THE TIVA TRAIN

Talk
Rely
Anticipate
Intervention
Neuromonitoring Team

Natania Axe, CRNA, MSN, BSN
Holy Spirit Hospital
Geisinger Affiliate
WHAT IS TIVA
TIVA

The exclusive use of IV anesthetics to provide general anesthesia.

General Anesthesia

Utilized

Hospitals settings

Ambulatory settings
WHY A TRAIN?
Objectives

- Define and describe TIVA (Total Intravenous Anesthesia) and IOM (Intraoperative monitoring)
- Identify the types of patients and/or surgeries where TIVA is indicated and IOM is appropriate.
- Discuss the advantages and disadvantages of TIVA
- List the different types of TIVA regimens and their affects on IOM
- Examine physiologic & pharmacologic factors that affect evoked potentials focusing on MEPs and SSEPs.
- Distinguish between physiologic & pharmacologic influences intraoperatively that can effect evoked potentials.
- Explain the importance of establishing collaboration between the surgeon, anesthesia, and neurophysiologists to provide safe patient outcomes.
THE PERSPECTIVES

- The Surgeon
- The neurophysiologist
- Anesthesia
TIVA
A SURGEON’S PERSPECTIVE
Operating room:
- Neurosurgery
- Orthopedic surgery
- Otolaryngology (ENT) surgery
- Cardiothoracic/ Vascular surgery
- Interventional Radiology (INR) surgery
- Diagnostic laboratories
- Nerve conduction studies
CASE BREAKDOWN

- Neurosurgery – 30%
  - INR – 12%
- Orthopedic – 33%
- Cardiothoracic/vascular – 25%
- ENT – 11%
- Spinal decompressions and fusion (anterior/ posterior)
- Chiari malformation decompression
- Cranial base tumors
- Posterior fossa tumors
- Microvascular decompressions
- CN VIII resection
- Brachial plexus/ peripheral nerve repair
- Intercranial aneurysms/ arteriovenous malformations
- Spinal tumors
- Spinal cord untethering
- Selective dorsal root rhizotomy
- Epilepsy localization and mapping
- Fronto-temporal tumors
- Instrumentation for spinal instability
- Scoliosis correction
- Pelvic hip arthroplasty
- Spinal decompression/ fusion (anterior/ posterior)
- Stabilization of odontoid/ dens fractures
- Peripheral joint procedures
- Heterotrophic ossification of the hip
THE PATH FOR TIVA

The Main Stakeholder in the Decision: Depends on what the surgeon ultimately want or need to perform the case. Which Monitoring option is the most desirable?

- Spine cord integrity: sseps meps
- Peripheral Nerve roots intact (EMG)
- Pedicle screw
- Location of surgery
- Patient’s baseline (preposition baselines)
- Surgeons comfort: Safety net
MAIN CONCERNS WITH TIVA
THE NEUROPHYSIOLOGIST'S PERSPECTIVE
You want to do what?!
**Neurophysiological monitoring:** any measure that is used to assess the functional integrity of the peripheral or central nervous system either in the operating room, the intensive care unit, or other acute care setting. 
American Society of Neurophysiological Monitoring (ASNM)
1. Identify neural injury immediately

2. Define the nature of the injury
IONM can reduce the incidence of iatrogenic (provider induced) and idiopathic (randomly induced) neurological injuries to patients during surgical procedures.
MOST FREQUENT MONITORING MODALITIES UTILIZED IN SPINAL SURGERIES

Somatosensory Evoked Potentials (SSEPs)

Motor Evoked Potentials (MEPs)
Evoked Potentials (Eps):
- Electrophysiologic responses of the nervous system to sensory or motor stimulation
- Stimulating leads to transmission of neural signals so they can be recorded as EPs

WHAT ARE EVOKED POTENTIALS?
Latency

- The time that elapses between a stimulus and the response to it measured in milliseconds

Amplitude

- The power of a signal. The greater the amplitude, the greater the energy carried
Primary sensory pathway – Dorsal Column Pathway

Sensory pathways are ASCENDING. They bring information from the outside into the nervous system
SSEP PERIPHERAL STIMULATION

Alternative Stimulation Sites

- Ulnar (wrist or elbow)
- Median (wrist or elbow)
- Femoral
- Peroneal (ankle or knee)
Problem with SSEP monitoring:

When monitoring Dorsal Column pathway only, no information is gathered about Lateral Cortical Spinal tract and other anterior pathways.

TCMEP testing provides that information.
MOTOR EVOKED POTENTIALS
Anatomy Primer: Transcranial Motor Evoked Potentials (TcMEPs)

Primary motor pathway – corticospinal pathway

Motor pathways are DESCENDING. They carry information from the motor cortex to the muscles on the periphery.
Advantages

- Time required for one stimulation is very brief
- Meaningful information
- Information can be updated multiple times during critical portion of the operation
- EMG

Disadvantages

- NMB must be minimized or avoided
- Stimulation will produce movement of limb and axial muscles
- Cerebral hemisphere stimulation
  - Activates masseter muscles
    - Tongue laceration, tooth fracture, mandible fracture
- Contraindicated: epilepsy, cortical lesions, skull defects, increased ICP, surgically implanted intracranial devices, cardiac pacemakers or other implanted pumps

MOTOR EVOKED POTENTIALS
Life is like a camera, focus only on what is important and you will capture it perfectly.

~ Linda Poindexter

idlequotes.com
Altered temperature:
- Hypothermia: Increase latency, decrease amplitude
- Hyperthermia: Decrease amplitude by up to 15% and SEPs are lost at 42C

Hypotension: Decrease in amplitude

Hypoxia: Decrease in amplitude

Hypocarbia: ETCO2 ≤ 25 mmHg latency increases

Hemodilution: Isovolemic hemodilution latency increase with hematocrit < 15% and amplitude decrease with hematocrit < 7%
PATIENT POSITIONING EFFECTS
ADDITIONAL EP MODALITIES: EMGS VERSUS EEGS
EMGS: ELECTROMYOGRAPHIC ACTIVITY

- Free-run and stimulated EMG
- When peripheral nerves or roots are at risk for potential injury
Electroencephalography (EEG): is the measurement of electrical activity produced by the cortex as recorded from electrodes placed on the scalp.

EEG is limited by the recording depth of the electrodes; usually only sensitive to electrical activity on the surface of the cortex.
Electroencephalography (EEG)

Helpful for any cases in which the brain is at risk
Perfusion, metabolism, epilepsy

Passive Recording
- subdermal scalp electrodes (extracranial)
- direct cortical strips (intracranial)

Measures significant changes in waveform patterns
- Frequency
- Amplitude
TIVA TRAIN: THE ANESTHETIC CONSIDERATIONS
WHAT YOU TALKIN BOUT WILLIS
Steady. Constant
Communication

Key to success
1. Proposed operative procedure
2. Determine what forms of IOM will employed
3. Choose an anesthetic approach
4. Have understanding of the affect of your anesthetic recipe on IOM
5. Maintain an constant concentration
6. Be cognizant of physiologic & pharmacologic influences intraoperatively that can effect evoked potentials
GENERAL ANESTHESIA

TOTAL INTRAVENOUS ANESTHESIA
Rates of False Positive Tce-MEP Changes
Inhalational Vs. TIVA

FALSE POSITIVE: PERSISTENT LOSS OF 90% OR GREATER OF THE AMPLITUDE OF TCE-MEPS

The Spine Journal 2013:
Differential rates of false-positive findings in transcranial electric motor evoked potential monitoring when using inhalational anesthesia versus total intravenous anesthesia during spine surgeries
- Plasma Drug concentration has to be reached quickly and maintained
- A loading dose based on volume of distribution and the initial plasma drug concentration
- Following initial administration the drug is both redistributed to tissues and eliminated
- To maintain desired plasma drug concentration a constant rate infusion (CRI) is initiated
- There will be variation to the response of CRI

THE PRINCIPLES OF TIVA
THE TIVA STARTING POINT
<table>
<thead>
<tr>
<th>Indication</th>
<th>Induction/Initiation</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Anesthesia (healthy &lt;55 yrs)</td>
<td>2-2.5mg/kg (40 mg every 10 sec until onset)</td>
<td>100-200 mcgs/kg/min (intermittent bolus increments of 20-50 mg needed)</td>
</tr>
<tr>
<td>General Anesthesia (elderly, debilitated, ASA III/IV)</td>
<td>1-1.5 mg/kg (20 every 10 sec until onset)</td>
<td>50-100 mcgs/kg/min</td>
</tr>
<tr>
<td>General Anesthesia (Pediatric &gt;3yrs)</td>
<td>2.5-3.5 mg/kg over 20-30 sec</td>
<td>200-300 mcgs/kg/min (1st 30 mins) 125-150 mcgs/kg/min (remainder)</td>
</tr>
<tr>
<td>General Anesthesia (cardiac)</td>
<td>0.5-1.5mg/kg (a slow rate of approx. 20 mg every 10 sec until onset; avoid rapid bolus inductions)</td>
<td>Primary propofol injection w/ secondary opioid: 100-150 mcgs/kg/min Low dose propofol injection w/ primary opioid: 50-100 mcgs/kg/min (no bolus)</td>
</tr>
<tr>
<td>General Anesthesia (neuro)</td>
<td>1-2 mg/kg (20 mg every 10 sec until onset)</td>
<td>100-200 mcgs/kg/min</td>
</tr>
</tbody>
</table>
- Fentanyl
  - 1 -10 mcgs/kg/hr (discontinue 45 to 60 mins before emergence)
- Remifentanil
  - 0.1-0.5 mcg/kg/min
- Alfentanil

- Sufentanil
  - 0.2 – 1 mcg/kg/hr (discontinue 45 to 60 mins before emergence)

- Long Acting narcotics
  - Morphine
  - Diladid
TOD B SLOAN
MBA, MD, PHD
Induction: As usual (with sux or short acting NDMB)

Maintenance: propofol infusion 100-200 mcg/kg/min

Long Acting Opioid: usual up front administration (Morphine 5 to 10mg bolus before incision or Dilaudid 1-2 mg)

Opioid Infusion: Sufentanil 0.2-0.3 mcg/kg/hr; Fentanyl 4-5 mcg/kg/hr (turn off 30-45 mins before emergence), or remifentanil 0.2-0.3 mgs/kg/min

NMB: As needed

Optional: if SSEP remains too small for monitoring: Ketamine infusion (.25-.5 mg/kg/hr)

**MONITORING SSEP WHEN A REDUCTION OR ELIMINATION OF THE INHALATIONAL AGENTS IS NEEDED**
Induction: As usual (preferable propofol since followed by infusion)

Pure TIVA: propofol infusion titrate to anes. Depth (100-200 mcg/kg/min).

Long Acting: usual up front administration (Morphine 5 to 10mg bolus before incision or Dilaudid 1-2 mg)

Opioid Infusion: Sufentanil 0.2-0.3 mcg/kg/hr; Fentanyl 4-5 mcg/kg/hr (turn off 30-45 mins before emergence), or remifentanil 0.2-0.3 mgs/kg/min

Options: Dexmedetomidine (0.2-0.3 mcg/kg/hr with propofol (starting at 100 mcg/kg/min OR Ketamine (0.25-0.5 mg/kg/hr) with propofol 100-150 mcg/kg/min.

No NMBs
ALTERNATIVES TO PROPOFOL OR ADJUNCTS

- Ketamine
- Etomidate
- Dexmedetomidate
- Lidoocaine
### KETAMINE ALTERNATIVE TO PROPOFOL

<table>
<thead>
<tr>
<th>Drug</th>
<th>Administration</th>
<th>Infusion</th>
<th>Bolus Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midazolam</td>
<td>Premed</td>
<td></td>
<td>2-4 mg</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Induction</td>
<td></td>
<td>1-2 mg/KG</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Maintenance</td>
<td>0.5-1/KG/HR</td>
<td>0.5-1mg/kg</td>
</tr>
<tr>
<td>Midazolam</td>
<td>Maintenance</td>
<td>1-2 mg per HR</td>
<td></td>
</tr>
<tr>
<td>Drug</td>
<td>Administration</td>
<td>Infusion</td>
<td>Bolus</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Midazolam</td>
<td>premed/ intraop</td>
<td></td>
<td>2-4mg</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>Premed 50-100mcgs</td>
<td></td>
<td>25-50mcgs</td>
</tr>
<tr>
<td>Ketamine</td>
<td></td>
<td>0.25-0.5 mg/kg/hr</td>
<td>0.5 mg/kg/hr</td>
</tr>
<tr>
<td>Propofol</td>
<td></td>
<td>Start 140-200mcgs/kg/min At 10 min: 100-120mgs/kg/min After 2 hours 80-120mcgs/kg/min</td>
<td></td>
</tr>
</tbody>
</table>

**Ketamine Propofol Mix: 2mg of ketamine per 1 mL of Propofol; taper off depending on length of case.**

**PROPOFOL/KETAMINE TIVA**
Advantages
- Enhancing SSEP and MEP amplitudes
- Meets anesthetic requirement: loss of consciousness an analgesia

Disadvantages
- Elevate cerebral blood flow: contraindicated in pts with increase ICP
- Postop Hallucinations (more common in adults than in pediatrics or geriatric patients
- Emergence delirium

KETAMINE
ETOMIDATE INFUSION

- Ultra short acting IV agent
- No structural relationship to other IV anesthetics, but MOA similar to propofol
- Minimal cardiac depression, respiratory depression
- Penetrates BBB quickly; reaches peak levels after 30-60 seconds
- Redistributes quickly and metabolizes rapidly
- Hemodynamic and CV stability, lower cerebral blood flow, cerebral metabolic rate for oxygen and ICP
<table>
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<th>Drug</th>
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<th>Bolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midazolam</td>
<td>Premed</td>
<td></td>
<td>2-4mg</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Induction</td>
<td></td>
<td>0.2-0.3mg/KG</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Additional Load</td>
<td></td>
<td>Total 0.5 mg/KG</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Maintenance</td>
<td></td>
<td>0.6 mg/KG/HR</td>
</tr>
<tr>
<td>Midazolam</td>
<td>Maintenance</td>
<td>1-2 mg per HR</td>
<td></td>
</tr>
<tr>
<td>Remifentanil</td>
<td>Maintenance</td>
<td>0.2-0.3mcgs/KG/Min</td>
<td></td>
</tr>
<tr>
<td>Decadron</td>
<td>Loading Dose</td>
<td></td>
<td>10 mg</td>
</tr>
</tbody>
</table>

**INITIAL GUIDELINE FOR ETOMIDATE INFUSION DURING SPINE SURGERY**
Facilitate the inhibitory effects of GABA

Smaller doses cause cortical excitatory reaction can present as EEG spikes at induction, Increase SSEP and MEP amplitudes or epileptiform activity on EEG in pts with seizure history

Advantage:
- no hypotension
- EEG patterns marked delta waves, higher theta than with propofol and prominent alpha activity and minimal beta: easier to monitor anesthetic depth

Disadvantage:
- No analgesic properties
- Pain with injection
- Myoclonus
- Epileptiform activity in pts with sz hx
- Occasional delirium
- N/V
- Depressed cortisol production
- Effects on Eps:
  - Suggested therapeutic levels: (0.5-0.7 mcgs/kg/hr) (compromises MEPs but not SSEP amplitudes)
  - With low dose Propofol 50-75mcgs/kg/min dexmeditomidine at (<0.35 mcgs/kg/hr) MEPs amplitudes not degraded

- Anesthesia Regimen:
  - Further investigation as a propofol alternative
  - ICU “opioid sparing effect” for Anesthesia Opioids infusion required and opioid boluses may be necessary

- S/E: hypotension and bradycardia r/t sympatholytic properties
- Contraindicated: poor cardiac reserve or heavily dependent on intact sympathetic system

**DEXMEDITOMIDINE**
The Effects of Anesthetic on SSEPs and MEPs (The overview)
<table>
<thead>
<tr>
<th>Agent</th>
<th>SSEP Amplitude</th>
<th>MEP Amplitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propofol</td>
<td>Decrease</td>
<td>Decrease</td>
<td>SSEP &amp; MEP usually recorded at anesthetic doses but MEP may be lost at high doses</td>
</tr>
<tr>
<td>Opioids</td>
<td>Minimal</td>
<td>Minimal</td>
<td>SSEP &amp; MEP usually recorded even at high doses</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Increase at low doses-decrease at higher doses</td>
<td>Increase at low doses- Decrease at higher doses</td>
<td>Enhancement of SSEP &amp; MEP seen at low doses, depression at very high doses</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Minimal, increase at low doses</td>
<td>Minimal, increase at low doses</td>
<td>Enhancement SSEP &amp; MEP seen at low doses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agent</th>
<th>SSEP Amplitude</th>
<th>MEP Amplitude</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzodiazepines</td>
<td>Minimal at low doses</td>
<td>Minimal at low doses, prolonged decrease at higher doses</td>
<td>SSEP &amp; MEP usually recorded with small doses for amnesia</td>
</tr>
<tr>
<td>Dexmedetomidine</td>
<td>Minimal</td>
<td>Minimal-decrease at higher doses</td>
<td>SSEP &amp; MEP usually recorded at low doses but MEP lost at higher doses</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Can be used as intravenous supplement in SSEP &amp; MEP</td>
</tr>
</tbody>
</table>

Shils JL, Sloan TB. Intraoperative neuromonitoring. *Int Anesthesiology Clin* 2015; 53;53
- Carboetomidate
- Fospropofol

NOVEL AGENTS
- Decreased PONV
- IOM can be utilized; less interference with SSEP, MEP
- Decrease Pollution to environment
- Avoid vasodilatation, expansion of gas cavities
- Occupational exposure
- Avoid MH risk
- Smooth emergence, less hangover
- Cost Benefit
- Improved surgical field (bleeding)

BENEFITS OF TIVA
DISADVANTAGE OF TIVA

- Not the ideal technique
- May require additional personnel like IOM
- Level of practitioner
- Hypotension
- Controlled substance accounting
- Set-up and use greater workload than vaporizers
- Fluid management
- Blood loss
- Gag reflex intact
- Dependent of IV for immobility
- Opioid side effects: biliary, muscle rigidity, GI motility, pruritus
- Adverse events if IV line disrupted
- Depth of anesthesia
FURTHER CONSIDERATIONS

Bis Monitoring
Neurological Disability
Pediatrics
Obesity
Target controlled infusions
Bispectral Index

- **Awake**
  - Responds to normal voice

- **General Anesthesia**
  - Low probability of explicit recall
  - Unresponsive to verbal stimulus

- **Deep Hypnotic State**
  - Burst Suppression

- **Flat Line EEG**
TARGET CONTROLLED INFUSION (TCI)
TCI

Microprocessor → Infusion System → Patient

Software → PKPD model → Algorithms
NEUROLOGICAL DISABILITY
ADDITIONAL CHALLENGES TO CONSIDER WITH TIVA
OBESE PATIENTS: LARGELY GUESSWORK????
BRINGING IT ALL TOGETHER
CHECKLIST OF INTRAOPERATIVE NEUROMONITORING CHANGES

Physiology

- Temperature
  - Whole body temperature
  - Local change (irrigation, cold IV fluids)
- Ventilation
  - Hypoxemia
  - Hyper or hypoventilation

- Ischemia/Reduced Blood Flow
  - Hypotension, poor cardiac output, bleeding
  - Local ischemia (retractor, clip, vasospasm)
  - Rheology/blood volume (change HC, colloids)
  - Loss autoregulation (hypoxia, hypercarbia, injury)
  - Vascular steal/Robin Hood

- Other
  - Raised intracranial, CSF. Or tissue pressure
  - Hypoglycemia, electrolyte abnormalities

CHECKLIST OF INTRAOPERATIVE NEUROMONITORING CHANGES

Positioning

- Mechanical stretch/pressure on plexus/nerves
- Vascular occlusion to area

Surgical

- Blunt or surgical trauma
- Mechanical effect (device, retractor, pledget pressure)
- Vascular occlusion to area
- Applied medications surface or intravascular (lidocaine, papaverine)
- Surgical stimulation
- Tissue resection

CHECKLIST OF INTRAOPERATIVE NEUROMONITORING CHANGES

CHECKLIST OF INTRAOPERATIVE NEUROMONITORING CHANGES

REFERENCES