Neurophysiology
Lecture One: Neurophysiology and Evoked Potentials
Lecture Two: Clinical Neuroanesthesia

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University Hospital
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Topics Covered Today

- Intracranial Pressure
- Intracranial Compliance
- Cerebral Metabolism
- Cerebral Blood Flow
- Blood Brain Barrier
- Evoked Potentials
Neuroanesthesia at Upstate

- Everyone does a Neuro rotation
- Please read a textbook prior to neurorotation
- Neuroanesthesia is not complex; however small errors lead to big price to pay in terms of poor outcome
The cranial vault is a rigid structure.

It consists of the brain (80%), blood (12%) and CSF (8%).

Any increase in one component is offset by an equivalent decrease in another or else ICP increases.

Normal ICP is 0-10 mmHg.
FIG. 5-10 Ventricular and intraparenchymal pressure monitoring systems. The stopcock of the ventricular monitoring system (right) is fixed and must be positioned at the same height as the tip of the intraventricular catheter to properly "zero" the system. The graduated cylinder may be adjusted vertically. The height at which the CSF fluid column just spills over into the cylinder, with respect to the zero value of the stopcock, is the ventricular fluid pressure. The intraparenchymal monitor (left) is "zeroed" before insertion, and the monitoring box position will not affect readings.
Use of ICP monitor

- Fiberoptic ICP monitor
- Standard ICP monitor hooked to our HP monitors
- Ask for help on how to use the equipment
- Sometimes the ICP is to be left open
- Overdrainage as well as underdrainage has been a problem at SUNY
- Do not inject anything into the catheter
- Please aspirate SLOW if asked by surgeons
Intracranial Compliance

- As intracranial pressure increases, the body compensates:
  - Shift CSF to spinal canal
  - Increase CSF absorption
  - Decrease CSF production
  - Decrease Ce vv capacitance

Can Compliance be measured??
- Saline Test … 1:4 ratio
Herniation Sites

- Sustained increases in ICP can lead to herniation and cerebral ischemia/infarction
  - Cingulate gyrus
  - Uncinate gyrus
  - Cerebellar tonsils thru foramen magnum
  - Any skull defect as in trauma
• Intracranial Pressure
• Intracranial Compliance
• Cerebral Metabolism
• Cerebral Blood Flow
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• Evoked Potentials
Cerebral Metabolism

- $\text{CMRO}_2$ parallels activity of brain cells
- $\text{CMRO}_2$ is greatest in the grey matter of CCx
- $\text{CMRO}_2$ is 3-5 ml/100gm/minute in adults = 50ml/min
- Brain uses 20% of total body oxygen consumption, most of it for ATP production
FIG. 1-5  Oxygen requirements of the normal brain. Values are those obtained in the canine. (From Michenfelder JD: The hypothermic brain. In Michenfelder JD: Anesthesia and the brain. New York, 1988, Churchill-Livingstone.)

\[ \text{CMRO}_2 = 5.5 \text{ ml} \cdot 100\text{g}^{-1} \cdot \text{min}^{-1} \]
\[ \text{Function} = 3.3 \text{ ml} \cdot 100\text{g}^{-1} \cdot \text{min}^{-1} \]
\[ \text{Integrity} = 2.2 \text{ ml} \cdot 100\text{g}^{-1} \cdot \text{min}^{-1} \]
Cerebral Metabolism

- 90% of brain metabolism is aerobic
- O2 reserves are low, consumption is high
- Narrow margin of safety with hypoxia
- Primary fuel is glucose and oxygen
- Hypoglycemia is not well tolerated
- Hyperglycemia leads to cellular acidosis during ischemia
### IV Anesthetic and CMRO2

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* Sevoflurane and Desflurane similar
** 2 MAC and hypocapnia
Topics Covered Today

- Intracranial Pressure
- Intracranial Compliance
- Cerebral Metabolism
- Cerebral Blood Flow: A sometimes confusing topic
- Blood Brain Barrier
- Evoked Potentials
CeBF and CMRO$_2$

- CeBF is proportional to CMRO$_2$
- CeBF: Grey matter versus white matter
- Total CeBF is about 20% of CO = 750 ml/min
- EEG is used clinically to judge adequate CeBF
  - EEG Slowing in a normal brain
    - 20-25 --> EEG slowing
    - 15-20 --> isoelectric EEG
    - <10 --> irreversible damage
CeBF and Children

- **Newborn**: lower than adults
- **Infants and above CeBF**: higher than adults
- **Big Children (adults)**: Average BF is 1 liter/min; Grey matter is 1.2l/min and white matter is 0.3l/min
Spinal Cord Blood Flow

- Grey matter: 60 ml/100gm/min
  - Cerebral cortex --> 80ml/100 gm/min
- White matter 15-20 ml/100gm/min
Measuring CeBF

- Inhale RA inert gases: N\textsubscript{2}O, Krypton and Xenon
- Intraaeterial injection of inert gas: 133 Xe
- PET Scanning (Positive emission tomography)
  - Using radionucleotide that emits particles called positrons (11C, 15O, 13N, 18F)
  - Injection or inhalation
  - Need cyclotron
- NMR: Nuclear Magnetic Resonance; future promise
A. Intraarterial injection method

\[ \Delta \text{Height} = 100 \cdot \frac{\Delta \text{Area}}{\text{ml/100 g/min}} \]

\[ \text{Counting Rate cpm} \]

\[ \text{Time (min)} \]

B. \( \text{Xenon133} \)

\[ r\text{CBF}_{\text{initial}} = 200 \cdot D_0 \cdot \text{ml/100 g/min} \]

\[ \log_{10} \text{of Counting Rate} \]

\[ \text{Time (min)} \]

C. \( \text{Xenon133} \)

\[ r\text{CBF}_{\text{gray}} = 100 \cdot \lambda_{\text{gray}} \]

\[ r\text{CBF}_{\text{white}} = 100 \cdot \lambda_{\text{white}} \]

\[ 0.693 \]

\[ \frac{1}{2} \text{ fast} \]

\[ \frac{1}{2} \text{ slow} \]
Regulation of CeBF

- Cerebral Perfusion Pressure
- Autoregulation
  - Myogenic, metabolic (CMRO2)
- Extrinsic Mechanisms
  - $\text{PaO}_2$, $\text{PaCO}_2$, Temp, and viscosity
Cerebral Perfusion Pressure

- CeBF remains constant CeBF remains constant between 50-160 mm Hg despite changes in CePP (CePP = MAP-ICP or CVP)
- Beyond these blood flow is pressure dependant
- Normal ICP = 10 mmHg
- CPP < 50 mm Hg EEG slowing (w/ no anesthesia)
- CPP 25-40 mm Hg EEG flat (w/ no anesthesia)
Autoregulation

- Mechanism for autoregulation: thought to be myogenic and metabolic
- Myogenic involves the intrinsic property of cerebral blood vessels to control blood flow
  - Property of cerebral blood vessels to keep blood flow constant between a MAP of 60-160 mm Hg
  - Beyond these, the blood flow becomes pressure dependant
FIG. 2-4  Idealized depiction of pressure autoregulation in terms of CBF, cerebrovascular resistance, and arteriolar diameter. See text for further explanation. (From Young JW: Clinical neuroscience lectures. Munster, Ind, 1991, Catheart Publishing.)
Hypertension and CeBF/ICP

- Untreated HTN --> autoregulatory curve shifted to right
- If MAP > 150 --> “Autoregulatory breakthrough”
  - As MAP increase, CeBF goes up as it is now pressure dependent
  - BBB is disrupted and cerebral edema can ensue
Autoregulation Loss

• Hypoxia
• Hypercapnia
• Ischemia
• Trauma
• CVA
Extrinsic Mechanisms for control of CeBF: Blood Gas Tensions

- **PaCO$_2$**: Direct proportion between 20-80
- **CeBF changes** 1-2 ml/100gm/1mm change in PaCO$_2$
- **Marked Hyperventilation**: Cerebral Ischemia
- **Marked Hypoventilation**: pressure dependant CeBF
- **Limitation of hyperventilation**: after 6 hours, hyperventilation will not be effective
Extrinsic Mechanisms for control of CeBF: PaO2

- PaO$_2$ < 50 causes a rapid increase in CeBF
- Hyperoxia has little effect on CeBF
- Spinal cord reacts the same way as the cortex
FIG. 2-8  Influence of oxygen content (CaO₂) and PaO₂ on CBF. A, CBF is inversely proportional to CaO₂. B, Replotting the straight line in A by applying a sigmoid O₂ dissociation curve and taking the reciprocal produces the more familiar asymptotic curve of PaO₂ vs. CBF, which disguises the dependence of CBF on CaO₂. 5 kPa is approximately 40 mm Hg. (Redrawn by Lester RJA, Jones JG. In Seurr C, Feldman S, Sani N, editors: Scientific foundations of anaesthesia: the basis of intensive care. ed 2. Chicago. 1990. Year Book Medical Publishers, p 205, from original
Extrinsic Mechanisms for control of CeBF: Temperature

- For every one deg decrease in body temp, CMRO$_2$ decreases 5% --> leads to fall in CeBF
- Brain temp of 20deg C --> isoelectric EEG
Extrinsic Mechanisms for control of CeBF: Viscosity

- Polycythemia is detrimental to CeBF and can cause a CVA
- HCTs less than 30 improve CeBF but at the expense of decrease O2 carrying capacity
- Studies suggest the optimal HCT to be between 30 and 40
CMRO$_2$ parallels activity of brain cells; volatile agents uncouple metabolism from CeBF needs. This is then *Luxury Perfusion*

*Cerebral Steal:*
Blood is shunted from an area of that is ischemic to normal area. Setting: patient with CeVascular disease getting isoflurane dilates vasculature. Ischemic area gets blood shunted away from it
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Blood Brain Barrier

- What is the BBB?
- Rules governing transport across BBB
- Movement of water?
- Factors Disrupting the BBB?

- Vascular Endothelium that is fused
- Charge, lipid solubility, protein binding
- Bulk Flow; Role of Na⁺
- HTN, Tumor, Trauma, CVA, Ix, CO₂ and O₂
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Last Topic: Evoked Potential