# Herniation and Beyond

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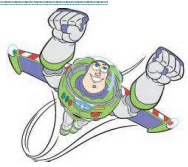


## Objectives

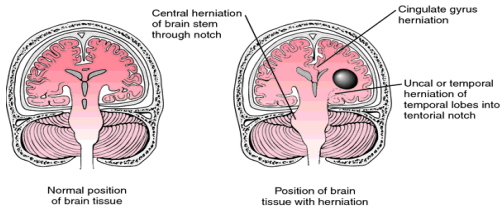
- Define Herniation Syndromes
- Explain care during herniation
- Identify how a brain death diagnosis is made
- Describe the care of an organ donation patient
- Case study

## Definition

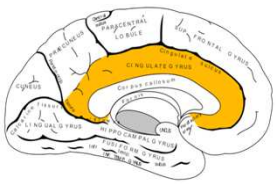
- Brain herniation represents mechanical displacement of normal brain relative to another anatomic region secondary to mass effect from traumatic, neoplastic, ischemic, or infectious etiologies.

## Herniation Syndromes

- Cingulate (Subfalcine)
- Uncal (Transtentorial)
- Central
- Infratentorial or Tonsilar
- Transcalvarial



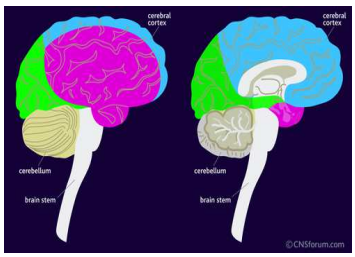

## Cingulate



- **cin·gu·late her·ni·a·tion**
- displacement of the cingulate gyrus beneath the falx.
  - Farlex Partner Medical Dictionary © Farlex 2012

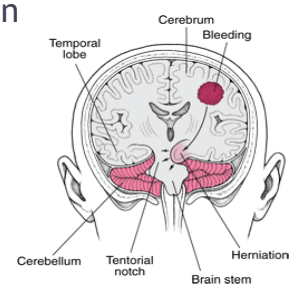
## Clinical Symptoms of Cingulate Herniation

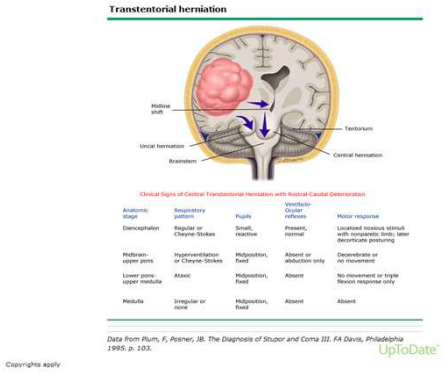
- usually none unless the Anterior Cerebral Arteries (blue in the picture) are compromised.
- Headache
- Contralateral leg weakness



## Uncal Herniation

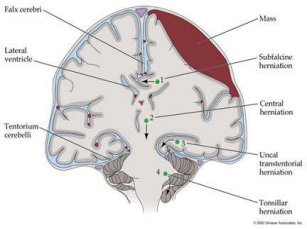
- Herniation of the medial temporal lobe inferiorly through the tentorial notch.
- Signs/Symptoms
  - Blown pupil
  - Hemiplegia
  - Coma




## Central Herniation

- central downward pressure
  - displacement of brain stem




## Infratentorial

**Downward Cerebellar (Tonsilar)**

- Herniation of the cerebellar tonsils through the foramen magnum.
- Compresses Brainstem
- Signs/Symptoms
  - respiratory arrest --> compression of some resp centers in the medulla.
  - Blood pressure instability
  - Small, dilated, fixed pupils
  - DI

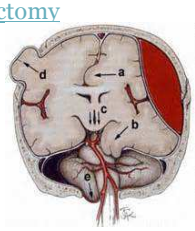
**Upward Cerebellar**

- where pressure from the back of the cranial cavity pushes the cerebellar tissue upwards.
  - expanding mass (tumor, blood) in the posterior fossa.

http://emedicine.medscape.com/article/337936-overview

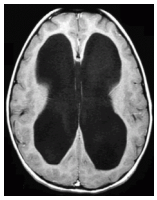
## Transcalvarial Herniation

- the brain squeezes through a fracture or a surgical site in the skull
- may occur during craniectomy



## Causes of Brain Herniation

- **Diffuse Causes**
  - Generalized swelling of the brain
  - Hydrocephalus
- **Focal Causes**
  - Abscess
  - Tumor
  - Intracranial hematoma



## Care During Herniation

Objective 2

## ICP (Intracranial Pressure)

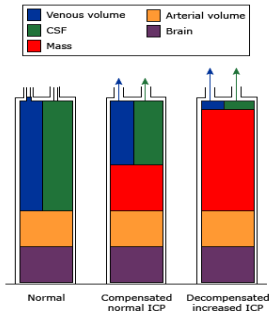
- Normal ICP ≤15mmHg
- Intracranial HTN present at pressures ≥20mmHg
- Intracranial components:
  - Brain parenchymal 80%
  - CSF 10%
  - Blood 10%
- ICP: function of the volume and compliance of each component of the intracranial compartment

## Causes of increased ICP

- Mass lesion
  - tumor, hematoma
- Cerebral edema
- Increased CSF production
  - choroid plexus papilloma
- Decreased CSF absorption
- Hydrocephalus
- Obstruction of venous outflow
  - sinus venous thrombosis
- Idiopathic intracranial hypertension
  - pseudotumor cerebri
- Vasculitis
- Traumatic brain injury
- ICH
  - Subdural, epidural, or intraparenchymal
- Ruptured aneurysm
- Diffuse axonal injury
- Arteriovenous malformation or other vascular anomalies
- Central nervous system infections
  - encephalitis, meningitis, abscess
- Ischemic stroke

## Intracranial compliance

- Compensatory mechanisms
  - Displacement of CSF
  - Decrease volume of cerebral venous blood
- Autoregulation
  - With normal CBF autoregulation occurs with CPP 50-100 mmHG
  - Less than normal CBF, brain can become very sensitive to even minor changes in CPP and cannot autoregulate

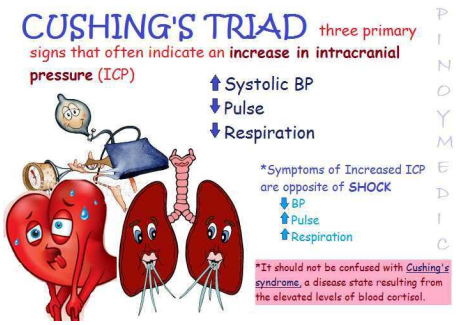



Data from Pathophysiology and management of the intracranial vault. In: Textbook of Pediatric Intensive Care, 3rd ed, Rogers, MC (Ed), Williams and Wilkins 1996. p. 646; figure 18.1. Graphic 65853 Version 3.0

http://www.uptodate.com/contents/image?imageKey=PULM%2F65853&source=outline_link

## Clinical Manifestaions of Increased ICP

- Headache
- Decreased LOC
- Nausea, Vomiting
- CN VI palsies
- Papilledema
- Spontaneous periorbital bruising
- Cushing's Triad:
  - Bradycardia
  - Respiratory Depression
  - Hypertension

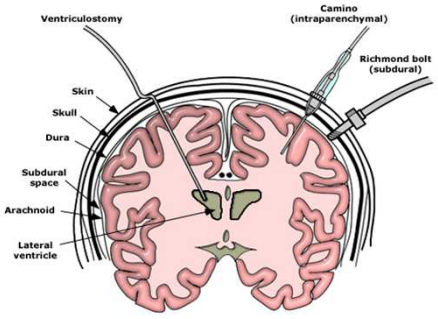


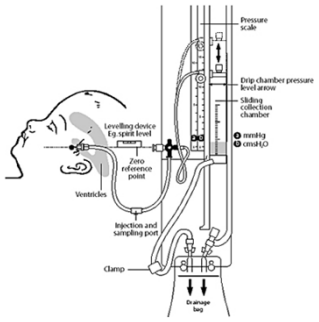

## Treatment of elevated ICP

- Head Elevation
- Neutral neck alignment
- Turn lights off
- Quite room
- Afebrile (and not shivering)
- Oxygen
- Sedation
- Paralytics

## Treatment of Elevated ICP cont.

- Resuscitation:
  - Avoid hypotension
  - Euvolemia
  - Isotonic fluids, no free water (hyponatremia common with elevated ICP)
- Mannitol, 23% sodium bolus
- Hyperventilation $PaCO_2$ 26-30
- Pressors
- EVD placement for monitoring ICP and removal of CSF
- Decompressive Craniectomy



# Diagnosis of Brain Death

Objective 3

## Brain Death Mimics

- Locked-in Syndrome
- Neuromuscular paralysis (polyneuropathies, NMBA)
- Drug intoxication
- Guillain-Barre syndrome
- Hypothermia
- Metabolic extremes (acid-base balance, endocrine or electrolyte abnormality)
- Shock (SBP<100)

## Perquisites for Brain Death Testing

- Coma, irreversible and cause known
- CNS depressant drug effect absent (if indicated toxicology screen; if barbiturates given, serum level < 10 µg/mL)
- No evidence of residual paralytics (electrical stimulation if paralytics used)
- Absence of severe acid-base, electrolyte, endocrine abnormality
- Core Temperature > 36° C / 96.8° F
- SBP > 100 mm Hg
- No spontaneous respirations

## Coma Scales

**FOUR Score**

| Eye Response | |
|---|---|
| **Action** | **Score** |
| Opens eyes spontaneously, tracks, blinks to command | 4 |
| Opens eyes, does not track or blink to command | 3 |
| Eyes closed; open to loud voice | 2 |
| Eyes closed; open to painful stimulation | 1 |
| Eyes remain closed following painful stimulation | 0 |
| **Motor Response** | |
| **Action** | **Score** |
| Obeys, makes sign, e.g., "thumbs up" | 4 |
| Localizes painful stimulus | 3 |
| Flexes to painful stimulus | 2 |
| Extends to painful stimulation | 1 |
| No response | 0 |
| Myoclonic status epilepticus | 0 |
| **Brainstem Reflexes** | |
| **Action** | **Score** |
| Pupils +, corneals +, cough + | 4 |
| 1 pupil unreactive, corneals +, cough + | 3 |
| Pupils -, corneals +, cough NA | 2 |
| Pupils +, corneals -, cough NA | 2 |
| Pupils -, corneals -, cough + | 1 |
| Pupils -, corneals -, cough - | 0 |
| **Intubation** | |
| **Action** | **Score** |
| Not intubated, normal respirations | 4 |
| Not intubated, Cheyne-Stokes respirations | 3 |
| Not intubated, irregular respirations | 2 |
| Not intubated, apneic | 0 |
| Intubated, breathes above ventilator settings | 1 |
| Intubated, breathes below ventilator settings | 0 |

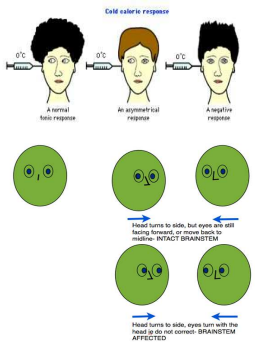
Legend: + = present, - = absent. Each category has a maximum of 4 and a minimum of 0. The results of each category are added together for the total FOUR score.

**Glascow Coma Scale**

| | | |
|---|---|---|
| Best eye response (E) | Spontaneous--open with blinking at baseline | 4 |
| | Opens to verbal command, speech, or shout | 3 |
| | Opens to pain, not applied to face | 2 |
| | None | 1 |
| Best verbal response (V) | Oriented | 5 |
| | Confused conversation, but able to answer questions | 4 |
| | Inappropriate responses, words discernible | 3 |
| | Incomprehensible speech | 2 |
| | None | 1 |
| Best motor response (M) | Obeys commands for movement | 6 |
| | Purposeful movement to painful stimulus | 5 |
| | Withdraws from pain | 4 |
| | Abnormal (spastic) flexion, decorticate posture | 3 |
| | Extensor (rigid) response, decerebrate posture | 2 |
| | None | 1 |

## Neurologic Exam

- Pupils nonreactive to bright light
  - CN II and III
- Absent Corneal, gag, cough reflex
  - Corneal: CN V and VII
  - Gag, Cough: CN IX and X
- Oculocephalic Reflex absent, Oculovestibular reflex absent
  - cranial nerve VIII, III and VI
-

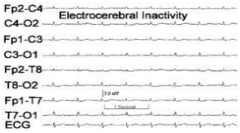



## Neurologic Exam Continued

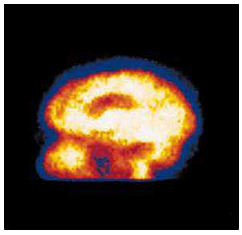
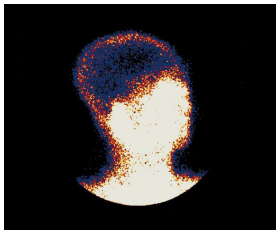
- Absence of motor response to noxious stimuli in all four limbs (spinally mediated reflexes are permissible)
- No facial movement to deep pressure on the condyles at the level of the temporomandibular joints and deep pressure at the supraorbital ridge
  - CN: afferent V and efferent VII

## Other tests

- **Apnea Testing**
  - Spontaneous respirations absent
  - $PaCO^2 \geq 60$ mm Hg or 20 mm Hg rise from normal baseline value
- Isoelectric EEG
- Nuclear Medicine Study
  - Absence of cerebral blood flow




## Nuclear Medicine Test

| Normal | Abnormal |
|---|---|
|  |  |

## Care of a organ donor patient

Objective 4

## History of Organ Transplants

- **800 B.C.**
  - Indian doctors had likely begun grafting skin—technically the largest organ—from one part of the body to another to repair wounds and burns.
- **16 Century**
  - Italian surgeon Gasparo Tagliacozzi, reconstructed noses and ears using skin from patients' arms. He found that skin from a different donor usually caused the procedure to fail, observing the immune response that his successors would come to recognize as transplant rejection.
- **Early 1900s**
  - European doctors attempted to save patients dying of renal failure by transplanting kidneys from various animals, including monkeys, pigs and goats. None of the recipients lived for more than a few days.
- **1905**
  - Eduard Zirm, an Austrian ophthalmologist, performed the world's first corneal transplant, restoring the sight of a man who had been blinded in an accident.
- **1912**
  - Transplant pioneer Alexis Carrell received the Nobel Prize for his work in the field. The French surgeon had developed methods for connecting blood vessels and conducted successful kidney transplants on dogs. He later worked with aviator Charles Lindbergh to invent a device for keeping organs viable outside the body, a precursor to the artificial heart.

## History of Organ Transplants Cont.

- **1936**
  - Ukrainian doctor Yu Yu Voronoy transplanted the first human kidney, using an organ from a deceased donor. The recipient died shortly thereafter as a result of rejection.
- **1954**
  - Surgeons in Boston transplanted a kidney from 23-year-old Ronald Herrick into his twin brother Richard; since donor and recipient were genetically identical, the procedure succeeded.
- **1960**
  - British immunologist Peter Medawar, who had studied immunosuppression's role in transplant failures, received the Nobel Prize for his discovery of acquired immune tolerance. Soon after, anti-rejection drugs enabled patients to receive organs from non-identical donors.
- **1960s**
  - The first successful lung, pancreas and liver transplants took place. In 1967, the world marveled when South African surgeon Christiaan Barnard replaced the diseased heart of dentist Louis Washkansky with that of a young accident victim. Although immunosuppressive drugs prevented rejection, Washkansky died of pneumonia 18 days later.
- **1984**
  - As transplants became less risky and more prevalent, the U.S. Congress passed the National Organ Transplant Act to monitor ethical issues and address the country's organ shortage. The law established a centralized registry for organ matching and placement while outlawing the sale of human organs. More than 100,000 people are currently on the national waiting list.

## Catastrophic Brain Injury Guidelines

- Maintain MAP>60
  - Ensure arterial monitoring and central line
  - Adequate volume resuscitation, Euvolemia
  - Vasopressor support if necessary
    - Phenyephrine, Norepinephrine, Dopamine
    - It is better to have two pressors at lower doses that one maxed out

## Catastrophic Brain Injury Guidelines

- Maintain Urine Output >0.5 mL/kg/hr-3mL/kg/hr
  - Vasopressin 1-2.5 u/h
  - DDAVP 1 mcg IVP every 15 minutes until UO <200mL/h

## Catastrophic Brain Injury Guidelines

- Maintain SaO2>94%
  - Minimum 5-8 PEEP
  - TV 6-8 mL/kg of Ideal Body Weight keeping plateau pressure <35
  - Frequent ABG with pH goal 7.2-7.5
  - Suction every one hour, Oral care every two hours
  - Turn patient every two hours
  - May need bronchodilators every 4 hours to prevent bronchospasm

## Catastrophic Brain Injury Guidelines

- Maintain sodium level <155 mmmol/L
- Monitor and treat electrolytes (K+, Mg, Phos, Ca)
- Monitor H&H and Coagulation factors
- Maintain temp >36 C
  - Need a rectal temp probe to closely monitor temperature
- Monitor glucose and treat with IV insulin
  - Maintain blood glucose 100-200

## MTN Orders

- Dextrose 5 % and sodium chloride 0.45 % infusion
- 100 mL/hr, Intravenous, Continuous
- Levothyroxine (T4) bolus and drip
  - 20 mcg Intravenous Once
  - levothyroxine (T4) infusion (1mcg/mL) at 10 mL / hour (10 mcg / hour)

## MTN Orders


- Methyprendisone 500 mg IV x1
- Narcan 8 mg IV x1
- Vecuronium 10 mg IV x1
- Lubricant eye drip, two drops each eye every hour

## MTN Orders

- Lymph node biopsy
- Surgery Consult for biopsy and lines (art line, central line)
- Cardiology Consult
- Chest X-ray
- Flo –Trac/PA catheter

## MTN Orders

- I & O every one hour
- VS with a core temp probe every one hour
- CO every 2 hours
- Suction every 1 hour
- Turn every 2 hours
- BC every 2 hours

## Labs

- CBC with Diff
- Mag
- Phos
- Calcium
- Lipase, Amalyse, AST, ALT, LDH,
- Albumin, total protein serum, Bilirubin total and direct
- Coags
- CK/CK-MB
- Blood, Urine, Sputum CX
- Serology and HLA matching
- Type and Cross
- Gamma Glutamyl Transferase
- Alkaline Transferase

## Case Study

Objective 5

## HD: History

- HD
  - 18 yo
  - Woke up with a HA at 0800
  - Went to work at 0900
  - Called mom at 1000 for HA medicine, vomited at work
  - Mom took her to pediatrician at 1100

## HD: History

- NP at pediatrician assessed patient
  - HA still there and getting worse
  - Photophobia
  - Temp 99.5 F oral
  - No nuclear rigidity
- NP and Physician decided to treat for a migraine
  - Demerol given IM
  - Phenergan given for nausea

## HD: History

- Mom checked on H every 20 minutes
- Mom heard a “thud” at 1400. H was not responsive on the floor and incontinent
- 911 called
- Taken to SLS, CT head showed edema
- LP done, cloudy in color, suspect meningitis
- Patient seized, intubated and sent to Plaza (1530)
- Mannitol pushed prior to heading to plaza

## HD: Admit

- Admit to NSICU at 1700
- Pressors started, SBP in 70's
- Multiple IV boluses
- Blood culture, urine culture, sputum culture sent (CSF sent at SLS)
- Left pupil 6 and nonreactive
- Spinal reflexes legs and arms
- No gag, no cough, no corneal reflexes

## HD: ICU day 1

- W2 shift: to MRI 1900
- Chemically coding patient prior to and during MRI
- MRI showed large abscesses in bilateral frontal sinuses
- Back to ICU: Right pupil 6 and nonreactive

## HD: Day 2

- UO increased to >300/h
- Hemodynamically stable, still on pressors
- No reflexes present
  - No motor
  - No corneal
  - No gag
  - No cough
  - Not over breathing ventilator

## HD

- Brain death testing done at bedside
- Nuclear med test completed
- Patient pronounced at 0930

## Donation Workup

- Cultures
- Regular work up
- Unable to go to the OR for 48 hours

## References

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