Neurology

Cranial Nerves

- Benign = transient palsy; Bad = herniation, aneurysm or stroke
- *3rd Nerve palsy* can be due to mechanical compression from uncal herniation or mechanical compression from aneurysm leading to ipsilateral blown pupil. Pupil sparing with eye down and out is due to ischemia
- *4th Nerve palsy* is vertical diplopia, can't read, can't go downstairs due to impaired superior oblique muscle palsy
- *5th Nerve palsy*: corneal reflex, herpes zoster, trigeminal neuralgia (women>men, electric pain, compression, carbamazepine, surgery?)
- *6th Nerve palsy:* lateral rectus, can't look to the left, can be a false localizing sign due to possibility of global increased intracranial pressure (ICP) leading to compression
- *7th Nerve palsy:* Bell's Palsy includes lower motor neuron finding, peripheral, involves forehead. If forehead sparing think central and stroke
    - Bilateral bell's palsy= Lyme disease
- *8th Nerve palsy:* impaired hearing is peripheral and balance and vertical nystagmus is central
    - The 5 D's (dizziness/vertigo, diplopia, dysarthria, dysphagia, dysmetria) concerning for central etiology and crossed findings of long tract of motor/sensory and plantar reflexes
- Isolated Vertigo:
    - **Acute Vestibular Neuritis**: viral, gradual onset, positive head impulse test, tx with suppression meds corticosteroids
    - **Benign Positional Peripheral Vertigo**: otolith debris, <1 minute episodes, positive Dix-Hallpike test, tx with Epley maneuver
    - **Cerebellar stroke**: vascular, sudden onset, negative head impulse test, tx with ASA and admit
- **Bilateral INO** (internuclear ophthalmoplegia) think combined 3rd and 6th nerve palsy and multiple sclerosis

Altered Mental Status and Coma

Less common and treatable diagnoses not to miss:

- CNS: non-convulsive status eplilepticus
- Toxic: CO toxicity, toxic alcohols, sedative/hypnotic withdrawal, aspirin toxicity, neuroleptic malignant syndrome, serotonin syndrome
- Trauma: non-accidental trauma
- Endocrine: thyroid storm, myxedema coma
- Environmental: bites and stings
- Metabolic: CO2 narcosis, hepatic/renal encephalopathy
- Hematology: thrombotic thrombocytopenic purpura

- Calculate GCS and think about airway protection with GCS <8
- Can give the coma cocktail
    - First thiamine (for Wernicke's encephalopathy)
    - Glucose (only if hypoglycemia)
    - Naloxone (if opioid overdose)

Hydrocephalus

Definition: dilated ventricles and large sulci

Normal pressure hydrocephalus

    - classic triad of wet, wacky, wobbly (incontinence of urine, altered, ataxia)
- VP shunt obstruction: need to compare to old CT to see if obstruction or there can be a shunt break/disruption which would be evident on xray.

Idiopathic Intracranial Pressure

- Formerly "pseudotumor cerebri"
- Chronic headaches (ICP pattern-worse in morning, improved with standing)
- Young obese women, can go blind, papilledema
- CT is normal, lumbar puncture is diagnostic and therapeutic
- Associated with hypercoagulable state (continuum with dural venous sinus thrombosis)

Movement Disorders

- Balance between dopamine and acetylcholine is disturbed
- Dystonia treated with anticholinergics
- Parkinson's treated with L-dopa

Hemorrhagic stroke

- Mortality worse in hemorrhagic stroke, but cells themselves are only stunned (i.e. recoverable) so if survives, ultimate prognosis is better

Intra-parenchymal hemorrhage

- Majority present with acute headache
- 4 classic distributions:
    - Basal ganglia (50%)
    - Thalamus
    - Pons (pinpoint pupils)
    - Cerebellum
- Treatment

    - Reverse coagulopathy
    - These tend to rebleed early
    - Lower ICP if herniating
    - Lower BP – controversial but recommended (goal 160/90)
    - Remember: no penumbra in bleed
- Surgical tx: craniotomy (cerebellar) vs ventriculostomy
- Complications (other than the obvious)
    - Bleed into ventricle → hydrocephalus

Subarachnoid hemorrhage (SAH)

- 3 major causes of spontaneous SAH
    - Ruptured aneurysm
        - Circle of Willis, most common is anterior communicating artery
    - Leaking arteriovenous malformation (AVM)
        - Can see popcorn calcifications in area of hemorrhage on CT
    - Peri-mesencephalic bleed
        - No evidence of aneurysm
- Diagnosis: sudden onset, maximal at onset, different from previous headaches, "worst headache" can be misleading, CT → if positive, no need for LP (otherwise LP as soon as possible)
- Treatment:
    - Neurosurgery consult
    - Pain control (will help bring BP down)
    - BP control
    - Spasm control (nimodipine)
    - Seizure control

Interpreting the LP

- CSF should clear almost completely of RBCs
    - Reducing RBCs without total clearing may just represent a traumatic tap + baseline SAH
    - When in doubt, repeat LP at a different interspace
    - Swadron says cutoff ~100
- Xanthochromia
    - Useful out of acute window once red cells are gone
    - Breakdown of red cell products
    - Reliable present by 12 hours
    - Measured by visual inspection (i.e. can be subjective)

Ischemic stroke

Large arteries (cortical)

- Motor, sensory + executive function deficit
- Deficits are on contralateral side of body
    - Anterior Cerebral Artery: leg deficit predominant
    - Middle Cerebral Artery: face and arm deficit predominant
    - Posterior Cerebral Artery (posterior circulation): homonymous hemianopsia
- Treatment
    - Airway!
    - Head of bed 30 degrees to prevent aspiration and decrease ICP
    - NPO
    - Bedrails
    - Aspirin 160-325mg PO (if no blood on CT and no anticoagulants)
    - *Gentle, gradual BP control* (over 24-48h) with repeat neuro exams
    - No hypotonic fluids (will worsen swelling)
    - Fever control
    - Blood sugar control (but avoid very tight control)
    - Reverse anticoagulation
        - daily risk of not being anticoagulated for underlying condition is far less than risk of bleeding into infarct
    - DVT prophylaxis (ward)
    - Hemicraniectomy in large infarct? … maybe

*Take home: skilled nursing care is critical! → largest reduction in stroke mortality in the acute phase

Indications for tPA

- Greater than 18 years old
- Onset < 4.5 hours
- Negative CT (i.e. no bleed, swelling)
- It's really a stroke!
    - Not hypo/hyperglycemia, Todd's paralysis, etc.

Contraindications to tPA

- **Too small or too big**
- Seizure
- Ischemic stroke/head trauma within 3 months
- Major surgery within 2 weeks
- ICH ever
- Sustained BP > 185/110 mmHg
- Aggressive BP treatment necessary
- Subarachnoid hemorrhage symptoms/signs

- GI/GU hemorrhage (within 21d)
- Arterial puncture at noncompressible site (within 7d)
- Heparin (within 48h with elevated PTT)
- PT>15s
- Platelets < 100,000 uL
- Serum glucose <50 or >400 mg/dL

Stroke mimics

- Metaboilc
- Hypoglycemia
- Hyperglycemia
- Hepatic encephalopathy
- Uremic encephalopathy
- Drugs/Toxins
- Psych
- Other CNS
- Space occupying lesion (tumor, subdural hematoma, abscess)
- Encephalitis
- Cord/Root peripheral lesions
- Post-ictal (Todd's paralysis): can last up to 24h!
- Hemiplegic migraine

Lacunar Stroke

- Affects small perforating vessels off of MCA/ACA (same vessels as intra-parenchymal hemorrhages)

Lacunar vs Cortical infarcts

Lacunar	Cortical
Small infarct	Large infarct
Better prognosis	Worse prognosis
Stuttering course	Progressively worse
LOC intact	Decreasing LOC
Motor OR sensory	Motor AND sensory
No cortical signs	Cortical dysfunction (ie aphasia/neglect)

Lacunar Infarcts

- Anatomy: The middle cerebral artery (MCA) and anterior cerebral artery (ACA) have **branches** known as **penetrating arteries** that provide blood to the brain's **deep structures**. These arteries can cause bleeding-type strokes or become occluded and result in ischemic **strokes** known as

"**lacunes**." As the area infarcts after time the areas liquefy and you see small lacunes/lakes in the brain. These strokes affect the electrical fibers of the brain

- Characteristics: Lacunar infarcts are **smaller** than cortical infarcts, have a **better prognosis**, **stuttering course**, and **consciousness remains intact**
- Sx: **pure motor OR sensory** symptoms, no cortical signs
- Tx: observation, occupational/physical therapy, and preventative measures for future (aspirin, anti-hypertensive, etc.)

Cortical Infarcts

- Anatomy: Cortical infarction involves a much larger territory and occurs when a **larger vessel** like the MCA is involved, it covers areas of **motor and sensation** which can have more drastic effects. These infarcts also affect the thinking part of the brain = **executive functions** (language, direction, recognition, etc). If a patient bleeds after their ischemic stroke, it is more likely going to occur in the cortical area.
- Characteristics: Cortical infarcts are **large**, have a **worse prognosis** than lacunar infarcts, get **progressively worse**, and patients have a **decreased level of consciousness**
- Sx: **motor and sensory symptoms**, **cortical dysfunction** (ex. aphasia/neglect)
    - Ex. 1. **MCA** stroke patients get **hemiplegia and sensory loss of the contralateral side** affecting the face/arm/hand, and can present with contralateral **homonymous hemianopia** – visual field deficits affecting the same half of the visual field in both eyes
    - Ex. 2. **ACA** stroke signs include **contralateral leg weakness and sensory loss**
- Tx: **thrombolysis** with tissue plasminogen activator (tPA) with a **last known well time <3 hours**, or **intra-arterial techniques**: thrombolysis, aspiration, and embolectomy

**Fun Fact: Transient global amnesia (TGA) is different than a cortical infarct! With TGA the patient has temporary disruption of short-term memory loss, will not have any motor/sensory findings, and work-up will be negative. The patient will improve with a good prognosis. TGA only recurs 1-5% of the time!*

Posterior Circulation Strokes

- Anatomy: Posterior circulation strokes occur at the base of the brain including the occipital lobes that are supplied by the **posterior cerebral artery (PCA)**. The PCA comes off the **vertebral basilar system** which supplies the **brainstem and cerebellum**. Circulation can be affected at the level of the vertebral arteries, basilar artery or PCA and their branches.

- Sx: **Stuttering**, may have **crossed findings** (in the brainstem fibers cross over), and the **5 D's: Dizziness (Vertigo), Diplopia, Dysarthria, Dysphagia, Dysmetria**
- Tx: thrombolysis if last known well time <3 hours, or intra-arterial techniques

Transient Ischemic Attack (TIA)

- Definition: TIAs are essentially mini-strokes, a TIA is a **brief episode** of neurologic dysfunction that results in **temporary cerebral ischemia** and is not associated with infarction
- Importance: 2-3 days after a TIA, 5% will have a major stroke, and within 90 days 10% will have a major stroke
- **Risk Stratification for TIA admission**: **ABCD2**
  Patients are assigned a specific score based on these high risk features:
  - **A**ge>60 years old
  - **B**P systolic >140 or diastolic > 90
  - **C**linical feature: unilateral weakness, **C**linical feature: speech disturbance without weakness
  - **D**uration of symptoms 10-60 min, **D**uration of symptoms >60min, **D**iabetes
  - The score will determine low/moderate/high risk, which will give a percent prediction of a major stroke within 2 to 90 days
- This will help determine if the patient should be **admitted** for **further work-up** for a **carotid doppler** and **echocardiogram**
  - Two interventions that **save lives after TIA** include:
    - **Carotid Endarterectomy** for **stenosis >70%**
    - **Anticoagulation for Atrial Fibrillation**, **LV thrombus**
- Tx: **Antiplatelet agent**: aspirin/dipyridamole/clopidogrel.

Cerebral Venous Sinus Thrombosis

- Definition: Presence of thrombosis (blood clot) in the dural venous sinuses
- Risk factors: **hypercoagulable states** including pregnancy, puerperium, malignancy, hormonal therapy, head and neck infections
- Sx: **severe headache**, drowsy, venous findings: **bilateral symptoms** of stroke-like symptoms but in a non-arterial/vascular pattern, seizures
- Dx: On CT scan of the head without contrast: **Delta sign** – blood clot in the confluence of sinuses (like a triangle). **Inverse Delta Sign** on the CT head with contrast: everything shows up white except the darker area in the confluence of sinuses (reverse of delta sign)
  - Diagnose with the gold standard: **MR Venography**
- Tx: neurosurgical consult, remove clot, dissolve with TPA, craniectomy

Cervical Artery Dissection

- Sx: severe, **thunderclap headache** (like SAH). If the dissection occurs in the carotid system: **lancinating pain** in the face, if in the vertebral system: nuchal lancinating pain
- May occur in minor trauma like yoga/vigorous coughing/chiropractic manipulation
- Work-Up: CT head negative/LP negative
- Importance: Clot from a dissection can secondarily cause a **stroke**
- Tx: **Anticoagulation** (neurosurgical consult – angioplasty/stenting in very rare cases)

CNS Infections

Bacterial Meningitis

- Sx: **headache, neck stiffness**, Brudzinski's and Kernig's signs (later findings), **fever**, **photophobia**
- *Note in children: no neck stiffness, irritable/not feeding well*
- Bacteria:
    - All age groups: **Strep pneumoniae** is **most common**
    - **College kids** living in a **dorm**: **Neisseria meningitidis** (rash, adrenal failure, shock)
    - **Infants < 1 month**: **Group B Strep, E. Coli, Listeria**
- Work-up: order CT head before LP especially if old, immunocompromised, altered mental status, focal neuro exam, if there is a **mass effect can cause herniation** with an **LP**
- LP results: gram stain+, >1000 cells (PMNs), low glucose
- Tx: **Steroids (first) then antibiotics** (**do not delay** if high suspicion!):
    - 3rd Generation Cephalosporin *(except in children less than 1 month use Cefotaxime, with **Ceftriaxone** can get kernicterus due to protein binding)* + **Vancomycin** (for DRSP=Drug Resistant Strep Pneumoniae) +/- **Ampicillin** (for Listeria, especially for very young/ old, immunocompromised)

Aseptic Meningitis

- Sx: **viral URI or GI symptoms** prior to meningeal symptoms, recurrent meningitis = Mollaret's meningitis
- Viruses: enteroviruses, west nile, herpesviruses: HSV2, VZV
- LP results: **negative gram stain**, <1000 cells (**lymphocytes/monocytes**), normal glucose
- Tx: IV **Acyclovir** (specifically for Herpes/Varicella Zoster Virus)

Tuberculous (TB) meningitis

- Affects base of brain where there is the most oxygen (**brainstem**)
- Sx: longer course of meningitis with **cranial nerve findings**, risk factors for TB
- LP results: **low glucose** in CSF, +AFB/+TB culture
- Tx: **steroids** and anti-TB medications (RIPE)

Fungal Meningitis

- Sx: longer course of symptoms in those who are immunocompromised (ex. low CD4)
- LP results: **cryptococcus** is seen on **India Ink Stain**, (high opening pressure with cryptococcus), +fungal culture
- Tx: IV Amphotericin B or fluconazole

Encephalitis

- Definition: Inflammation involving the inside of the brain, most commonly caused by viral infections or spread from bacterial meningitis
- Sx: **altered mental status**, no meningismus (unless patient has meningoencephalitis)
- Viruses: most important is **HSV1** causing **bloody and necrotizing encephalitis** – mainly affecting the temporal lobe (high mortality)
- LP results: nontraumatic RBCs with HSV1, diagnosis with PCR
- Tx: **IV Acyclovir**

Brain Abscess

- Ddx of brain mass lesion: brain abscess, toxoplasmosis (most common mass lesion in AIDS), tumor
- Tx: IV antibiotics, steroids, +/- surgical drainage (neurosurgical management)

Spinal Epidural Abscess

- Risk Factors: **IVDU/immunocompromised** (AIDS/diabetes)
- Sx: **midline back pain** (especially **thoracic**), may be afebrile
- Dx: **ESR is sensitive**, **MRI**

    - On the MRI: ddx includes bleeding, tumor, ependymoma, abscess, discitis (life threatening staph infection in the spine), osteomyelitis
- Tx: **decompress the spine** (neurosurgical management)

Fun Fact: These are **important spinal cord levels to memorize!*
Dermatomes: T4-nipple. T10-umbilicus
Reflexes: C5-Biceps, C7-Triceps, L4-Quadriceps (patellar tendon), S1-Ankle, T8-T12 Abdominal, L1-L2- Cremaster, S2-4-Anal reflex

Upper Motor Neuron Findings vs Lower Motor Neuron Pathology

- UMN Sx: hyperreflexia, positive Babinksi, increased tone
- LMN Sx: wasted muscle, hyporeflexia, fasciculations (spontaneous muscle contractions)

Lower Motor Neuron Emergencies

Cauda Equina Syndrome

- Definition: **any lesion/central disc herniation into the cauda equina** (**below L1**)
- Sx: **back pain**, **urinary retention** with overflow incontinence, **fecal incontinence**, **saddle anesthesia**, bilateral weakness/sensory loss (ex. bilateral sciatica)
- Tx: STAT surgery (neurosurgical management)

Conus Medullaris Syndrome

- Definition: similar to cauda equina syndrome, but it's **above L1** and it is a upper motor neuron lesion
- Sx: acute presentation can be similar to cauda equina syndrome.
- Signs: initially this UMN lesion can present with LMN lesion-type signs (UMN signs/symptoms develop later), **Babinski** will be always **positive** in an UMN lesion
- Tx: neurosurgical management

Guillain Barre Syndrome

- Definition: **Autoimmune demyelination**
- Sx: **preceding infection**: gastroenteritis (Campylobacter), or pneumonia (Mycoplasma), with subsequent **ascending weakness, loss of reflexes**, and **sensory loss**
- Tx: **plasmapheresis** (remove circulating antibodies) or **IVIG**, manage the **airway** when necessary (diaphragm may become paralyzed)

Tick Paralysis

- Sx: similar symptoms to Guillain Barre, with ascending weakness (no sensory symptoms)
- Tx: remove the tick

Upper Motor Neuron Emergencies

Multiple Sclerosis (MS)

- Definition: demyelinating disease of the brain and spinal cord
- Classic Signs: **Bilateral INO** (internuclear ophthalmoplegia), **optic neuritis** (acute blindness with **APD** – afferent pupillary defect – with/without pain and with/without disc edema), **Lhermitte's sign** (flex neck and electrical sensation down spine), **different lesions separated by space and time** (ex. tingling in arm one year ago, now weakness in left leg)
- Dx: MRI brain shows plaques of MS, "Dawson's Fingers"
- Tx: steroids, interferon (different treatments for symptoms/acute attacks)

Amyotrophic Lateral Sclerosis (ALS)

- Sx: mix of **upper and lower motor neurons affected**, progressive illness, spasticity, fasciculations, muscle wasting
- Tx: riluzole, supportive care

Syringomyelia

- Definition: development of a cyst or **cavity in the upper spinal cord**
- Sx: **wasted muscles** in the **hands** (interosseous wasting), **loss of pain and temperature sensation in hands**, as expands may have upper motor neuron lesions and symptoms, profound **headaches** from **Chiari malformation** associated with syrinx: **tonsillar herniation** causing intermittent obstruction of CSF and headaches
- Tx: neurosurgical management of syrinx (watchful waiting with MRI or drain syrinx if severe symptoms), with Chiari malformation: **decompress the cerebellar tonsils**

Myasthenia Gravis (MG)

- Autoantibodies against cholinergic receptors
- 25% of cases associated with Thymoma
- Presentation: CN 3 palsy, ptosis, impairment of extra-ocular movement
- Proximal muscle weakness → unable to get out of chair, weak pelvic girdle muscles

- Diaphragmatic weakness → **hypoventilation/airway compromise**
- Cardiac arrhythmias and AV blocks sometimes seen on ECG
- Treatment/Dx: **Airway is First Priority** – follow vital capacity and intubate in necessary
    - Edrophonium (Tensilon) test → blocks acetylcholinesterase and increases [Ach]
    - If improvement with Edrophonium → diagnostic
    - Ice Pack Test: if ptosis improves with ice pack application → diagnostic
    - If associated with Thymoma, surgical removal

Critical Differential Dx: Horner's Syndrome, CN 3 palsy, Lambert-Eaton

- MG → fatigue with repetitive movement
- Lambert Eaton → increase in strength with repetitive movement

Acute Periodic Paralysis

- Hereditary condition associated with **thyroid disease (hyperthyroid)**, generally in young men, low K+ (1.6)
    - Not a deficit in whole body potassium, transmembrane shift of K into cells
- Presentation: typically young men who present with lower extremity weakness
- Treatment: **Do not aggressively replace K+**
    - Oral replacement of K+, start off with 40-80meq KCl PO
    - Beta Blockers → shift of K+ outside of cells

Critical Differential Dx: Spinal Cord Compression, Guillain-Barre, and Tick Paralysis

Seizures

- Abnormal/disorganized cortical electrical activity in the brain
- Various types: generalized/partial/tonic-clonic/absence/temporal
    - Generalized = loss of consciousness
- Etiology of seizures is vast → consider: metabolic, structural, toxin, febrile, infections, and eclampsia
- **Status Epilepticus → seizure without return to baseline and/or persistence of seizure**
- Treatment: Stop the seizure:
    - First line: Benzos/Barbiturates
    - Second Line: phenytoin, levetiracetam, propofol
- Treatment in Special Circumstances:
    - **Eclampsia** → check HCG, treat with Magnesium 6gm IV
    - If isoniazid (INH) toxicity suspected → Vitamin B6/Pyridoxine
        - **B6 treatment is 1gm per 1gm of INH toxicity**

    - If patient without return to baseline, **consider subclinical status→ obtain EEG**

Important Seizure Concepts: AED (antiepileptic drugs) cause problems → SJS/TEN, hypersensitivity

- Todd's Paralysis → neurologic deficits/findings post seizure lasting up to 24 hours
- Pseudoseizures are highly associated with underlying seizure disorder

Primary Headaches

- Non life-threatening headaches: Tension, Migraine, and Cluster headaches
    - Tension Headache: bilateral, musculoskeletal, generally associated with stress
    - Migraine Headache: unilateral with aura, can be associated with photo/phonophobia
        - **Menses → common trigger**
    - Cluster: Intense lancing headache generally unilateral behind eye
- Treatment: overlapping treatments for all primary headaches
    - Triptans, Dopamine Antagonists (Compazine, Reglan, Prochlorperazine)
    - Oxygen via nasal cannula
    - Intra-nasal lidocaine

Critical Differential Dx: Rule out life-threatening causes of headache, i.e. SAH, meningitis, mass