the tongue
- Observe for:
  - Deviation (Away from lesion)
  - Loss of strength (Tongue in cheek)
  - Difficulty with pronunciation
    • Light, tight, dynamite
  - Fasciculation in LMN Disease
2.1d Motor Function

- Muscle Bulk
- Muscle Tone
- Abnormal Movement
- Pronator Drift
- Flexion
- Extension
- Abduction
- Adduction
- Proximal to distal

Motor Grading Scale

0 No Contraction
1 Flicker of movement
2 Active movement with gravity eliminated
3 Active movement against gravity
4- 4+ Active movement against gravity and some resistance
5 Full power
2.1e Sensory Functions

- **Dorsal Column**
  - Light touch
  - Vibration
  - Joint Position/proprioception
- **Spinothalamic**
  - Pin prick (pain) and Temperature
- **Cortical**
  - Stereognosis
  - Graphesthesia
  - 2 point discrimination
  - Extinction

- [http://www.youtube.com/watch?feature=player_detailpage&v=7iULrrlV4-s](http://www.youtube.com/watch?feature=player_detailpage&v=7iULrrlV4-s)
2.1f Cerebellar Functions

- Cerebellum provides coordination, precision and timing to movement
- Has a role in speech
- Observe for:
  - Occipital headache
  - Ataxia
  - Nystagmus
  - Vomiting
Cerebellar Function

• Test with:
  – Finger to Nose
  – Heel to Shin
  – Finger to Thumb
  – Rapid Alternating Movement
  – Romberg
  – Tandem Gait

2.1g Vital Signs

• Blood Pressure
• Pulse
• Respiratory Rate and Pattern
• Oxygen Saturation
2.1h Pain

• Use a pain scale
  – Visual analogue
  – Faces
  – Numerical Scale
• OPQRST (Onset, Palliation/Provocation, Quality, Region/Radiation, Severity, Time)
• Assess at least once per shift
• Clues about etiology in description

Pain

• Signs of Meningeal Irritation:
  – Kernig – bend hip to 90°, then extend knee past 90° http://www.youtube.com/watch?v=rJ-5AFuP3YA
  – Brudzinski – raising head causes involuntary flexion of hips and knees http://www.youtube.com/watch?v=jO9PAPI-yus
  – Lhermitte’s sign – flexion of the neck produces and electrical shock-like sensation down the back and into the limbs
2.1i Speech and Language

- Expressive (Broca’s Aphasia)
  - Fluency
  - Repetition
  - Word-finding
- Receptive (Wernicke’s Aphasia/Global Aphasia)
  - Comprehension
  - Devoid of content
- Delay
- Alexia

2.1j Swallowing

- Gag reflex
- Bedside evaluation
  - Various food and fluid consistencies
- Blue-dye
- Modified Barium Swallowing Test
2.1k Gait

• Standing from sitting
  – Proximal Weakness requires a push-off
  – Parkinson’s may cause rocking
• Observe walking for:
  – Speed
  – Rhythm
  – Base of stance
  – Stride

2.1k Gait

• Vocabulary
  – Antalgic
  – Cerebellar Ataxia
  – Gait apraxia
  – Hemiplegic (paralysis) or hemiparetic (weakness)
  – Myopathic
  – Parkinsonian/Extrapyramidal
  – Sensory ataxia
  – Spastic
  – Trendelenburg gait
  – Vestibular ataxia
2.1 Reflexes

- Correspond to a specific spinal level
  - Biceps
  - Triceps
  - Brachioradialis
  - Knee
  - Ankle
  - Plantar

Reflex Grading Scale

0 No Reflex
1+ Hyporeflexic
2+ Normal
3+ Hyperreflexic
4+ Hyperreflexic with clonus
5+ Hyperreflexic with sustained clonus
2.2 Demonstrates knowledge of common assessment measures (e.g., Glasgow Coma Scale, stroke assessment scale, spinal cord assessment scales, cognitive and functional assessments).

Glasgow Coma Scale

<table>
<thead>
<tr>
<th>GLASGOW COMA SCALE</th>
<th>Patient Name:</th>
<th>Score:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Note:</td>
<td>Name:</td>
</tr>
<tr>
<td></td>
<td>Date:</td>
<td></td>
</tr>
</tbody>
</table>

**EYE OPENING**

- 1 = Eye opening to verbal stimulus
- 2 = Eye opening to pain
- 3 = No eye opening

**MOTOR RESPONSE**

- 1 = Localized response
- 2 = Bilateral decorticate posture
- 3 = Bilateral decerebrate posture
- 4 = No response

**VERBAL RESPONSE**

- 1 = Oriented
- 2 = Incontinent
- 3 = Incomplete
- 4 = No response

**TOTAL (1–15)**

References

Caraauser, G. Struct.
"Assessment of coma and impaired consciousness: A practical scale."

Transcribed by the Iowa State Board — mncs.ia.gov/ia/
Stroke Assessment Scales

- NIH Stroke Scale
- Canadian Neurological Scale
- European Stroke Scale
**NIH Stroke Scale**

**Patient Identification:**

**Hospital:**

**Date of Exam:**

<table>
<thead>
<tr>
<th>Interval</th>
<th>Baseline</th>
<th>2 hours post treatment</th>
<th>24 hours post onset of symptoms</th>
<th>7-10 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Left Leg (Motor)</td>
<td>1. No weakness</td>
<td>2. Weakness present</td>
<td>3. Weakness present</td>
<td>4. Weakness present</td>
</tr>
</tbody>
</table>

**NIH Stroke Scale**

**Patient Identification:**

**Hospital:**

**Date of Exam:**

<table>
<thead>
<tr>
<th>Interval</th>
<th>Baseline</th>
<th>2 hours post treatment</th>
<th>24 hours post onset of symptoms</th>
<th>7-10 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Speech (Not motor)</td>
<td>1. Normal</td>
<td>2. slurred speech</td>
<td>3. slurred speech</td>
<td>4. slurred speech</td>
</tr>
<tr>
<td>NIH Stroke Scale</td>
<td></td>
<td></td>
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<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>Patient Information:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race:</td>
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<td></td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Age:</td>
<td></td>
<td></td>
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<td>Date of Birth:</td>
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<tr>
<td>Date of Admission:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interval:</td>
<td>Baseline</td>
<td>2 hours post treatment</td>
<td>24 hours post onset of symptoms</td>
<td>48-48+ days</td>
</tr>
<tr>
<td>1. Retraction of extremities and facial muscles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Arm position:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Hand position:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Eye position:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Face position:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Eye closure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Eye opening:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Eye deviation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Face deviation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Speech:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Motor function:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Sensation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Cognitive function:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Revision: 09/12/2013

2015/07/06
You know how.

Down to earth.

I got home from work.

Near the table in the dining room.

They heard him speak on the radio last night.
Canadian Neurological Scale

MAMA
TIP – TOP
FIFTY – FIFTY
THANKS
HUCKLEBERRY
BASEBALL PLAYER
## Canadian Neurological Scale

### Section A: Motor Function

**Face:** Have patient smile; ask to wrinkle forehead, close eyes, and pull down corners of mouth.

**Speech:** Ask patient to say “hello.”

**Arm:** Have patient raise arms above head and then externally rotate shoulders.

**Leg:** Have patient bend and extend knees and ankles.

### Section B: Motor Response

**Posterior Column Present:**

- **Face:** Ask patient to close eyes and turn head to one side. Then have patient turn head back to midline.

- **Speech:** Ask patient to repeat after you.

- **Arm:** Have patient extend arms and hold them up in front of body.

- **Leg:** Have patient bend and extend knees and ankles.

### Canadian Neurological Scale

**Patient Name:**

**Rate Name:**

**Date:**

<table>
<thead>
<tr>
<th>Motility</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td>Orientation</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td>Speech</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Disordered</td>
</tr>
<tr>
<td></td>
<td>No response</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL:**

### Section A: Motor Functions

<table>
<thead>
<tr>
<th>Motor Functions</th>
<th>Weakness</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDI</td>
<td>None</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm</td>
<td>None</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Significant</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.5</td>
</tr>
<tr>
<td>Leg</td>
<td>None</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Significant</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**TOTAL:**

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**Provided by the internal sinea center — www.smallerinc.org**
### Spinal Cord Assessment Scales

- **ASIA American Spine Injury Association**
  - [http://www.asia-spinalinjury.org/elearning/Key_Sensory_Points.pdf](http://www.asia-spinalinjury.org/elearning/Key_Sensory_Points.pdf)
Muscle Function Grading
0 = total paralysis
1 = palpable or visible contraction
2 = active movement, full range of motion (ROM) with gravity eliminated
3 = active movement, full ROM against gravity
4 = active movement, full ROM against gravity and moderate resistance in a muscle-specific position
5 = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e., pain, disture) were not present
5+ = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e., pain, disture) were not present.
NTP = not testable (i.e., due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contraction of >50% of the range of motion).

ASIA Impairment (AIS) Scale

- A = Complete: No sensory or motor function is preserved in the sacral segments S4-S5.
- B = Incompletely Incomplete: Sensory but no motor function is preserved below the neurological level and includes the sacral segments S4-S5 (light touch, pinprick at S4-S5, and deep sensation) (D6H). ASIA for motor function is preserved more than one grade below the motor level on either side of the body.
- C = Motor Incomplete: Motor function is preserved below the neurological level, and more than half of key motor functions below the single neurological level of injury (ONL) have a muscle grade 3 or better (Grades 0–3).
- D = Motor Incomplete: Motor function is preserved below the neurological level, and at least half/whole of the key motor functions below the ONL have a muscle grade 3 or better (Grades 0–3).
- E = Normal: Sensation and motor function as assessed with the ASIA C score is graded as normal for all segments, and the patient had pain below the AIS grade E. Sensation without an initial SCI does not receive an AIS grade.

Steps in Classification

1. Determine sensory levels for right and left sides.
2. Determine motor levels for right and left sides.
3. Determine whether the injury is Complete or Incomplete (i.e., absence or presence of spinal sparing).
4. If there is a known traumatic event, the AIS C5 or C6 sensory score ≤ S5 or ≤ S5 does not indicate a Complete injury.

Examples of Complete SCI:

- AIS A: Complete motor (0) or sensory (0) function.
- AIS B: Decreased motor or sensory function below the neurological level.

Examples of Incomplete SCI:

- AIS C: Partial motor (3) or sensory (3) function below the neurological level.
- AIS D: Hypotonicity without movement (0) or sensation (0) below the neurological level.

NOTE: The level of injury is determined by the lowest sensory level (S1-S5) and the lowest motor level (0-5) that is present. The level is determined based on the lowest level of both motor and sensory function. The injury level is then classified based on the presence or absence of motor and sensory function below the level of injury.
Spinal Assessment

- Muscle strength grading
- Sensory Levels Segmental (T4 Nipple, T10 Umbilicus)
- Respiratory function (C5=alive)
- Bowel Function (Below T12)
- Bladder Function
- Autonomic Dysreflexia (T5 and above)

Cognitive and Functional Assessments

- MMSE Mini-Mental Status Exam
  - 1975
  - Marshal Folstein, Susan Folstein and Paul McHugh
  - Scored out of 30.
- MOCA Montreal Cognitive Assessment
  - [http://www.mocatest.org/](http://www.mocatest.org/)
The mini mental state examination

Orientation
- Year, month, day, date, season
- Country, county, town, hospital, ward (clinic)

Registration
- Examiner names three objects (for example, apple, pen, and table)
- Patient asked to repeat objects, one point for each.

Attention
- Subtract 7 from 100 then repeat from result, stop after five subtractions. (Answers: 93, 86, 79, 72, 65)
- Alternatively if patient can subtract they can spell world backwards: D I R O W
- Score best performance on either task.

Recall
- Ask for the names of the objects learned earlier.

Language
- Name a pencil and a watch.
- Repeat: 'Red, blue, and white.'
- Give a three stage command. Score one for each stage (for example, "Take this piece of paper in your right hand, fold it in half and place it on the table.
- Ask patient to read and obey a written command on a piece of paper stating: 'Close your eyes.'
- Ask patient to write a sentence. Score correct if it has a subject and a verb.

Copying
- Ask patient to copy intersecting pentagons.
- Score as correct if they overlap and each has five sides.

Total score: __/30
Other Cognitive Tests

• 3 words – 3 minutes
• Clock Draw
• Serial 7’s
• Nickel, Dime, Quarter, Penny
• Proverbs
• Digit Span
• Similarities
• Judgement (You smell smoke)

Behaviour Grading Scale

• Agitated Behaviour Scale (ABS)
  http://www.tbims.org/combi/abs/index.html
• Rancho Los Amigos Levels of Cognitive Impairment Scale
  http://www.rancho.org/research/bi_cognition.pdf
• Hamilton Rating Scale for Depression
  http://healthnet.umassmed.edu/mhealth/HAMD.pdf
2.3 Demonstrates knowledge of the following diagnostic studies, provides pre- and post-procedure care and understands the implications of abnormal results

CT / CTA

• Computed Tomography
• Uses X-Rays
• Dose depends on the type of scan
• Head CT = 243d of Background Radiation (2mSv)
• CTA requires injection of IV contrast media
• Contrast is cleared by kidneys important to know Creatinine and eGFR prior to procedure.

•  http://www.fda.gov/radiation-emittingproducts/radiationemittingproductsandprocedures/medicalimaging/medicalx-rays/ucm115329.htm

What do you see?

MRI / MRA / MRV

- Powerful magnets align hydrogen bearing molecules
- Radio waves tilt water molecules off axis and on cycling off the radio waves measure the time for the molecule to relax back into position (T1 & T2)
- Blood moving though arteries and veins can’t be timed and appears as a void
- Isodense tissues can be viewed better with Gadolinium contrast media which increases T1 relaxation time
- Diffusion sequence can reveal areas of infarction
- [http://radiographics.rsna.info/content/26/2/513.full](http://radiographics.rsna.info/content/26/2/513.full)
- [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1064998/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1064998/)
MRI

# Neuroimaging

A simplified tabulation of tissue image characteristics:

## Normal Tissue

<table>
<thead>
<tr>
<th>Tissue</th>
<th>MR T1</th>
<th>MR T2</th>
<th>X-ray CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense bone</td>
<td>Dark</td>
<td>Dark</td>
<td>Bright</td>
</tr>
<tr>
<td>Air</td>
<td>Dark</td>
<td>Dark</td>
<td>Dark</td>
</tr>
<tr>
<td>Fat</td>
<td>Bright</td>
<td>Bright</td>
<td>Dark</td>
</tr>
<tr>
<td>Water</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
</tr>
<tr>
<td>Brain</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

1. Bright means high signal intensity, dark means low, and interm. means intermediate.
2. Bright means high density/high attenuation of X-rays, dark means low.
3. Grey matter appears grey, white matter white.

## Abnormal Tissue

<table>
<thead>
<tr>
<th>Tissue</th>
<th>MR T1</th>
<th>MR T2</th>
<th>X-ray CT</th>
<th>Enhance/den.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infarct</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
<td>Subacute</td>
</tr>
<tr>
<td>Bleed</td>
<td>Bright</td>
<td>Bright</td>
<td>Bright</td>
<td>No</td>
</tr>
<tr>
<td>Tumor</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
<td>Yes</td>
</tr>
<tr>
<td>MS plaque</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
<td>Acute</td>
</tr>
</tbody>
</table>

1. Blood-brain barrier leak: For MR, gadolinium; for CT, iodinated contrast material.
2. Unless very fresh or very old.
3. Unless calcified.
4. Often subacute.

Angiography

- Catheter inserted in radial or femoral artery
- Positioned in vascular territory under investigation
- Radio-opaque contrast material injected and vessels downstream can be visualized
- Abnormal findings:
  - Vessel occlusion/stenosis
  - Aneurysm
  - SAH
  - AVM

Angiography

http://en.wikipedia.org/wiki/File:Cerebral_Angiogram_Lateral.jpg
Videoflouroscopy

- Swallowing study most common
- Also used in orthopedic surgery and tube/catheter insertion
- Continuous exposure to x-ray
- Produces a video rather than still image
  - [http://www.youtube.com/watch?v=xu_YYOAIZEw](http://www.youtube.com/watch?v=xu_YYOAIZEw)

CSF Studies

- Sample obtained by Lumbar Puncture (LP) or via drain or shunt
- LP site most commonly L3-4 but may be one level above or below
- Traumatic tap may result in local bleeding intrathecally
- Prolonged headache (>2d) post-procedure may required an autologous epidural blood patch at LP site
- Post LP headache most common side-effect and may require bedrest for 1-2 days
Lumbar Puncture

- Normal CSF: Clear, Protein <0.45g/L, 60% of serum glucose >3.0 mmol/L, 0-5WBC, 0 RBC, 0 neutrophils. Opening Pressure 10-25 cmH₂O
- 5 Tubes are obtained for: Cell count and Diff, Chemistry, Microbiology, Cytology, and RBC Count
- Abnormal:
  - Increased Protein (GBS, MS)
  - Increased lymphocytes (infection)
  - Low glucose (TB)
  - RBCs elevated (SAH all tubes = RBC count)
  - Xanthochromia (SAH, Neoplasm)

http://www.aafp.org/afp/2003/0915/p1103.html
Electrophysiologic Studies

• Electromyography (EMG)
  – Uses fine needle electrodes to detect muscle action potentials
  – Can identify “motor units” Nerve + Muscle Fibres
  – Can detect Neuropathy and Myopathy
    • [http://painmd.tv/electrodiagnostics/](http://painmd.tv/electrodiagnostics/)

• Nerve Conduction Study
• Evoked Potentials (MS) Visual, Auditory, Somatosensory

Nuclear Medicine Studies

• Technetium 99m ($^{99m}$Tc) most common isotope used
• Allows imaging of cellular process such as glucose uptake, neurotransmitter uptake, cerebral blood flow
• Good Article:
  [http://www.acnr.co.uk/ND09/ACNRND09_nuclear.pdf](http://www.acnr.co.uk/ND09/ACNRND09_nuclear.pdf)
Ultrasound Studies

• Carotid Doppler
  – Atherosclerosis
  – Vertebral Dissection
  – Vessel occlusion
• Transcranial Doppler (vasospasm)
• Embolus detection test

Biopsy - General

• Pre-procedure patient teaching specific to test performed
• Informed consent obtained
• Post-biopsy wound monitoring:
  – Bleeding
  – Infection
  – Pain
Biopsy - Muscle

• Minor surgical procedure.
• Done under local anesthetic.
• Required less as disease causing genes are identified.
• Invasive test to confirm a diagnosis in:
  – Mitochondrial Disease (MELAS)
  – Neuromuscular Diseases

Biopsy - Nerve

• A small piece of nerve from wrist or ankle may be obtained to test for demyelinating diseases and nerve degeneration
• Abnormal:
  – Amyloidosis
  – Inflammation
  – Sarcoidosis
  – Demyelination
  – Leprosy
Biopsy - Hair

• Hair specimens may be tested for the presence of heavy metals
• Abnormal:
  – Elevated Mercury, Lead or Arsenic
• Provide a DNA sample for genetic testing

Blood Testing

• Electrolytes
• Osmolality
• Hormone Levels
• Coagulability
• Pregnancy
Urine Studies

• Osmolality
• Electrolytes
• Creatinine Clearance
• Hormone Levels

Genetics

• Huntington Disease
• Charcot Marie Tooth
• Tay-Sachs Disease
• MELAS

• http://www.genedx.com/test-catalog/genetic-testing-for-neurological-disorders/
Bringing it all Together

• Increased Intracranial Pressure
  – Level of Consciousness
  – Pupillary Dysfunction
  – Motor weakness (hemi)
  – Sensory deficits
  – Cranial Nerve Palsy
  – Headache
  – Vomiting
  – Respiratory
  – Blood Pressure and Pulse

References

Please visit the websites embedded within this presentation for more useful resources

Some old school book sources: