Updates and Current Trends in Neuro-anesthesia

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But First, A Review….
- Of a few but very, very important key points to bear in mind related to brain physiology!

10 KEY POINTS Related to Neurophysiology
- Intracranial compartment has a fixed volume
- Hypoxia and ischemia = cell death
- Anesthetics decrease brain metabolism
- Preconditioning and augmentation of endogenous processes of repair (aka neurogenesis) are promising approaches to brain protection
- No evidence to support hypothermia
- No evidence to support: prophylactic Etomidate prior to vessel clamping
- Mg++ loading in ischemic stroke
- Intra operative NIO and ketamine
- Intra operative moderate hypothermia in SAH
- Post operative Nimodipine
- EP and Cerebral O2 monitors - effective to assess cerebral function, pharmacologic interventions and detect ischemia
- Image guiding – YES
- Safe anesthesia – involves basic principles of neurophysiology and effects of agents on the brain
- Anesthetic management of those with supratentorial disease maximizes therapeutic modalities that reduce ICP
- Challenge of infratentorial surgery – involves spinal neurologic監督 with surgical correction and exploration
Neurogenesis

- The development of new neurons continues during adulthood in 2 regions of the brain:
  - Subventricular zone (SVZ)
    - forms the lining of the lateral ventricles
  - Subgranular zone
    - forms part of the dentate gyrus of the hippocampus area

- Important discovery role of the neurosteroid ‘allopregnanolone’
  - Aiding neurogenesis in the brain
  - Levels of allopregnanolone start to decline in the elderly and in patients with Alzheimer’s disease
What affects Neurogenesis from occurring?

- Age; the older you get, the slower it occurs
- Other factors
  - excessive alcohol use, smoking, stress, and anxiety
  - Negative effects
- Positive effect on Neurogenesis
  - small amounts of alcohol, antidepressants, exercise, a healthy social status, and mental activity

Switching gears: SSEP Monitoring

Somatosensory Evoked Potentials

- Spinal cord electrophysiological monitoring techniques arose ~ 1970s, when SSEPs were described for monitoring the spinal cord during surgical deformity correction for scoliosis
- Ability to monitor SSEPs evolved tremendously →
  - Currently remains the mainstay of spinal cord monitoring
  - CURRENTLY used to assess intra operative neural function during a wide variety of spinal procedures
Upper extremities
- median nerve (C-6, C-7, C-8, and T-1 roots)
- ulnar nerve (C-8 and T-1) - frequently selected for monitoring

Lower extremities
- posterior tibial nerve (L-4, L-5, S-1, and S-2)
- peroneal nerve (L-4, L-5, and S-1) - frequently monitored

SSEPs
- Involve electrical stimulation of mixed sensory and motor fibers caudal to the region of the spinal cord at risk, paired with recording of these signals rostral to the region at risk (typically at the dorsal neck and scalp)
- Electrical stimulation in the extremities produces major positive and negative deflections as signals ascend via the somatosensory pathway

Alarm criteria of a 50% reduction in amplitude and/or a 10% increase in latency are generally used as guidelines for notifying the surgeon of a potential deficit, and corrective intervention should be considered if these changes correspond to a particular surgical manipulation.

Indication for SEP Monitoring
- SSEP Monitoring: Spinal, lumbar, or sacral surgery; Cauda equina syndrome; Lumbar puncture
- SSEP Monitoring: Peripheral nerve lesions; Carpal tunnel syndrome; Ulnar nerve entrapment
- SSEP Monitoring: Spinal cord injury; Spinal cord tumor; Intracranial mass

Evoked Potential Monitoring
- Motor Evoked Potential (MEP) Monitoring: Motor cortex, spinal cord, peripheral nerve, muscle; Monitoring of lower extremity muscles; Monitoring of upper extremity muscles
- Somatosensory Evoked Potential (SSEP) Monitoring: Spinal cord, brain stem, thalamus, cerebral cortex; Monitoring of sensory fibers in the spinal cord
- Auditory Evoked Potential (AEP) Monitoring: Auditory cortex, thalamus, brain stem; Monitoring of auditory pathways
- Ocular Evoked Potential (ERP) Monitoring: Visual cortex, thalamus, brain stem; Monitoring of visual pathways

A complex neuro surgical procedure
A difficult anesthetic
1. Supratentorial Intracranial Tumors
   1. Maximize reduction in ICP
   2. Infratentorial Intracranial Tumors

Cerebral (Intracranial Aneurysms) - FACTS

- 85% in anterior circle of willis
### Intracranial Aneurysm Treatments

**Surgical: Clipping**
- Direct
- Temporary clipping
- Balloon suction decompression
- Trapping with clip reconstruction +/- EC/IC bypass
- Adenosine cardiac standstill
- Deep hypothermic circulatory arrest

**Non surgical Treatments**
- Coiling
- Stent Assisted Coiling

### Craniotomy for Aneurysm Clipping
- Treatment of intracranial aneurysms has evolved over the past few decades
  - Includes various endovascular techniques
  - Intra-operative rupture can sometimes lead to catastrophic consequences in absence of temporary control
- Challenge for the neurosurgeon to apply temporary clips at difficult locations like paraclinoid aneurysms and giant aneurysms
  - In these situations, intravenous administration of adenosine has been successfully used by various groups to produce reversible flow-arrest so that it helps in decompressing the aneurysm sac and improve visualization to facilitate clip application.
Adenosine

<table>
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<th>Actions</th>
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<tr>
<td>□ Slows conduction through AV node</td>
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<td>□ Negative chronotropic effect at the SA note</td>
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<th>Not given when-</th>
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<tr>
<td>□ History of CAD</td>
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<td>□ Conduction defects</td>
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<td>□ Pacemakers</td>
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<tr>
<td>□ Severe reactive airway disease</td>
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<tr>
<td>□ Allergy</td>
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<tr>
<td>□ Dipyridamole, methylxanthines and nimodipine (relative contraindication) administration may prolong adenosine duration of action</td>
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The Use of Adenosine in Cerebral Aneurysm Clipping: A Review
Khan et al 2013

Using adenosine-induced flow arrest during intracranial aneurysm surgery depends on a number of variables:
1 location, size of the aneurysm
2 morphology
3 risk of rupture
How to administer Adenosine
(the anesthetic management)

The operative set up is similar to that in routine aneurysm surgery

→ All get routine intraoperative monitoring
→ a radial arterial catheter and a central venous catheter
→ place transcutaneous pacing pads as a precautionary measure, should pacing or cardioversion be required (4% incidence)

Dosing:
Achieve BP < 60mmHg for approximately 60 seconds
Median dose ~ .34 - .4 mg/kg of ideal body weight during propofol induced burst suppression

Other Neuroprotective Strategies During Aneurysm Clipping

Temporary clip placed on parent vessel
Allows manipulation of aneurysm w/o rupture

Problem – focal cerebral ischemia by clipped vessel
Need an intervention! Which one?

Protection during temporary clipping to prevent global ischemia

- Techniques that have been used:
  □ Cooling (mild)
  □ Titration of IV anesthetic burst suppression
  □ Induced hypertension for improved collateral flow

- IHAST trial Intra-operative Hypothermia for Aneurysm Surgery Trial
  □ (remember our 10 key points!)
Reanalysis of IHAST

- Studied those who had the temporary clips

- Summary of main findings:
  - Neither mild T nor supplemental pharmacology intervention had any meaningful association with early or late neurologic outcome in the setting of temporary clipping.
  - LONGER TEMPORARY CLIP TIMES (>20 MINUTES) → LESS FAVORABLE OUTCOMES

Coiling of aneurysm:

Endovascular treatment involves the use of catheter-based devices to surgically repair an aneurysm. The procedure involves inserting a catheter into an artery and navigating it to the aneurysm. Then, a microcatheter is inserted to deliver a coil or other device directly into the aneurysm, occluding it and preventing further bleeding.

The following diagrams show how aneurysm coiling is done:

- Microcatheter in aneurysm for coiling
- Coiling of aneurysm: prevention of blood from entering it
Post-Surgery Care

- After surgery, a patient might expect to return home after spending one night in the Neuro Intensive Care Unit, and may expect to return to normal activities within 2 days. Your physician will provide specific details regarding your post-surgical care prior to your discharge from the hospital.


Intravenous OR inhalation agents?

- Decision to use intravenous and inhalation agents as primary anesthetic
  - should be dictated by the underlying physiology/patho
- Propofol may have slight advantage – is a tightly coupled decrease of cerebral blood flow in response to decreased cerebral metabolic rate
- Metabolism –
  - flow coupling occurs with inhalation agents BUT the ratio is altered due to cerebral vasodilation of agents

The Effects of Volatile Anesthetics on Brain Physiology

- The common 3 have direct vasodilatory effects that increase CBF
  - returning to baseline 3 hours after 1.3 MAC
- Desflurane ↑s CBF > Isoflurane
- Sevoflurane ↑s CBF < Isoflurane
- All reduce cerebral metabolic rate
Key Points: Neurophysiology

- 3rd Key Point – Anesthesia Intravenous Drugs AND our Volatile Agents ↓ brain metabolism. *Is that good?*
  - Must balance the metabolism with blood flow!
  - Question - What is flow metabolism coupling?
  - Answer – Is what determines the extent of increase or decrease CBF with our drugs!
What is the current controversy about Dexmedetomodine?

Dexmedetomidine? Safe?

- The greatest advantage - conscious sedation with rapid recovery with analgesic action and ability to test neurological intactness during neurosurgery
  - Known as cooperative sedation
- Widespread during functional neurosurgery i.e. deep brain stimulation
  - Maintains the abnormal movements, neuro-navigational procedures and awake craniotomy for tumor and epilepsy surgery
- Useful in coiling of aneurysms in interventional neuroradiological suite
  - There are limited randomized data available in comparison with propofol/remifentanil combination

Past thoughts; current evidence

- First, past thoughts
  - Canine studies – cerebral vasoconstrictive effect not associated with coupled reduction in CMR
    - Supply demand mismatch
    - Deleterious effect
  - Human studies
    - Coupled decrease in CBF and Metabolism (non-vasodilated)
    - Assessing brain O2 measurements (vasodilated)
      - Parenchymal at regions at risk of perfusion - stable O2
Potential advantages of hypertonic saline over mannitol for brain relaxation

Mannitol vs. Hypertonic Saline

- Hypertonic (6% to 8%) saline
  - Increases serum osmolality and draws free water into osmotic gradient
  - Edema less likely to occur, lowered blood pressure
  - Can also be given as a continuous drip
  - Hypertonic in the brain; mannitol is not

- Mannitol (25%)
  - Causes direct damage to the brain and increased cerebral blood flow
  - Does not cause cerebral edema

The SCALP Block

- Six nerves need to be blocked bilaterally:
  - supratrochlear,
  - supraorbital,
  - zygomaticotemporal,
  - auriculotemporal,
  - and the lesser and greater occipital nerves

- Minor contributions from the greater auricular nerve and third occipital nerve rarely encroach into the surgical field. An exact knowledge of the craniotomy site and head pin position can allow more selective blockade
“Scalp block” during craniotomy: a classic technique revisited.

We have definitely come a very long way!

- Scalp block in 2015
- Tourniquets for craniotomy in 1904

Dr. Harvey Cushing - In 1904, created a pneumatic tourniquet

Pneumatic tourniquets: With special reference to their use in craniotomies
LMA versus ETT

- ProSeal Laryngeal Mask Airway Attenuates Systemic and Cerebral Hemodynamic Response During Awakening of Neurosurgical Patients: A Randomized Clinical Trial.

**Methods and Results:**
- N = 42
- Procedure ~ supratentorial craniotomy under general anesthesia
- Randomized open-label parallel trial
  - Group 1 awaken with the ETT in place
  - Group 2 awaken after replacement with a ProSeal LMA
- **Primary endpoints:** MAP, HR, middle cerebral artery flow velocity, regional cerebral oxygen saturation, norepinephrine plasma concentrations, and coughing

**Conclusions:**
- Replacing the ETT with the LMA before neurosurgical patients emerge from anesthesia results in a more favorable hemodynamic profile, less cerebral hyperemia, and a lower incidence of coughing
Nicardipine is superior to esmolol for the management of postcraniotomy emergence hypertension: a randomized open-label study.

- Bebewy JF, Houston CC, Kosky JL, Badri AM, Hemmer LB, Moreland NC, Carabini LM, Kohl TA, Gupta DK

CONCLUSIONS:

Nicardipine is superior to esmolol for the treatment of postcraniotomy emergence hypertension. This type of hypertension is thought to be a transient phenomenon not solely related to sympathetic activation and catecholamine surge but also possibly encompassing other physiologic factors. For treating postcraniotomy emergence hypertension, nicardipine is a relatively effective sole drug, whereas if esmolol is used, rescue antihypertensive medications should be readily available.

Nicardipine Use

- ‘slow’ calcium channel blocker
- Mechanism Of Action
  - Inhibits transmembrane influx of calcium ions into cardiac muscle and smooth muscle without changing serum calcium concentrations
  - Contractile processes of cardiac muscle and vascular smooth muscle are dependent upon the movement of extracellular calcium ions into these cells through specific ion channels
  - The effects of nicardipine are more selective to vascular smooth muscle than cardiac muscle. In animal models, nicardipine produced relaxation of coronary vascular smooth muscle at drug levels which cause little or no negative inotropic effect.
- Pharmacokinetics –
  - t ½ life
  - Metabolism
In pathology and anatomy the **penumbra** is the area surrounding an ischemic event such as an ischemic, thrombotic or embolic stroke. Immediately following the event, blood flow and therefore oxygen transport is reduced locally, leading to hypoxia of the cells near the location of the original insult.
Thank you!

Questions?