<table>
<thead>
<tr>
<th>Day</th>
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<td>February 26th</td>
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Sunday, February 26th
Update on Anesthetic Neurotoxicity in Children: Clinical Challenges

Dean B. Andropoulos, M.D., M.H.C.M.
Anesthesiologist-in-Chief and Chair, Texas Children’s Hospital
Department of Anesthesiology, Perioperative and Pain Medicine
Professor, Anesthesiology and Pediatrics
Vice Chair for Clinical Affairs, Department of Anesthesiology
Baylor College of Medicine, Houston, Texas

CRASH 2023: February 26, 2023

Learning Objectives

• Summarize the up to date animal and human neurotoxicity evidence
• Discuss the 2016 FDA Warning about prolonged or repeated anesthetics in young children
• Determine whether certain elective surgeries could be postponed until after 3 years of age
• Answer the question: Should the FDA Warning Affect My Practice?

FDA Drug Safety Communication: FDA review results in new warnings about using general anesthetics and sedation drugs in young children and pregnant women
[12-14-2016]

Safety Announcement
The U.S. Food and Drug Administration (FDA) is warning that repeated or lengthy use of general anesthetic and sedation drugs during surgeries or procedures in children younger than 3 years or in pregnant women during their third trimester may affect the development of children's brains.

"Lengthy" = >3 hours
"Deficits in cognition, learning, and behavior....."

Warning Label Requirement

• FDA warning has been added to the labels of general anesthetic and sedation drugs

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>desflurane</td>
<td>Suprane</td>
</tr>
<tr>
<td>etomidate</td>
<td>Amidate</td>
</tr>
<tr>
<td>halothane</td>
<td>Only generic is available</td>
</tr>
<tr>
<td>isoflurane</td>
<td>Forane</td>
</tr>
<tr>
<td>ketamine</td>
<td>Ketalar</td>
</tr>
<tr>
<td>lorazepam</td>
<td>Ativan</td>
</tr>
<tr>
<td>methohexital</td>
<td>Brevital</td>
</tr>
<tr>
<td>midazolam</td>
<td>Only generic is available</td>
</tr>
<tr>
<td>pentobarbital</td>
<td>Nembutal</td>
</tr>
<tr>
<td>propofol</td>
<td>Diprivan</td>
</tr>
<tr>
<td>sevoflurane</td>
<td>Ultane, Sojourn</td>
</tr>
</tbody>
</table>

*This list includes anesthetic and sedation drugs that block N-methyl-D-aspartate (NMDA) receptors and/or potentiate gamma-aminobutyric acid (GABA) activity. No specific medications have been shown to be safer than any other.

Recommendations for Health Providers and Parents

• Health Providers:
  • Balance benefits of appropriate anesthesia against potential risks
  • Discuss benefits, risks, and appropriate timing of surgery or procedure

• Parents:
  • Discuss potential adverse effects of anesthesia on brain development
  • Understand the appropriate timing of procedures that can be delayed without jeopardizing health

Disclosures

• No financial disclosures
• Member of the SmartTots Scientific Advisory Board
• Dexmedetomidine is not labeled for pediatric use by the U.S. Food and Drug Administration and will be discussed

http://www.fda.gov/Drugs/DrugSafety/ucm532356.htm

http://www.fda.gov/Drugs/DrugSafety/ucm532356.htm
Similarly, surgeries or procedures in children younger than 3 years should not be delayed or avoided when medically necessary. Consideration should be given to delaying potentially elective surgery in young children where medically appropriate.

Evidence for the FDA Warning

- Adverse effects on brain development following use of general anesthetic and sedation drugs have been demonstrated in multiple animal species, ranging from flatworm to nonhuman primates.
- Consistent with animal studies, recent human data suggest that a single, relatively short exposure to general anesthetic and sedation drugs in infants or toddlers is unlikely to have negative effects on behavior or learning. However, further research is needed to fully characterize how early life anesthetic exposure might affect children’s brain development, particularly for more lengthy or repeated exposures and in more vulnerable children.
- No specific anesthetic or sedation drug has been shown to be safer than any other.

Evidence for the FDA Warning (cont’d)

- Based on comparisons across species, the window of vulnerability to these changes in the brain is believed to correlate with exposures in the third trimester of pregnancy through the first year of life, but may extend to approximately 3 years in humans. The clinical significance of these nonclinical findings is not clear.
- Some published studies suggest that similar deficits in cognition and behavior may occur in children, particularly after repeated or prolonged exposures to anesthetic drugs early in life. These studies have limitations, and it is not clear if the effects reported are due to the anesthetic/sedation drugs, or to other factors such as the surgery or underlying illness.

CURRENT KNOWLEDGE:
POSSIBLE NEGATIVE EFFECTS OF ANESTHETICS ON THE DEVELOPING BRAIN IN ANIMALS AND HUMANS

Anesthetics/Sedatives/Analgesics and Receptors

<table>
<thead>
<tr>
<th>Agent</th>
<th>GABA</th>
<th>NMDA</th>
<th>μ-opioid</th>
<th>α2-adrenergic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halogenated anesthetics (sevoflurane, isoflurane, desflurane)</td>
<td>+</td>
<td></td>
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<tr>
<td>Nitrous oxide</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Benzodiazepines</td>
<td></td>
<td>+</td>
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<tr>
<td>Propofol</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
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<tr>
<td>Barbiturates</td>
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<tr>
<td>Esmolol</td>
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<td></td>
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<tr>
<td>Chloral hydrate</td>
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<tr>
<td>Ketamine</td>
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<tr>
<td>Opioids</td>
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<tr>
<td>Dexmedetomidine</td>
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</table>

GABA = gamma-aminobutyric acid; NMDA = N-methyl-D-aspartate

This study gained the attention of the pediatric anesthesia community and is credited with initiating the concern about anesthetic and sedative neurotoxicity.
Proposed Mechanism of Anesthetic-Induced Neurodegeneration

- 6-day old rhesus monkeys (n=6) exposed to deep plane of isoflurane anesthesia for 3h
  - Controlled endotracheal ventilation, extensive physiological monitoring
  - Compared with unexposed controls (n=5)
- ISO treatment increased neuroapoptosis of neurons and oligodendrocytes >4-fold (p<0.024)
  - Oligodendrocyte injury throughout white matter; neuronal injury in cortex, caudate, putamen, thalamus

Isoflurane Anesthesia Has Long-term Consequences on Motor and Behavioral Development in Infant Rhesus Macaques

- 24 neonatal rhesus monkeys exposed to anesthetic starting on DOL 6
  - Isoflurane 0.7-1.5% end-tidal for 5 hours
  - 8 animals with single exposure, 8 with 2 additional exposures on DOL 9 and 12, 8 control animals
- Behavioral and motor testing at DOL 14, 30, 3 months, 12 months

Neurobehavioral Outcomes

- Infant isoflurane exposure affects social behaviours, but does not impair specific cognitive domains in juvenile non-human primates
  - Viola Neudecker1, Jose F. Perez-Zugasti2, Kristine Coleman1, Martha Neuringer1, Nicole Roberson1, Alexandria Berens1, Jess Glideman1, Kristie Schenning1, Daniel A. Paul1, Lauren D. Martin1, Gregory A. Diener1 and Angela M. Hurdzinski1
**Summary of Animal Data**

- GABA and NMDA binding agents cause neuroapoptosis in animal models of the developing brain
  - Volatile anesthetic agents, N₂O, benzodiazepines, propofol, ketamine
  - *In vitro*, rodents to primates
  - Reproducible effects, long lasting neurobehavioral sequelae
  - Mechanisms being elucidated
    - Interference with neurotransmission → failure of neurons to connect/communicate → neuroapoptosis → dendrite/spine formation and neuronal migration

**Anesthesia and Sedation in Infants and Children**

- ≈6 million children undergo anesthesia or sedation annually in the U.S.
- ≈1.5 million are less than 12 months, and 2-3 million less than 36 months of age
- The question of possible anesthetic and sedative neurotoxicity has major public health implications
- Exponential growth of sedation procedures in young children, e.g. MRI, is of significant concern
- Untreated or undertreated pain definitely causes neurodegeneration and long term neurobehavioral consequences

**Is There a Clinical Problem in Children?**

- This “disease” is the inverse of most pathology in that the animal model was first and gave rise to clinical concern
- Phenotype of neurodevelopmental-behavioral problems has not been observed clinically
  - Not obvious from the millions of children undergoing anesthesia and sedation annually in U.S.
  - Pre-existing medical conditions, and significant prevalence of neurobehavioral problems
- What is the clinical evidence to date?

**Neuropsychological and Behavioral Outcomes after Exposure of Young Children to Procedures Requiring General Anesthesia**

- 997 children enrolled: 380 single exposure, 206 multiple exposure, 411 no exposure to GA at <3 years, 1994-2007
- Battery of neuropsychological tests at age 8-12, or 15-19 years
- Primary outcome: full scale IQ

---

**No difference** in Full Scale, Performance, or Verbal IQ

No difference in directly measured tests of memory, language, attention, executive function

Minor differences in behavior by parental questionnaire
722 infants <60 weeks PCA randomized to GA (sevoflurane) vs. spinal (bupivacaine) for inguinal herniorrhaphy

- Bayley Scales of Infant and Toddler Development III assessed at 2 years (secondary outcome)
- Clinical equivalence margin defined as difference in means of ± 5 points
<table>
<thead>
<tr>
<th>GA group as per protocol</th>
<th>RA group as per protocol</th>
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<tbody>
<tr>
<td>Cognitive, scaled score</td>
<td>238.8 (7.4)</td>
</tr>
<tr>
<td>Cognitive</td>
<td>294.9 (6.8)</td>
</tr>
<tr>
<td>Language</td>
<td>272.7 (6.7)</td>
</tr>
<tr>
<td>Receptive</td>
<td>272.7 (6.7)</td>
</tr>
<tr>
<td>Expressive</td>
<td>272.7 (6.7)</td>
</tr>
<tr>
<td>Language</td>
<td>272.7 (6.7)</td>
</tr>
<tr>
<td>Motor</td>
<td>272.7 (6.7)</td>
</tr>
<tr>
<td>Fine motor</td>
<td>254.3 (10.6)</td>
</tr>
<tr>
<td>Gross motor, awake usual</td>
<td>254.3 (10.6)</td>
</tr>
<tr>
<td>Motor, composite score</td>
<td>232.8 (8.7) (12.6)</td>
</tr>
<tr>
<td>GA group as per protocol</td>
<td>274.0 (7.9) (13.4)</td>
</tr>
</tbody>
</table>

**No difference in any ND assessment**

**Median anesthesia time = 54 minutes**

**Implications:** Short duration GA does not increase risk of adverse neurodevelopment.
Are We Out of the Woods With a Single Brief Exposure Yet?

- The GAS, PANDA, and MASK studies are very reassuring for cognitive and other directly measured outcomes of neurodevelopmental abilities that a single brief exposure is not a widespread problem
  - We are not creating a population of children with profound neurodevelopmental handicaps
- However, there is a signal that behavioral diagnoses may be affected
  - Additional analyses/studies needed
- Studies to date are in “normal” children without pre-existing developmental delay risk factors, genetic syndromes, previous brain injury, etc.
  - These vulnerable populations deserve our attention and efforts

---

Mayo Anesthesia Safety in Kids continued: two new studies and a potential redirection of the field

Caleb Ing, and Ansgar M. Brambrink

Interestingly, all three of these studies (MASK, PANDA, and GAS) also asked parents to rate their child for things, such as executive function and behavior, and all three reported worse scores in some of these parent-reported outcomes, even after a single exposure.
Physiologic Derangement as a Cause of Anesthetic Neurotoxicity

- European view is that this is more likely than neurotoxicity from the drugs
- Hypotension: Multicenter EMR study
- Critical events: APRICOT Study
- NIRS: Low cerebral oxygen saturation multicenter observational study
- EEG changes: seizures and silence

Incidence of severe critical events in paediatric anaesthesia (APRICOT): a prospective multicentre observational study in 261 hospitals in Europe

- 32,127 anesthetics in 30,874 infants and children – 33 countries
- Incidence of severe critical events: respiratory, neuro, cardiac, allergic requiring immediate intervention to prevent disability or death
- Incidence 5.2%
  - Respiratory 3.1%
  - Cardiac 1.9% (immediate poor outcome in 5.4%)
- All cause 30-day in hospital mortality 10 in 10,000

Reference Values for Noninvasive Blood Pressure in Children during Anesthesia

A Multicentered Retrospective Observational Cohort Study

Most significant risk factors for cardiac events: cardiac surgery, ASA III-V

Protective factors: years of experience of anesthesiologist (1%/year)

As much as 20-30-fold difference in incidence of severe critical events by country

An International, Multicenter, Observational Study of Cerebral Oxygenation during Infant and Neonatal Anesthesia

Although severe cerebral desoxgenation does occur during infant anesthesia, it is both rare and brief, and this is unlikely to explain the reported learning and behavioral abnormalities associated with general anesthesia and surgery: 0.1% of anesthetic time during severe episodes.
Clinical Evidence for Any Effect of Anesthesia on the Developing Brain


ABSTRACT

A recent U.S. Food and Drug Administration warning advised that prolonged or repeated exposure to general anaesthetics may affect neurodevelopment in children. This warning is based on a wealth of preclinical animal studies and relatively few human studies. The human studies include a variety of different populations with several different outcome measures. Interpreting the results requires consideration of the specific task, the power of the study, the length of exposure and the efforts to reduce the confounding effects of comorbidity and surgery. Must be, were all of the key population-based studies find evidence, for a correlation between surgery in early childhood and later cognitive or emotional deficits a cause of a behavior problem? In several studies, much of added risk is a more robust chemical, there is some evidence for increased association with multiple exposures. These results may be consistent with the preclinical data, but the possibility of confounding means the positive associations can only be regarded as weak evidence for causation. Finally, there is strong evidence that brief exposure is not associated with any long term risk in humans. (Neurotoxicity 2010; 12(6):6050-55)

Dexmedetomidine

- Dexmedetomidine (DEX) is a novel sedative/hypnotic/analgesic agent
  - α-2 receptors: locus cerebellar and spinal cord
  - α2:α1 selectivity 1000:1 (clonidine 200:1)
  - Minimal respiratory depression
  - Reduces post-cardiac surgical tachyarythmias
  - Reduce doses of volatile anesthetic agents (VAA), opioids, benzodiazepines
  - No neuroapoptosis in the developing brain
  - Blocks neuroapoptosis by anesthetic agents
  - Neuroprotective in hypoxia-ischemia
  - Neuroprotective in inflammatory states

Systematic review

A systematic review and narrative synthesis on the histological and neurobehavioral long-term effects of dexmedetomidine

Camille E. van Hoorn, Sanne E. Hoeks, Heleen Essink, Dick Tibboel, Jurgen C. de Graeff.
Why Dexmedetomidine?

- Clinician’s perspective:
  - Familiarity
  - Feasibility for research and adoption into clinical practice
- Widely used in pediatric anesthesia and ICU:
  - Post-surgical, medical ICU, premed, opioid sparing for tonsillectomy, TIVA for spines, emergence agitation, procedural sedation
- Significant body of clinical research/clinical publications in infants/children:
  - 314 in infants birth-23 months
  - 809 in children 0-18 years
- FDA labeled for adults 18+
  - ICU sedation intubated patients
  - Procedural sedation: non-intubated patients; surgical and other procedures

TREX Study: (Toxicity of Remifentanil-Dexmedetomidine)

- 60-subject pilot study; outcome: feasibility and safety
- 1-12 month old infants >120 min anesthesia time
- Surgical site covered by caudal anesthetic (hypospadias)
- Sevoflurane induction; d/c <10 minutes
- Dexmedetomidine 1 mcg/kg load; 1-1.5 mcg/kg/hr
  - Glycopyrrolate 5 mcg/kg before DEX
- Remifentanil 1 mcg/kg load; 0.2-0.5 mcg/kg/min
- Caudal catheter with ropivacaine 0.2% 1 ml/kg; top up with 0.5 ml/kg at 90-120 min

TREX Study Objectives

- To determine the feasibility of a Dexmedetomidine-Remifentanil-Caudal based anesthetic for lower abdominal/lower extremity surgery in infants 1-12 months of age

  - Primary objective:
    - The frequency of having to abandon the protocol for any reason

TREX Study (Toxicity of Remifentanil-Dexmedetomidine)

- 8 sites enrolled subjects: (1-20)
- Eye-opening times about 7 minutes
- Most had excellent analgesia in PACU, most discharged <60 minutes
- No protocol abandonment in 56 subjects
- No serious adverse events: mild/moderate hypotension (25%) and bradycardia (16%)
- 80% had “rescue” treatment for light anesthesia (movement/hypertension)
- Protocol is feasible: 87.5% of patients with functioning caudal required no sevoflurane or propofol rescue

TREX Study (Toxicity of Remifentanil-Dexmedetomidine)

- 23 subjects Protocol 03
- 15 subjects Protocol 02
- 23 subjects Protocol 04
- 22 subjects Protocol 01
- 18 subjects Protocol 05
- 16 subjects Protocol 06
- 17 subjects Protocol 07

60 subjects consented

Dexmedetomidine/Remifentanil/Low Dose Sevo vs. Standard

- ENROLLMENT STARTED AUGUST 2017: 411 ENROLLED AS OF 12/1/22
  
  TO DATE—SLOW ENROLLMENT -- CHANGE TO 2 HOURS SURGERY/2.5 HOURS ANESTHESIA TIME

- NO MAJOR ADVERSE EVENTS

- ABOUT 40% INCIDENCE OF LIGHT ANESTHESIA IN DEX/REMI GROUP VS. 2% IN SEVO GROUP

- >100 3-YEAR NEURODEVELOPMENTAL EXAMS

My Perspective on the FDA Warning

- Timing was unexpected
  - ???2016 Election effect???

- Basis is primarily animal data
  - FDA CDER scientists strongly feel that non-human primate data has applicability to humans
  - >3 hours and <3 years also based on animal data

- GAS and PANDA studies of a single, brief anesthetic exposure <3 years old were NOT associated with later neurodevelopmental problems

- MASK Study results had been expected imminently

- Specifically addresses multiple anesthetics

National Anesthesia Societies’ Perspective

Warnings, uncertainty, and clinical practice

We suggest that when clinical data are weak, incomplete, or uncertain, especially when those data are generated from retrospective cohort analyses prone to confounding by unmeasured variables, clinicians must be familiar with the pertinent current literature and prepared to address parents’ queries if they arise, but be circumspect about proactively advising about the risk of unknown or uncertain adverse outcomes.

*David M Polaner, Jeannie Zuk, Mary Ellen McCormack, Andrew Davidson
SHOULD PARENTS BE EDUCATED ABOUT THE FDA WARNING?

Panelists acknowledged that the FDA had an obligation to alert the public to the possible danger of anesthetic neurotoxicity based on the multiple studies in animals. However, they were dissatisfied with the way the safety communication was developed and released, especially in its original version. The communication and the lay media’s interpretation of it added to parent and provider stress, and many practitioners felt unprepared for the questions and concerns from parents that quickly arose.

All panelists agreed that emergent and semie emergent surgery should not be delayed due to the concern for neurotoxicity. The timing of elective procedures should take into account a number of factors including anesthetic risk, especially in younger patients. While there is no evidence that anesthetics and surgical practice has changed much since the FDA drug safety communication, discussion with parents and families regarding some aspects and anesthetic risk has evolved and been more extensive. Most surgical societies do not have their own...
Number of Anesthetic Cases by Calendar Year: TCH Pediatric Anesthesiology

TCH Anesthetic Cases by Subspecialty
2019 Annualized Volumes

TCH Patients Affected by FDA Warning
TCH Department of Anesthesiology, Perioperative and Pain Medicine

Discussion Points: Surgeons, Proceduralists, Anesthesiologists, and Referring Physicians

Anesthesia and Your Child – Q&A

Distribution Tool and Locations:
- Surgery Packets
- Radiology Registration
- Pre-op Clinics – PASS, Heart Center
- TCH Anesthesiology Website, Connect Site, EPIC Anesthesia Virtual
- Community Campuses
- English and Spanish Translations
- Addresses general information about anesthesia, the associated risks, and the FDA Safety Announcement

Discussion Points:
- Created based on Breakthrough Communications Program principles
- Focused on 3 questions:
  1. Should the procedure be done now or when the child is older?
  2. How long do we expect the procedure to take?
  3. Will repeated or additional procedures be needed?
- Distributed to all TCH Medical Staff, TCP Providers, and APP staff
Texas Medical Disclosure Panel New Informed Consent Language

THE “WHAT A REASONABLE PATIENT WOULD WANT TO KNOW” STANDARD FOR DISCLOSING RISKS OF A MEDICAL PROCEDURE

EPIC EMR Documentation of FDA Warning

FDA Warning in 2023
- Routinely discussed at TCH in 2023, very few questions, essentially no postponements of anesthetics
- SmartTots is drafting a letter to FDA requesting revision/updating of FDA Warning
  - Reassuring human data
  - Behavioral phenotype
  - 3-year age “cutoff”, 3-hour duration
  - “Physiologic” neuroprotection
- Will require public meetings, i.e. FDA Science Board

TCH Department Practice: FDA Warning in EPIC

N=1103 patients <3 years of age scheduled for >3 hours of surgery

Of 842 patients with 2 or more anesthetics from Jan-Aug 2018, 84% had FDA warning discussed in EPIC

MRI Questions

- MRIs are among the most frequently cited procedures under anesthesia that possibly could be delayed: but what is the data?
- What are the indications for brain MRI for developmental delay or new onset seizures, especially in children with no neurological or syndromic findings?
- What percentage of sedated MRIs in children <3 years are abnormal? Diagnostic? Which of these are actionable findings?

NEUROIMAGING: IS IT NECESSARY IN ALL CASES?
Pediatric Anesthesiology

- **ANALYZED 1 YEAR OF BRAIN MRI WITH ANESTHESIA/SEDATION <3 YEARS, IMMEDIATELY BEFORE THE FDA WARNING**
- **INDICATIONS:** global developmental delay, new onset seizure
- **COLLABORATIVE PROJECT:** Neurology, Radiology, Anesthesiology
- **MRI DATA**
  - Abnormal Yes/No
  - **Findings:** Diagnostic findings: etiologic diagnosis
  - **Hypothesis:** 10% yield for etiologic diagnosis

Pediatric Anesthesiology

- **TCH MRI Indications Study Results**
  - **Global Developmental Delay**
    - Etiologic diagnosis in 63/222 (28%)
    - 19/222 changed medical management (8.6%)
  - **New Onset Seizure**
    - Etiologic diagnosis in 53/339 (16%)
    - 29/339 changed medical management (8.5%)
  - **Overall 21% etiologic diagnosis**
    - Higher than hypothesized

Pediatric Anesthesiology

- **Anesthetic Exposure Data**
  - Mean anesthesia time 61.9 ± 20.6 minutes (median 58 min)

Pediatric Anesthesiology

- **AAP Surgical Advisory Panel “Optimal Timing” Task Force**
  - Multidisciplinary task force with representation from the 10 AAP pediatric surgical specialty sections
  - Consensus that many pediatric surgeries are not “deferrable” due to critical windows for neurodevelopment and function
  - Initial survey of task force members has generated preliminary list of "non deferrable" surgeries based on medical literature and consensus
  - Work in progress, not finalized, discussions ongoing

Pediatric Anesthesiology
Surgeries with “Critical Window” for Repair < 3 years

• General Surgery
  - Inguinal hernia
  - Lung malformations
  - Branchial cleft, thyroglossal duct cysts
  - Lymphangioma

• Otolaryngology
  - All procedures, including PE tubes, T&A

• Neurosurgery
  - All procedures except some dermoid cysts

• Ophthalmology
  - Cataract
  - Strabismus
  - Ptosis
  - Glaucoma

• Orthopedics
  - Hip dislocation
  - Casting for early scoliosis
  - Club foot

• Urology
  - Undescended testicles
  - Hypospadias

Source: Constance Houck, M.D., MPH, Chair of AAP Surgical Advisory Panel

Vulnerable Populations

• Pediatric ICU Patients
  - Approximately 15/1000 population annually
  - 2/3 <4 years old
  - 20% have moderate to severe disability on discharge
  - No published data about long term sedation and neurocognitive outcomes

• Neonatal ICU Patients
  - 77.9/1000 live births (300,000 annually in U.S.)
  - No long term data about sedation and neurocognitive outcomes

2007 vs. 2023: What Has Changed?

• 2007: First FDA meeting; significant concern about real cognitive effects of a single anesthetic
• 2007: Only a few retrospective studies; no prospective studies, no defined post-exposure neurodevelopmental outcomes testing
• 2007: Negative media attention and frequent questions from parents, some postponement of cases
• 2023: Many more prospective and otherwise well defined studies
• 2023: No cognitive (i.e. IQ) effect of a single brief exposure
• 2023: Behavioral phenotype emerging:
  - Externalizing/internalizing/executive function: small (3-5%) effect but significant

WE ARE FAR MORE REASSURED THAT EFFECTS ON NEUROCOGNITIVE OUTCOMES ARE LESS SEVERE THAN ORIGINALLY ANTICIPATED
BEHAVIOR CHANGES ARE RELATIVELY SMALL BUT CONCERNING
NO REASON TO POSTPONE ALMOST ANY ELECTIVE SURGERY OR ANESTHETIC
Case Study

- 13-month-old otherwise healthy male for hypospadias repair anticipated to require 2 hours of surgery, 2.5 hours anesthesia
- No previous anesthetic history, or family history of significant problems
- Parents are very concerned about the possible anesthetic effect on the brain and ask if they should postpone surgery until after age 3 years
- They are also asking about epidural or spinal anesthesia if the surgery must be done now
- They also read about dexmedetomidine and are asking for this drug if he has to have general anesthesia
POLL

Participate in polling in one of two ways:

VIA TEXT MESSAGE:
Text LJaneStewart to 22333 to start
Put your responses in the message at the appropriate time

VIA THE WEB:
https://pollev.com/LJaneStewart
OR
Scan QR Code

BLUNT TRAUMA AND THE USE OF REBOA

L. Jane Stewart, MD, JD, MPH
Denver Health and Hospital Authority
University of Colorado
DISCLOSURES

No financial disclosures
Slide minimalist
I work at a Level I Trauma Center

LEARNING OBJECTIVES

Be able to discuss the epidemiology of blunt trauma and current treatments
Understand the use of REBOA in trauma
Understand operating room management of REBOA for anesthesiologists
Understand the potential complications of REBOA
Know applications of REBOA outside of trauma

POLL

Participate in polling in one of two ways:
VIA TEXT MESSAGE:
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VIA THE WEB:
https://pollev.com/LJaneStewart
OR
Scan QR Code

TRAUMA: EPIDEMIOLOGY

4.4 million

TRAUMA TREATMENTS FOR NON-COMPRESSIBLE TORSO INJURY

Tranexamic Acid (TXA)3,4
Interventional Radiology5
Extrapertoneal Pelvic Packing (EPP)6,7
Resuscitative Thoracotomy (RT) + Aortic Clamping.8-10

REBOA: OVERVIEW

History and Purpose
Placement
Contraindications
Removal
Evidence/Recommendations
REBOA: HISTORY & PURPOSE

REBOA: HISTORY

- Korean War use of aortic occlusion in 2 patients by Lt. Col. Carl Hughes
- 21 patients at the Trauma Center for Brooklyn
- First case series with 6 civilian trauma patients published

REBOA: PLACEMENT

- Proximal pressure reading: above the balloon BP (reads off the REBOA catheter)
- Distal pressure reading: below the balloon BP (reads off the 7Fr sheath)
REBOA: PLACEMENT (ZONES)

Zone 1: Supra-diaphragmatic
Zone 2: Between celiac trunk and renal arteries
Zone 3: Below renal arteries, proximal to iliac bifurcation

REBOA: OCCLUSION TIME

Zone 1: Supra-diaphragmatic
Zone 2: Between celiac trunk and renal arteries
Zone 3: Below renal arteries, proximal to iliac bifurcation

REBOA: CONTRAINDICATIONS

Unable to obtain femoral access

Used with permission from Prytime Medical
REBOA: CONTRAINDICATIONS

Unable to obtain femoral access
Aortic diameter greater than 3.2cm (32mm)
Contrast media allergy
Pediatric Use

REBOA: EVIDENCE

Quick arterial access is key
Probably best placed under fluoro
Hardest to place in Zone III
Probably a survival benefit
There are risks

REBOA: REMOVAL

REBOA removal after definitive hemorrhage control
Sheath removal
Hold pressure for 5 mins

REBOA: GUIDELINES

Systematic review to evaluate algorithms for REBOA use in trauma and identify a consensus for patient selection

REBOA: GUIDELINES

A Western Trauma Association critical decisions algorithm: Resuscitative endovascular balloon occlusion of the aorta

Yes

Penetrating Trauma?

Consider Zone 1 REBOA*

No

Insert CFA A-line + eFAST + CXR

Major Thoracic Vascular Injury? No REBOA

Yes

NO

Insert CFA A-line + eFAST + CXR

Free intra-abdominal fluid? Laparotomy or Zone 1 REBOA

Pelvic Fracture? Pelvic XR

Pelvic fracture?

Pelvic fracture?

Zone 1 REBOA or Angioplasty

History and Purpose

Placement

Contraindications

Evidence/Guidelines

OR MANAGEMENT

Monitors

Hemodynamics

Other Considerations

OR MANAGEMENT: MONITORS
**REBOA: PLACEMENT**

1. **Proximal pressure reading**
   - above the balloon BP (reads off the REBOA catheter)

2. **Distal pressure reading**
   - below the balloon BP (reads off the 7Fr sheath)

**OR MANAGEMENT: MONITORS**

- Proximal arterial pressure monitoring via 7Fr arterial catheter
- Distal arterial pressure monitoring via 7Fr REBOA catheter
- Consistent pressure monitoring

- Radial Arterial Line
  - Blood Sampling
  - Removal
  - Consistent Pressure Monitoring
OR MANAGEMENT: HEMODYNAMICS

REBOA: COMPLICATIONS
- Thromboembolic Events
- Vascular Injury
- End Organ Damage
- Compartment Syndrome
- Fatal Hemorrhage/Increased Intracranial Pressure

REBOA: NON-TRAUMA USES
- Placenta Accreta/Percreta
- Non-trauma cardiac arrest

REBOA: THE FUTURE
- Common Femoral Access
- Pediatric Uses
- Non-Trauma Uses
- Patient Selection

QUESTIONS?
Monday, February 27th
Update on Geriatric Anesthesia

Nathaniel J Brown, MD, PhD
Assistant Professor
CU SOM Dept of Anesthesiology
Rocky Mountain Regional VAMC
February 27 2023

Disclosures
No financial disclosures

Learning Objectives
Discuss innovations in preoperative assessment strategies for the geriatric population.

Learn about a couple of studies that can shed light on intraoperative care of the elderly.

Appreciate delirium and postoperative cognitive decline as major concerns in the postoperative care of the elderly.

Overview
This update is intended to discuss novel findings in areas of science that impact perioperative care.
We will divide the talk into three unequal, if predictable, sections: preop, intraop, postop.

The prevention of postoperative cognitive issues is probably the biggest issue facing anesthesia, so we will spend the most time there.
I will have the least to say about intraoperative care.

Preoperative Assessment
Frailty is associated with an array of poor surgical outcomes, but there is no gold standard frailty assessment tool.
A study from last October (2022) looked at 3 frailty assessments:

Rabelo et al 2022

Results: Out of 58 patients, 41%, 37%, and 45% had abnormal PRISMA, TUG, and CDT screening, respectively. Postoperative delirium was more likely to occur in patients with abnormal TUG screening (19% vs. 3%, p = .021) and CDT (21% vs. 4%, p = .019). When analyzing screening tool combinations, patients with abnormal PRISMA and TUG had a higher rate of non-home discharge (38% vs. 17%, p = .006) and patients with abnormal TUG and CDT had a higher rate of postoperative delirium (21% vs. 3%, p < .001) and non-home discharge (38% vs. 18%, p = .014).

Conclusions: Approximately 40% of elderly surgical patients have abnormal PRISMA, TUG, and CDT screening tools for frailty, and they are associated individually or in combination with increased risk of adverse postoperative outcomes. The results will aid in designing studies to further stratify patients at risk of frailty and attempt to modify associated outcomes.
A wider look

Not great news

Multipronged approaches work better

A fun finding

Intraoperative Anesthesia

A data-backed use for BIS
Results

The “Hidden BIS” group spent more time with a BIS <40 compared to the “Visible BIS” group (11 min vs 26 min).

The Visible BIS group also spent about 3 fewer days inpatient.

Post-op delirium rate lower, too.

A meta-analysis on the same topic

Postoperative badness:

The big players

Delirium

Post Operative Cognitive Dysfunction (POCD)

Delirium vs POCD

Delirium:

“Acute confusional state with alterations in attention and consciousness.”

(One of the agreed upon definitions)

POCD

“Decline in a variety of neuropsychological domains [including processing speed, memory, executive function, etc.]”

(One of many definitions)

Delirium

Delirium is diagnosed by criteria set out in the DSM.

Stated succinctly as: “a disturbance in consciousness that is accompanied by a change in cognition that cannot be better accounted for by a preexisting or evolving dementia.” (DSM)

Has 3 main “flavors” described as: hyperactive, hypoactive, and mixed.

The majority (68%) are hypoactive with mixed presentation second most common at 31%. Isolated hyperacute delirium is rare (~1%).

CAM (confusion assessment method) is the most commonly used to score delirium.

Postoperative Delirium

A major concern in the elderly

Prevalence 10% or more

Cardiac and hip surgery carry big risk

ICU care carries the biggest risk (up to 60-80%)

Age is a big risk factor for postoperative delirium.

Unsurprisingly, the greater the number of predisposing risk factors (called “vulnerability” factors) the smaller the stress needed to induce delirium.
Postoperative Delirium

Major vulnerability factors are advanced age, visual impairment (visual acuity < 20/70), illness severity (APACHE score >16), cognitive impairment (MMSE <24), hearing impairment, dehydration, sleep deprivation, immobility, among others.

Prevention is key
Once delirium has begun there are few interventions that have much of a proven effect.

Efficacy of perioperative dexmedetomidine on postoperative delirium: systematic review and meta-analysis with trial sequential analysis of randomised controlled trials

X. Du et al., R. Rossaint, R. D. Sanders, J. V. Wasenbergh and A. Kowrk

Conclusion: Dexmedetomidine can reduce PAD incidence for adult cardiac and non-cardiac surgical patients. The optimal dose and timing of dexmedetomidine and influence on other outcome or particular patient populations with risk factors warrants further studies.

What about in people?

The association between gut microbiota and postoperative delirium in patients

Zhenqong Xie, Ting Zhong, Kehyron Badiga, Yuanmin Deng, Wenju Song, Minhua Wu, Xia Deng, Arieel Mtoni, Timothy Whillier, Edward Mastorakos

PMID: 36747860 PMCID: PMC935608110.1016/j.sxxx.2023.03.0949

The association between postoperative delirium of the 85 participants (age 71.0 ± 16.0, 25-75% percentile of quartiles, 75% female, 12% developed postoperative delirium. Postoperative gut bacteria Parabacteroides distasonis (Obesity T1 [OR] 2.15, 95% Confidence Interval (CI): 1.08-4.31, P = 0.025) was associated with postoperative delirium after adjusting for age and sex. The association between delirium and both Provatek (OR: 0.69, 95% CI: 0.33-1.04, P = 0.046) and GutCheck (OR: 0.42, 95% CI: 0.21-0.83, P = 0.016) did not reach statistical significance. These findings suggest that postoperative gut microbiota (e.g., Parabacteroides distasonis) may serve as biomarkers in the pathogenesis of postoperative delirium, pending confirmation studies.

A deeper look

The effects of microbiome-targeted therapy on cognitive impairment and postoperative cognitive dysfunction: A systematic review

Sabine Säcker, Peggy Taub, Sandra Kopp

PMID: 36748922 PMCID: PMC9458406 DOl: 10.1037/jopr0000000

Conclusion: In the studies we examined, most showed that MTRs decrease inflammation by down-regulating inflammatory cytokines and oxidative stress in both perioperative and non-perioperative settings. In general, MTRs also seem to have a positive effect on cognition through neurocognitive, immune, endocrine, and metabolic pathways. However, these effects have not yet reached a consensus regarding preventive strategies or treatments. Based on these current research results, MTRs could be a potential new preventive strategy for cognitive improvement after surgery.
Preventing Postoperative Delirium

Antipsychotics may help (may also hurt?). Desmopressin may help.

Prophylaxis?

Intraoperative correction of metabolic derangements (electrolytes, volume status, etc.)

Intraoperative and postoperative: decrease known trigger medications such as opioids, benzodiazepines, dihydropyridines CCBs, etc.

Multimodal pain management, avoiding sedating medications.

TIVA vs volatile anesthetics?

---

2018 Cochrane Review
28 RCTs and over 4500 participants.

There was heterogeneity in the data. Noted difficulty in blinding the anesthesia technique to the provider, some important variables (like intraoperative hypotension) could not be adequately controlled for. Data reporting inconsistencies also made the analysis less reliable.

A more recent analysis (2022) did show a small effect favoring TIVA.
Preventing Postoperative Delirium
A wrinkle

Many advocate for use of neuraxial and regional techniques to avoid GA in the elderly.

Conflicting data
Recent-ish study (2020) showed no benefit specifically in hip surgery, which is one of the higher risk surgeries for postoperative delirium.

114 patients, ages 65+, ASA 2-4 with hip fracture

On the more positive side:

Bottom line: Regional might be better for geriatric patients in some settings

Cognitive function in older patients and their stress challenge using different anesthesia regimes: a single center observational study

Sween Wagner 1, 2, Martin Sciortino 3, Eirini Arekousa 4, Irene Keeling 5, Oliva Kuentz 5, Christine Thomas 5, Christine A. von Arx 6, Andreas Walter 3

Affiliations 1-6 are provided
PMID: 36063921 PMCID: PMC6857374 DOI: 10.1098/rsif.2021.0379

Conclusions: We did not observe a difference in postoperative cognitive function between patients undergoing regional or general anesthesia for dermatologic surgery. However, we found lower mortality levels in the RA group. Based on these findings, future studies should investigate alternatives to reduce stress in a general anesthesia setting.

Post-Operative Cognitive Decline (POCD)

Not a single, specific diagnosis in the DSM
Inconsistent definitions, but here's one: “[a new] dysfunction in cognition, that is not explained by a preexisting neurocognitive disorder” (Mitsuka et al.)

Is gradual in onset, in contradistinction to delirium.
Requires neuropsychometric testing to track.
Usually self-limiting.
POCD and Risk

Age is thought to be the most significant risk factor. Some newer data point to possible biomarkers (neuron-specific enolase (NSE) and S100b), but as of now it’s too early to know. Cardiac surgery is, again, a higher risk surgery. The label “POCD” may represent several different underlying problems. Because of the possibility that several layers of etiology are possible...

Promise for the future

Clinical Interventions in Aging

Postoperative cognitive dysfunction – current preventive strategies

Exhibit undesirable side effects. Interventions to reduce oxidative stress and neuroinflammation could prove beneficial. Preventive strategies, early recognition, and management of perioperative risk factors are key. But, by far, the best strategy to deal with POCD is further progress in therapeutic interventions evolves.

Anesthesiology and cognitive impairment: a narrative review of current clinical literature

Jill C Betro' and Ruegger R. Zeppernik

Abstract

Background: The impact of general anesthesia on cognitive impairment is controversial and complex. A large body of evidence supports the association between exposure to surgery under general anesthesia and development of delayed neurocognitive disorders in a subset of patients. Existing literature continues to debate whether these short-term effects on cognition can be attributed to anesthetic agents themselves or whether other variables are causative of the observed changes in cognition. Furthermore, there is conflicting data on the relationship between anesthetic exposure and the development of long-term neurocognitive disorders, or development of incident dementia in the patient population with normal preoperative cognitive function. Patients with pre-existing cognitive impairment present a unique set of anesthetic considerations, including potential medication interactions, challenges with cooperation during assessment and non-general anesthesia techniques, and the possibility that pre-existing cognitive impairment may impact a susceptibility to further cognitive dysfunction.

Change in Nomenclature?

SPECIAL ARTICLE

Recommendations for the Nomenclature of Cognitive Change Associated with Anesthesia and Surgery—2018

The working group recommends that “peroperative encephalopathy” be used as an overarching term for cognitive impairment identified in the perioperative or postsurgical period. We include cognitive-dysfunction in the operating room (described as encephalopathy), any form of acute events (encephalopathy delirium) and cognitive decline diagnosed up to 30 days after the procedure (delayed encephalopathy recovery) and up to 12 months (peroperative encephalopathy disorders).

Is It the Anesthesia? (we don’t know)

Clinical Interventions in Aging

General anesthetic and the risk of dementia in elderly patients: current insights

“Neither the route of anesthesia nor the type of anesthetic appears to be significantly associated with the development of postoperative delirium or postoperative cognitive dysfunction.”

Active prevention? Maybe?


doi: 10.1097/MD.0000000000002219.

Transcutaneous electrical acupoint stimulation for the prevention of perioperative neurocognitive disorders in geriatric patients: A systematic review and meta-analysis of randomized controlled trials

Shanghe Li 1, Feifan Jiang 1, Wei Liu 1, Ya Yang 1, Chenlong Yin 1, Hua Chen 1, Hucheng Su 1, Q. Zhao 1, Y. Zhang 1, Chen Li 1

AFFILIATIONS: 1 Shanghai Lihu Central Hospital, Shanghai, China

PMID: 36352910 PMCID: PMC8771560 DOI: 10.1097/MD.0000000000002219
This review did show promise

**Conclusion:** In terms of clinical effectiveness, TIVA appeared to be beneficial for prophylaxis of POCD during a relatively recent period; noting the limitations of the current evidence.

---

Is all POCD really POCD?

Is it possible that sometimes an acute event can cause greater scrutiny or reflection by a patient or family members?

Humans are excellent pattern-finders, so we sometimes pin changes that have been happening over months or years to a specific event thought to be sentinel.

Not all POCD research depends on clinical assessments of cognitive function.

Not every patient complaint of being "mentally different" after surgery is POCD or one of its kin.

Nevertheless, POCD remains common, and a problem of significant concern.

---

A great deal of research is needed

**You saw that coming, didn’t you?**

This is an area of active research, and compared to what we need to know, very little has yet been discovered.

In the meantime, various multimodal approaches are the best we can do regarding preventing or ameliorating postoperative changes in cognition.

Prevention starts with pre-op assessments. Multidisciplinary approaches have been shown to improve an array of outcomes.

---

Some take-home points

It is best to prevent delirium (you knew that already)

POCD remains a thorny question from definition to prognostication to active research.

There is no treatment. Some degree of active prevention may be possible, but the research isn’t there yet.

How we administer anesthesia “might” matter; if so, there is a mild bias toward:

- TIVA
- Regional

but this is far from established in the literature.

Frailty is a major predictor of many unfavorable postoperative outcomes (you know that already)

---

Thank You!
Anesthesia for Non-Cardiac Surgery in Congenital Heart Disease

Dean B. Andropoulos, M.D., M.H.C.M.
Anesthesiologist-in-Chief and Chair, Texas Children’s Hospital
Department of Anesthesiology, Perioperative and Pain Medicine
Professor, Departments of Anesthesiology and Pediatrics
Baylor College of Medicine, Houston, Texas, U.S.A.

CRASH 2023
Vail, Colorado
February 27, 2023

Disclosures
• None

Major References

Learning Objectives
• Understand the basic pathophysiologic approach to congenital cardiac lesions
• Review the preoperative evaluation of CHD patients
• Discuss conduct of anesthesia for non-cardiac surgery for CHD patients
• Discuss recent changes to infective endocarditis guidelines
• Review the outcomes of anesthesia for non-cardiac procedures in patients with CHD

Incidence/Prevalence of Congenital Heart Disease
• 8-12 per 1000 infants in the U.S. are born with CHD
  – Most common birth defect requiring treatment
  – Similar incidence worldwide
• Survival now >95% for CHD surgery in many countries
  – >30,000 CHD surgeries annually in US: 25,000 <18 yrs; 5,000 >18 yrs; mortality 2.7%
  – 120 CHD surgery programs, approximately 350 surgeons
• ~1.4 million adults/1 million children with CHD in U.S.—1 in 150
  – 55% simple lesions: ASD, VSD most common
  – 30% moderately complex: TOF most common
  – 15% complex lesions: TGA, single ventricle lesions
  They will require anesthesia for non-cardiac surgery. (Circulation 2022;145:e153)
Non-Cardiac Surgery in Congenital Heart Disease

- 30% of children with CHD have extracardiac anomalies
- 41% of patients who had cardiac surgery <1 year of age also had at least 1 non-cardiac surgery by age 5 years
- NC surgery procedures in U.S. increased from 38,212 in 2015 to 45,993 in 2019 (20%)
- At Texas Children’s Hospital, 20-30 patients with CHD per day have non-cardiac surgery or diagnostic procedures

Ventricular Septal Defect (VSD): Anatomy

A: Supracristal; subarterial
C: Perimembranous
F: Inlet; canal-type
D,E,G: Muscular

VSD Pathophysiology

- Ranges from small, asymptomatic with minimal left-to-right shunt
  - Endocarditis
  - Aortic valve insufficiency
- Larger VSD with CHF symptoms
- Unrestrictive VSD with pulmonary hypertension
  - Eisenmenger Syndrome possible

Tetralogy of Fallot: Anatomy

TOF Pathophysiology

- Unrepaired:
  - Acyanotic with left to right shunt
  - Cyanotic
- Repaired:
  - Pulmonary insufficiency
  - RV dilation/dysfunction
  - Arrhythmias

Atrial Septal Defect

1: Secundum
2: Primum
3: Superior sinus venosus
4: Inferior sinus venosus
Atrial Septal Defect Pathophysiology

- Primarily left-to-right shunt, often asymptomatic for years
- May have paradoxical embolus: TIA, stroke
- II/VI systolic murmur, fixed split second heart sound
- A cyanotic, cardiomegaly on CXR
- Diagnosis: echocardiography
- Treatment: device closure in cath lab or surgery with CPB
- Beware of partial anomalous pulmonary venous return

Patent Ductus Arteriosus Pathophysiology

- Acyanotic: Left to right shunt depends on diameter, length, tortuosity, resistances in systemic/pulmonary circulations
- II-III/VI long systolic or continuous murmur
- Diagnosis: echo
- Adults: beware calcified, dilated, hypertensive PDA
- Treatment: surgery via L thoracotomy (non-bypass), device closure in cath lab
- Eisenmenger Syndrome possible

Coarctation of the Aorta

- Surgery:
  - Repaired via left thoracotomy, cath lab stenting
  - May have had subclavian flap: diminished BP left arm
- Diagnosis: echo/MRI
- Residual hypertension, coarctation, collateral circulation
- LV hypertrophy, early atherosclerosis
- Coarctation Repair

Coarctation of the Aorta Pathophysiology
D-Transposition of the Great Arteries

- Aorta and PA reversed in utero
- Parallel circulations: depends on communication for oxygenation: ASD, VSD, PDA
- Often profound cyanosis at birth
- Diagnosis: echo, may need balloon atrial septostomy
- Surgery: arterial switch operation since mid-1980's
- Still possible to see Mustard or Senning patients

Atrioventricular Canal

- Most frequently associated with Trisomy 21 (Down Syndrome)
- Early pulmonary hypertension possible with delayed repair
- Residual or progressive mitral regurgitation may necessitate surgery later in life
- Adults may have Eisenmenger Syndrome

Single Ventricle Lesions: Tricuspid Atresia
Single Ventricle Lesions: Hypoplastic Left Heart Syndrome
• 0.7% of CHD but one of most common neonatal operations
• Severe mitral and aortic stenosis or atresia
• Very small or non-existent LV
• Treatment: Norwood operation; “hybrid” Norwood, transplant
• Formerly 100% fatal in first month; now 70-75% survive long term
• We are now seeing young adults who had Norwoods in the 1980s-1990s

Norwood Stage I Palliation
“Classic” BT Shunt
Sano Modification

Fontan Connections
Lateral Tunnel
Extracardiac

Bidirectional Cavopulmonary Anastomosis (Glenn)

Single Ventricle Pathophysiology After Fontan
• CVP is the driving force for pulmonary blood flow
• Hypovolemia is poorly tolerated
• Positive pressure ventilation increases intrathoracic pressure, decreases pulmonary blood flow, decreasing cardiac output
• Pneumoperitoneum may be poorly tolerated
• Non-sinus rhythm is poorly tolerated
• May have fenestration: beware air in IV
Preoperative Evaluation of Patients with Congenital Heart Disease

10 Fingers of CHD Diagnosis

Cardiology Consultation

Common Preop Planning Issues

- Preoperative Evaluation: Practical Pathophysiologic Approach to CHD
  - Is the patient cyanotic or acyanotic?
    - Cyanotic: is there a single functional ventricle?
    - Acyanotic: Left-to-right shunting, or obstructive/regurgitant lesion?
  - Corrective or palliative surgery?
    - Resulting anatomy and residual defects?

- General recommendations:
  - Cyanotic patients:
    - Well compensated: cardiology visit/echo within 6 months
    - Less well/poorly compensated: preoperative consultation
  - Acyanotic patients:
    - Well compensated: no consultation unless otherwise indicated
    - Less well/poorly compensated: preoperative consultation

- CHD center with expertise
  - Cardiologist, Surgeon, ICU, Anesthesiologist for complex patient or procedure
  - Inpatient vs. outpatient surgery
  - Proximity to help/expertise, inpatient admission
  - ASA III can undergo outpatient procedures if well compensated/minor surgery/plan to return
  - Invasive monitoring: need increases with complexity
  - of lesion/patient status/invasiveness of surgery
  - Availability of emergency drugs/cardioversion/defibrillator
  - Blood transfusion: goals for oxygen carrying capacity
  - Need for inotropes/vasodilators
  - ICU care: postoperative ventilation/observation
Conduct of Anesthesia

- No single drug or technique is prohibited for non-cardiac surgery in CHD
- Understand the pathophysiology and desired hemodynamic and ventilatory state
- Design anesthetic techniques to achieve the desired goals

Infective Endocarditis Prophylaxis

- More limited cardiac indications
- More limited procedural indications

Infective Endocarditis Prophylaxis

Table 3. Cardiovascular Conditions Associated With the Highest Risk of Adverse Outcome From Endocarditis for Which Prophylaxis With Dental Procedures is Reasonable

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prophylaxis Before Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Conditions</td>
<td></td>
</tr>
<tr>
<td>Congenital heart disease (CHD)</td>
<td></td>
</tr>
<tr>
<td>Unrepaired congenital defects or other conditions</td>
<td></td>
</tr>
<tr>
<td>Complete, repaired congenital heart defect with prosthetic material or device, unless repaired by surgery or by catheter intervention, during the first 6 months after the procedure</td>
<td></td>
</tr>
<tr>
<td>Repairable CHD with residual defect at the site or adjacent to the site of a prosthetic patch or prosthetic valve which needed stabilization</td>
<td></td>
</tr>
<tr>
<td><em>Except for the conditions listed above, antibiotic prophylaxis is no longer recommended for any other form of CHD.</em></td>
<td></td>
</tr>
</tbody>
</table>

Circulation 2007;116:1736

Infective Endocarditis Prophylaxis

Table 4. Regimens for a Dental Procedure

<table>
<thead>
<tr>
<th>Anticipated Agent</th>
<th>Dosage</th>
<th>Time Before Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxicillin</td>
<td>2 g</td>
<td>1 h before procedure</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>600 mg</td>
<td>1 h before procedure</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>1 mg</td>
<td>1 h before procedure</td>
</tr>
</tbody>
</table>

Circulation 2007;116:1736

Classification of CHD

Table 1. ACS-RSCT Classification of Congenital HD Based on Residual Lesion Burden and Functional Status

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>CHD condition with or without mitral valve disease, small left-to-right shunt, minimal left ventricular dysfunction</td>
<td>Residual lesion burden ≤ 10% and no functional abnormalities</td>
</tr>
<tr>
<td>Major</td>
<td>CHD condition with mitral valve disease, moderate left-to-right shunt, moderate left ventricular dysfunction, Reversal of congenital HD with residual low-output heart failure and no complications</td>
<td>Residual lesion burden &gt; 10% and functional abnormalities</td>
</tr>
<tr>
<td>Severes</td>
<td>CHD condition with residual hemodynamic abnormalities with or without complications (e.g., depression of left ventricular function with pulmonary hypertension, hypoplastic left heart syndrome including stage I palliation)</td>
<td>Residual lesion burden &gt; 20% and severe complications</td>
</tr>
</tbody>
</table>

Approach to the Adult with CHD for Non-Cardiac Surgery

Major References

TABLE 11

<table>
<thead>
<tr>
<th>ACHD Management Issues for Noncardiac Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarify CHD diagnosis</td>
</tr>
<tr>
<td>- Be aware that history obtained from only the patient and family may be faulty or incomplete</td>
</tr>
<tr>
<td>- Obtain and review old records to ensure accurate understanding of past procedures and clinical course</td>
</tr>
<tr>
<td>- Complete additional investigations required to define ACHD AP classification</td>
</tr>
<tr>
<td>- Develop management strategies to minimize risk and optimize outcome</td>
</tr>
</tbody>
</table>

J Am Coll Cardiol 2019;73:e81-e192
Pregnancy and CHD: General vs. Neuraxial Anesthesia

Pregnancy and CHD • Pacemakers/Defibrillators and CHD

Factors associated with increased risk of perioperative morbidity and mortality (51.2.12-12): [Images and text]

- Cyanosis
- Congestive HF
- Poor general health
- Younger age
- Pulmonary hypertension
- Operations on the respiratory and nervous systems
- Complex CHD
- Urgent/emergency procedures

Issues to consider:
- Endocarditis prophylaxis
- Complications related to underlying hemodynamics
- Abnormal venous and/or arterial anatomy affecting venous and arterial access
- Pulmonary embolism
- Vascular disease
- Arrhythmias, including bradyarrhythmias
- Hypertension
- Pulmonary vascular disease
- Mechanical line care (also consider air filters for intravenous lines) to reduce risk of paradox embolism in patients who are cyanotic because of right-to-left shunting
- Adjustment of anticoagulant volume in tubes for some blood work in cyanotic patients
- Prevention of venous thrombosis
- Monitoring of renal and liver function
- Perioperative anticoagulation
- Possible need for nonconventional drug dosing
- Increased prevalence of hepatitis C infection because of prior procedures and remote blood transfusions
- Developmental anomalies

Pregnancy and CHD

Pacemakers/Defibrillators and CHD

- Primary issue: electrosurgery often interferes with/disables pacemaker sensing/pacing, or can be interpreted as arrhythmia with defibrillators
- Crucial to understand underlying rhythm: is the patient pacemaker-dependent? (Life threatening bradycardia as underlying rhythm)
- Beat-to-beat BP monitoring essential; arterial line or well-functioning pulse oximeter; ECG and BP cuff alone insufficient
- Turn on pacemaker spike detection on OR ECG monitor
- Pacemaker/defibrillator pads for pacemaker dependent patients
- Consult cardiologist or industry representative whenever possible; often converting to asynchronous pacing and turning off defibrillator function is the approach

- Nephrectomy
- Hemodynamic changes

- Pregnancy and CHD: General vs. Neuraxial Anesthesia

- Primary vs. Neuraxial: General anesthesia
  - Spontaneous ventilation
  - No anesthetic manipulation
  - Less bleeding
  - Episodic cardiac ischemia
  - Pain with spontaneous birth of baby

- Neuraxial anesthesia
  - Spinal
  - Epidural

- Pregnancy and CHD

- Pacemakers/Defibrillators and CHD

- Primary vs. Neuraxial: General anesthesia
  - Spontaneous ventilation
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- Pacemakers/Defibrillators and CHD

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  - Pain with spontaneous birth of baby

- Neuraxial anesthesia
  - Spinal
  - Epidural
Pacemakers/Defibrillators and CHD

Case Study

- 42 y.o. female with history of tricuspid atresia
  - Atrial-pulmonary Fontan age 5 years
  - Fontan conversion to lateral tunnel (fenestrated) with Maze procedure at age 35
  - Pacemaker-defibrillator for sick sinus syndrome/atrial fibrillation
  - Medications: sotalol, amiodarone, low dose aspirin
- Presents for laparoscopic cholecystectomy
- What additional information do you need?
- General approach to anesthetic?

Conclusions

- Prevalence of CHD, high survival, and frequent non-cardiac conditions contribute to growing numbers of CHD patients having non-cardiac surgery
- Careful preoperative evaluation and planning can help direct appropriate resources to CHD patients having non-cardiac surgery
- A relatively simple risk stratification tool can help plan for the resources needed to care for these often complicated patients

Thank You
Pulmonary Hypertension Case Presentations: Your Questions Answered

Monday 27th February 2023
4.00 – 6.00pm

Welcome!

Dean B. Andropoulos, MD, MCHM
Anesthesiologist-in-Chief,
Texas Children's Hospital
Chair, Texas Children's Department of Anesthesiology, Perioperative and Pain Medicine
Burkett S. Dunbar, M.D.
Chair in Pediatric Anesthesiology
Baylor College of Medicine Department of Anesthesiology

Joy Hawkins, MD
Anesthesiologist
Director of Obstetric Anesthesia
University of Colorado School of Medicine

Thin Air, Thick Vessels
Hypoxia, Pulmonary Hypertension, the Centennial State
A Case Report
Dr. Mark Twite, MA MB BChir FRCP
Professor for Anesthesiology
Director of Congenital Cardiac Anesthesiology
University of Colorado Anschutz Medical Campus & Children's Hospital Colorado

Definition of Pulmonary Hypertension

- An elevation in mPAP, from any cause
- First classified as mPAP > 25mmHg (1st World Symposium on PH in 1973)
- New classification as mPAP > 20mmHg (6th World Symposium on PH in 2018)
- Why the change?
  - Emerging evidence of poor survival in patients with mPAPs of 21 – 24 mmHg
  - Normal distribution of data in a healthy population

Hemodynamic Classification of PH

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definitions</th>
<th>Clinical groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-capillary PH</td>
<td>mPAP &gt; 25mmHg</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>Post-capillary PH</td>
<td>mPAP &gt; 25mmHg</td>
<td>1, 2, 3, 4, 5</td>
</tr>
</tbody>
</table>

Simonneau G et al. Eur Respir J. 2019;53
Clinical Classification of PH

1. PAH
   1.1. Idiopathic PAH
   1.2. Heritable PAH
   1.3. Drug and toxin induced PAH (Table 2)
   1.4. PAH associated with:
      1.4.1. Connective tissue disease
      1.4.2. HIV infection
      1.4.3. Portal hypertension
      1.4.4. Congenital heart disease
      1.4.5. Schistosomiasis
   1.5. PAH long-term responders to calcium channel blockers
   1.6. PAH with overt features of chronic thromboembolic (CTEPH) involvement
   1.7. Postsplenectomy pulmonary hypertension of the newborn (PSPN)

2. PH due to left heart disease
   2.1. PH due to heart failure with preserved LVEF
   2.2. PH due to heart failure with reduced LVEF
   2.3. Valvular heart disease
   2.4. Congenital/irreversible cardiovascular conditions leading to post-capillary PH

3. PH due to lung disease and/or hypoxia
   3.1. Obstructive lung disease
   3.2. Restrictive lung disease
   3.3. Other lung disease with mixed or unclassifiable respiratory pattern
   3.4. Hypoxic without lung Disease
   3.5. Developmental lung disorders

Genomic Classification of PH (PVDOMICS)
Redefining Pulmonary Hypertension through Pulmonary Vascular Disease Phenomics

Simonneau G et al. Eur Respir J. 2019;53
Hermes et al. PVDOMICS Study Group. Circ Res. 2017;121(10)
Cardiopulmonary Responses to Hypoxia

- Acute Maladaptation
  - Acute Mountain Sickness (unacclimatized person travelling above 8,000 Ft)
  - HAPE
  - HACE

- Chronic Changes
  - Hypoxia Induced PH

Hypoxic Pulmonary Vasoconstriction

- Acute hypoxia causes pulmonary vasoconstriction
- Importance in V/Q matching
- Problematic if it occurs in the entire lung
- HAPE (High Altitude Pulmonary Edema)

Von-Euler Liljestrand mechanism

Cattle Ranches in Colorado...and Pulmonary Hypertension

DON’T FEAR
THE BRISKET
Pregnancy-induced pulmonary hypertension in cows susceptible to high mountain disease

John “Jack” Reeves 1928 – 2004
University of Colorado
‘Brisket Disease’

Physiological Response to Hypoxia

Consequences of acute HPV

Above 5,000 Ft a 10% decrease in VO2 is observed for every additional 3,000 Ft of altitude gained.

Pulmonary Vascular Responses to Hypoxia

PH reverses on return to sea level
Future PH Therapy Targets: HIF Inhibitors

Map showing populated regions at altitudes of 8,000 Ft or higher

Genetic selection vs acclimatization

Future PH Therapy Targets: HIF Inhibitors

Dr. Charles Snead Houston 1913 - 2009

GOING HIGHER
Oxygen, Men, and Mountains

Characteristics of populations
- Altitude
- Heart rate
- Blood pressure
- Acclimatized


Case Report

- 15yr old male, 34kg, presents for surgical VSD closure Sept 2022
- Lived in the mountains of Guatemala (8,000 Ft) until 6 months ago
- Diagnosis made in Guatemala but surgery not available. Interimnt treatment with diuretics
- Relocated to Albuquerque, New Mexico (5,100 Ft)
- Initially seen by a cardiologist at an outside hospital
- Echocardiogram and cardiac catheterization performed

Echocardiogram September 2022

1. Dextrocardia, situs solitus, concordant atrioventricular connection and concordant ventriculoarterial connection.
2. Large inlet ventricular septal defect with unrestrictive (low-velocity), primarily left to right shunting. The defect VSD measures 2.53 cm X 3.28 cm.
3. Moderately to severely dilated left atrium.
4. Moderate-to-severe mitral valve stenosis in the setting of a substantial shunt, mean gradient of 14 mmHg.
5. The left ventricle is severely dilated with mildly diminished systolic function. Biplane LV EF 53.1 %.
7. The left pulmonary artery is normal. The right pulmonary artery is severely dilated.
8. The right ventricle is moderately dilated with normal systolic function.
9. Moderate tricuspid valve regurgitation on color flow Doppler.
10. Mild-to-moderate septal flattening in systole and diastole.
What PH is this?

- Increased mPAP 45 - 55 mmHg
- PCWP 21 mmHg
- Mean Mitral Valve Gradient 13.5 mmHg
- Qp/Qs 3:1
- PVRI 2 Wum²

There are lies, damn lies and cath data.....

Adapted from Mark Twain

---

Guidance for assessing operability in pulmonary arterial hypertension associated with congenital heart disease

<table>
<thead>
<tr>
<th>PVRI Wood units m²</th>
<th>PVRI Wood units</th>
<th>Correctability / favorable long-term outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>&gt; 2.3</td>
<td>Yes</td>
</tr>
<tr>
<td>&gt; 8</td>
<td>&gt; 4.6</td>
<td>No</td>
</tr>
<tr>
<td>4 – 8</td>
<td>2.3 – 4.6</td>
<td>Individual patient evaluation in tertiary center</td>
</tr>
</tbody>
</table>

---

Surgery 9/22/22

Preop diagnosis: Ventricular septal defect, pulmonary hypertension, mitral valve stenosis possible mitral valve supravalvar ring, dextrocardia situs solitus

Procedure: Mitral valve repair with resection of supra mitral valve ring, Gore-Tex patch from right ventriculotomy

Indication: This patient is a 15-year-old male who has had a large ventricular septal defect with dextrocardia, situs solitus, bilateral SVC no bridging vein. Patient has evidence of elevated right heart pressures, but the VSD is completely unrestrictive. Pulmonary vascular resistance on a previous catheterization was calculated as normal. Patient has oxygen saturations that are 98% on room air. Patient has an echocardiogram that reveals systolic and diastolic left to right flow through the VSD. Inexplicably this patient does not have fixed pulmonary hypertension despite having a huge VSD. Patient also has evidence of mitral stenosis with a gradient of 15mmHg across the mitral valve in the face of a large left-to-right shunt. Patient likely has a supra mitral valve ring with some parachute subvalvular apparatus abnormality.

---

Echocardiogram 9/28/22

1. There is an organized thrombus with well defined borders that is adhered inside the right atrial appendage.
2. Mild tricuspid valve regurgitation on color flow Doppler. TR Vmax = 3.7 m/s, peak gradient = 56 mmHg.
4. The left ventricle is moderately to severely dilated with normal wall thickness and mildly to moderately diminished systolic function. Biplane LV EF = 40.1 %. Compared to the previous study on 9/26/22, the left ventricle systolic function appears much improved, was moderate-severely diminished with an EF% of 30.2%.
5. The right ventricle is mildly dilated with moderate hypertrophy and normal systolic function.
6. There is no residual ventricular level shunting from the views obtained.

---

Discharged 10/4/22

- Apixaban
- Furosemide
- Spironolactone
- Lisinopril
- Metoprolol
Represent 1/25/23

He is currently critically ill with ventricular dysfunction with fluid overload in the setting of difficulties obtaining his baseline cardiac medications. Additionally, there is concern for VSD patch dehiscence which would explain his heart failure that has been exacerbated by medication non-adherence. He is currently requiring respiratory support with low-flow nasal cannula.

Echocardiogram 1/26/23

1. Status post patch closure of inlet VSD. There is dehiscence of the basal aspect of the VSD patch with a likely small-to-moderate shunt that is predominantly left-to-right.
2. Mild to moderate tricuspid valve regurgitation on color flow Doppler. TR Vmax = 4.9 m/s; peak gradient = 16 mmHg.
3. The left ventricle is moderately to severely dilated with normal wall thickness and severely diminished systolic function. Biplane LV EF = 27.9%.
4. The previous right atrial appendage thrombus is no longer visualized.
5. Moderate mitral stenosis. Mean gradient = 8.7 mmHg at a heart rate of 110bpm.
6. Moderately to severely dilated left atrium.
7. There is echocardiographic evidence of pulmonary hypertension.
8. The right ventricle is mildly dilated with moderate hypertrophy and normal systolic function.

Surgery 2/2/23

Indication: This patient is a 16-year-old male with a history of an untreated ventricular septal defect and mitral valve stenosis with a supra mitral valve ring. Earlier this year the patient underwent repair of the ventricular septal defect and resection of the supra mitral valve ring. Patient had significant pulmonary pulmonary hypertension and decreased left ventricular function at the time of that surgery. Patient has subsequently returned with recurrent ventricular septal defect with dehiscence of the patch and mild mitral stenosis and mild insufficiency. Patient has severe left ventricular dysfunction and pulmonary hypertension. Patient presents now for repair of recurrent VSD and possible mitral valve repair. Patient is extremely high risk.

Findings: Patient was found to have significant vegetation on the VSD patch with dehiscence in the inlet portion of the VSD. Cultures were sent of the vegetation material and the patch. There was mild mitral valve insufficiency arising from the commissure. There was severe adhesions within the mediastinum there is dextrocardia with significant severe pulmonary hypertension and decreased left ventricular function.

Echocardiogram 2/9/23

1. The left ventricle is moderately to severely dilated with normal wall thickness and severely diminished systolic function. Biplane LV EF = 27.6%.
2. The right ventricle is mildly dilated with moderate hypertrophy and low normal systolic function.
3. Moderate tricuspid valve regurgitation on color flow Doppler. TR Vmax = 3.8 m/s; peak gradient = 56 mmHg.
5. Status post revision of VSD patch. Previously noted tiny residual membranous ventricular septal defect not visualized.

Post-op

Extubated following day, milrinone, low dose epinephrine

Infective endocarditis: Dehisced VSD patch coag negative staph (Staph Warmeri)

Currently continues with milrinone, mexilitene (PJRT), aldactone, furosemide, magnesium and potassium supplements, cefazolin

Heart Failure Treatment: Entresto (Sacubitril/Valsartan)

Sacubitril - neprilysin inhibitor
Volartan - angiotensin receptor blocker
Remains an inpatient on nasal canula O2 and AIAPS at night.
Pulmonary Hypertension Case Presentations: Your Questions Answered

Dean B. Andropoulos, M.D., M.H.C.M.
Anesthesiologist-in-Chief and Chair, Texas Children’s Hospital Department of Anesthesiology, Perioperative and Pain Medicine
Professor and Vice Chair, Baylor College of Medicine Department of Anesthesiology

CRASH 2023
February 27, 2023

Case Presentation

9-year-old female with pulmonary hypertension (PH) due to bone morphogenetic protein receptor type 2 mutation (BMPR-2)

Presents for emergency laparoscopic appendectomy

RLQ pain/tenderness, fever, nausea, positive ultrasound

Receiving triple-drug therapy for PH: epoprostenol (Flolan) IV, bosentan, sildenafil

Tires easily with minimal exertion

PH Center is 500 miles away

Case Presentation (cont’d)

Surgeon says case is emergent, no time for transfer to PH center

What are your considerations?

Additional preoperative testing

Intraoperative approach to monitoring, medications, emergency preparations, pain control

Postoperative admission/monitoring

Disclosures

None
**Patient Data**
- Echo: Mild TR 5.7-6 m/sec, mod/severe RVD/RVH, mildly depressed RV function, MPI 0.59; compressed LV with EF 63%

**Catheterization Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAP mm Hg</td>
<td>6</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>RAP mm Hg</td>
<td>97/60 (70)</td>
<td>98/52 (67)</td>
<td>98/52 (67)</td>
</tr>
<tr>
<td>PA Sat %</td>
<td>65</td>
<td>70</td>
<td>78</td>
</tr>
<tr>
<td>PCWP mm Hg</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>PA pressure mm Hg</td>
<td>60/40 (52)</td>
<td>70/44 (57)</td>
<td>70/40 (51)</td>
</tr>
<tr>
<td>PA Sat %</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CI (L/min/m²)</td>
<td>2.2</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>PVRI (WoodU/m²)</td>
<td>30</td>
<td>25.9</td>
<td>22.8</td>
</tr>
<tr>
<td>SVRI (WoodU/m²)</td>
<td>20.9</td>
<td>21.8</td>
<td>16</td>
</tr>
<tr>
<td>Rp/Rs</td>
<td>1.44</td>
<td>1.19</td>
<td>1.43</td>
</tr>
</tbody>
</table>

**Pediatric PH and Perioperative Risk**
- Children with PH have a 30-400 times greater risk of cardiac arrest under anesthesia for non-cardiac surgery and cardiac catheterization, compared to children without PH/heart disease.
- Children with PH have a 20-350 times greater risk of death under anesthesia for non-cardiac surgery and cardiac catheterization, compared to children without PH/heart disease.
- Risk increases with severity of PH.
- Suprasystemic PH confers the greatest risk.

**PH Pathophysiologic Classification for the Anesthesiologist**
- Degree of PH:
  - 50-75% systemic
  - 75-100% systemic
  - Suprasystemic
- Reactivity to oxygen and iNO, other pulmonary vasodilators
- Symptomatology
- Medications: prostaglandins, PDE5 inhibitors, endothelin antagonists, anticoagulation
Pathophysiology of a PH Crisis

- Hypoxia, hypercapnia, acidosis, sympathetic stimulation
- Right heart failure, R to L shunting, further hypoxemia
- Myocardial ischemia, low CO, increased airway resistance
- Cardiac arrest and death
- Baseline PH: mPAP >25 mm Hg or >50% systemic

Prevention of PH Crises During/After Anesthesia

- Choose anesthetic that does not increase PVR, or lower SVR excessively
- Exception: PV obstruction—lowering PVR may worsen
- Monitoring: invasive arterial/central venous/PAP for high risk non-cardiac cases; echo—transthoracic or TEE
- Frequent ABG
- Prophylactic iNO for high risk cases
- ICU care and medical consultation postoperatively
- Excellent multidisciplinary communication

PH Crisis Diagnosis Under Anesthesia

- Direct PAP monitoring
- Used infrequently; can measure easily with open chest
- Reserve for high-risk cases; not available for non-cardiac surgery
- May use with SvO2
- Echocardiography
  - Thromesophageal, epicardial, transthoracic
  - TR jet velocity consistent with RVP>50% systemic
  - Flattening/paradoxic motion of interventricular septum
- Depressed RV function
- Preserved with lesser PH crisis, or with significant inotropic support

Treatment of PH Crisis During Anesthesia

- Hyperoxygenation and hyperventilation
- Both acutely decrease PAP/PVR
- Increase depth of anesthesia
- Lower PVR without affecting SVR
- Synthetic opioids, i.e. fentanyl 10-25 mcg/kg are most effective
- Increase pH with IV sodium bicarbonate
- Provide adequate RV preload

PH Crises During Anesthesia

- Mild
  - PAP 50-75% systemic with no hemodynamic compromise, baseline SpO2
  - Perhaps not a “crisis”
- Moderate
  - PAP 75-100% systemic
  - Compromised RV function
  - Decreased SpO2 <10%, and systemic BP not >20%
- Severe
  - Suprasystemic PAP
  - Significant arterial desaturation >10%
  - >20% decrease systemic BP
  - Myocardial ischemia
  - Increased airway resistance

Treatment of PH Crisis During Anesthesia

- Inotropic support:
  - Milrinone infusion with loading dose if tolerated
  - Epinephrine bolus or infusion
  - Vasopressin to maintain SVR
  - iNO 20 PPM
  - CPR
  - ECMO
- E-CPR: rapid institution if no response to standard CPR

References:
- Freisen et al Ped Anesth 2008;18:208
- Adatia et al Cardiol Young 2009;19:E-supplement-1:23
Anesthetic Agents and PH
- No single agent is ideal
- Combinations/balanced technique
- Hemodynamic goals more important than individual agents
- Opioids
- Anesthetic gases
- Ketamine
- Etomidate
- Propofol
- Dexmedetomidine

Adult PH: Anesthetic Approach

Our Case: Anesthetic Considerations
- Short painful procedure; not cooperative
- No ASD
- Minimal reactivity to pulmonary vasodilators
- Requires immobility, maintained airway with normal/low PaCO₂, high SaO₂
- Avoid catecholamine surge with port placement
- Rapid awakening without respiratory depression
- Resuscitation drugs and iNO in OR
- Continue all PO PH medications; DO NOT STOP IV PH medications!

Anesthetic Course
- Preoxygenation FiO₂ 1.0
- Etomidate induction 0.3 mg/kg IV
- Sevoflurane 2-3% end-tidal
- Remifentanil 0.2-0.25 mcg/kg/min
- Muscle relaxation with rocuronium
- Laryngotracheal anesthesia 30 mg lidocaine
- ET intubation
- Ropivacaine 0.2% 4 cc to sites by surgeon
- Stable throughout; trachea extubated awake
- 60 minute anesthetic

Questions and Comments?
PULMONARY HYPERTENSION IN PREGNANCY:
CASE PRESENTATION

Joy L. Hawkins, MD
* I have no conflicts to disclose.*

GOALS & OBJECTIVES
1. Discuss the diagnosis, management, and outcomes of pulmonary hypertension (PH) during pregnancy.
2. Review the physiologic effects of obstetric medications and techniques on PH.
3. Develop a safe delivery plan for vaginal or cesarean delivery.

CASE SCENARIO
J.C. was a 36-year old G2P1 at 25+ weeks gestation who had been followed for 3 years in our Pulmonary Hypertension clinic for severe primary pulmonary hypertension (PPH). Her pregnancy was diagnosed at ~ 20 weeks, and although unplanned was much desired. Termination was discussed but refused. The fetus was growing normally at that point.

Following her initial diagnosis 3 years ago, she had been stabilized on a regimen of Coumadin, Lasix, oxygen by nasal cannula, and a continuous prostacyclin infusion via port and central line. Because she responded so well, she had been removed from the active pulmonary transplant list. When her pregnancy was diagnosed, Coumadin was changed to heparin due to teratogenic concerns.

The Anesthesiology service was initially consulted when a central line infection required removal and replacement, along with vancomycin therapy. Her obstetric history was additionally complicated by:
• Prior cesarean delivery for dystocia 14 years ago.
• Morbid obesity with BMI 45, 260 lbs.
• New diagnosis of fetal hypoplastic left heart.
• Breech fetus at 25 weeks; receiving betamethasone.

Issues at our multi-disciplinary care conference:
• Thrombocytopenia of 67K platelets, presumably due to heparin (HIT), so LMWH was substituted.
• Teratogenicity concerns: Coumadin, Bosentan
• Tocolytic agents: because of their side effects, no attempt would be made to treat PTL if it occurred.
• Oxytocic choices were also limited because of their physiologic side effects.
### SIDE EFFECTS OF OBSTETRIC MEDICATIONS

- L&D meds that ↑ pulmonary vascular resistance:
  - Prostaglandin F-2 alpha (Hemabate)
  - Methylergonovine (Methergine)
  - Parenteral narcotics (hypoventilation and ↑ CO₂)
  - Butorphanol (Stadol)
  - Nitrous oxide for labor analgesia or GETA

- L&D meds that ↓ systemic vascular resistance:
  - Neuraxial local anesthetics
  - Parenteral IV morphine
  - Calcium channel blocking agents
  - Beta-agonist tocolytics (e.g. terbutaline)
  - Magnesium sulfate when given as a bolus
  - Oxytocin as a bolus or in high concentrations

### CASE SCENARIO

This was our anesthesia problem list:
- Severe pulmonary HTN with PAS 70-90 mmHg and severely dilated right ventricle
- Anti-coagulation with LMWH after thrombocytopenia with heparin
- Morbid obesity
- High probability of repeat cesarean if induced
- Fetal hypoplastic left heart syndrome

### PULMONARY HTN DURING PREGNANCY

#### DIAGNOSIS

- A diagnosis of exclusion, e.g. mitral stenosis, lupus, pulmonary embolism, peripartum cardiomyopathy
- Primary PH is typically women 20-30 years old
- Estimated incidence of 1-2 per million
- Mortality 30-50% during pregnancy & postpartum; possibly improved with new therapies
- NYHA functional class III or IV has ↑ mortality
- Most deaths occur within 1 month postpartum

#### PHYSIOLOGY

- ↑ blood volume and cardiac output during 2nd and 3rd trimester may ↑ PA pressures further, increasing afterload on the RV → PH crisis; usually 20-28 weeks gestation
- Hypercoagulability during pregnancy and postpartum may ↑ the tendency for thrombus formation in the lungs, thus a need for anti-coagulation
- Pregnancy is contraindicated due to high maternal and fetal mortality. But then so is hormonal contraception – thus pregnancies occur.
CASE SCENARIO

Our patient understood her risks but would not end the pregnancy. Her stated goal was to see her daughter’s 1st birthday.

The primary objective of her medical management was to achieve low-risk clinical status: lower PVR and improve right heart function as much as possible, optimizing RV systolic function at the least degree of TR.

PULMONARY HTN DURING PREGNANCY – MEDICAL MGT

- Continuous oxygen therapy for O₂ sat > 95%
- Anti-coagulation with LMWH; heparin at term
- Diuretics as needed based on symptoms and CVP
- Oral vasodilators: sildenafil (Viagra, Revatio) or tadalafil (Cialis), calcium channel blockers
- Epoprostenol / Flolan by continuous infusion as a vasodilator and platelet inhibitor
- Nitric oxide for acute exacerbations intrapartum

VAGINAL VS. CESAREAN DELIVERY

VAGINAL DELIVERY

Advantages
- Less blood loss
- Able to time the delivery and have consultants available
- Avoids surgical stress
- Avoids the need for emergency cesarean - highest morbidity/mortality
- Better hemodynamic stability
- Early ambulation

Disadvantages
- Labor can be prolonged and unpredictable
- Involves a major abdominal surgery and anesthetic
- ↑ risk of hemorrhage
- ↑ risk of postoperative infection
- ↑ postop pulmonary cx

DELIVERY PLANNING

Thus, mode of delivery should be based on obstetric indications

Monitors: arterial line and PA catheter placed in the cath lab under fluoro due to ↑ PAS and dilated RV versus avoid PA cath 2nd arrhythmias, thrombus, PA rupture?? TEE is not an option in labor

Analgesia for labor: continuous spinal opioid infusion (i.e. wet tap → 5 mcg sufentanil / hour) pending coagulation status (LMWH, platelets)

Planned assisted vaginal delivery to avoid Valsalva

DELIVERY PLANNING

Anesthesia for cesarean delivery: slow titration of continuous spinal or epidural using bupivacaine, versus GETA with a rapid sequence induction (etomidate, opioids) after aspiration prophylaxis

Location: main OR versus L&D operating rooms using resources and personnel brought there?

Nitric oxide would be on standby

Recovery in the MICU with the Pulmonary Critical Care service

ODDS & ENDS FROM CASE REPORTS

- Epidural lidocaine + aerosolized prostacyclin for C/S
- Choose epidural ropivacaine for its slow onset during titration and ↓ cardiotoxicity
- Have a variety of pulmonary vasodilators for GETA
- TEE is more useful than a PA catheter during GA to diagnosis decompensation due to hypovolemia
- ECMO can be instituted prior to C/S if acute decompensation occurs, but there is a high rate of complications in pregnancy
Case series have shown no difference in outcomes with C/S versus vaginal delivery or neuraxial anesthesia versus general.

NTG boluses are sometimes used for uterine relaxation during labor and delivery; patients taking sildenafil (or similar drugs) can experience profound hypotension – avoid!

In a recent series of cardiac surgery patients, the highest risk factor for pre-incision cardiac arrest was severe pulmonary hypertension (OR 3.40).

At 36 weeks there was no interval fetal growth and the biophysical profile was only 4/10, necessitating delivery.

Breech presentation and non-reassuring fetal monitoring required cesarean delivery.

We chose to use the L&D OR with MICU / PH attendings present for consultation. Cardiac surgery was aware and available for possible ECMO. An OB anesthesia attending and a Cardiac attending co-managed the case.

A PA catheter was placed in the cardiac cath lab prior to transport to the O.R. A pre-induction arterial line was inserted. General anesthesia was induced uneventfully with an easy intubation. TEE was placed and positioned.

Hemodynamic goals: maintain preload & afterload but avoid volume overload, tachycardia or ↑ cardiac output that would ↑ pulmonary blood flow.

Just after delivery her PA pressures rose to 120 mmHg and her systemic pressure fell to the 90s, but both responded to dobutamine, phenylephrine and NTG.

Nitric oxide was available in the room with respiratory therapy present, but was not used.

She was extubated in the OR and taken to the MICU with stable hemodynamics.

CONCLUSIONS THAT HAVEN’T CHANGED IN OVER A DECADE

“Primary pulmonary hypertension is associated with a poor survival and a poor quality of life. At present there is no cure, understanding of the disease is incomplete, and treatment options are limited...As maternal mortality is 30-50%, pregnancy is best avoided and some advocate termination...The optimum mode of delivery is unclear.” Int J Obstet Gynecol 2009;18:156
REFERENCES

- J Cardiovasc Dev Dis 2022; 9: 195
  Management of pulmonary arterial hypertension in pregnancy: experience from a nationally accredited center
  Breathing for two
Tuesday, February 28th
WHAT’S NEW IN OBSTETRIC ANESTHESIA FROM 2022?

Joy L. Hawkins, M.D.
University of Colorado SOM

Disclosure: I have no financial relationships with commercial support to disclose.
GOALS & OBJECTIVES

Discuss how literature from the past year may:

1. Change clinical practice in obstetric anesthesia via new guidelines and policies.
2. Produce best practices for analgesic and anesthetic techniques during labor and delivery.
3. Optimize and expedite management of anesthetic and obstetric complications.
4. Alter practices affecting the fetus and newborn.
GUIDELINES, POLICIES & PROCEDURES

"It's a baby. Federal regulations prohibit our mentioning its race, age, or gender."
STATEMENT ON ORAL INTAKE IN LABOR

ASA Committee on Obstetric Anesthesia (approved 10/22) found at www.asahq.org / Guidelines

• Gastric emptying in labor is delayed as much as 90%; worse with opioids or no analgesia, improved with neuraxial.
• Lower esophageal sphincter pressure is reduced as early as 1\textsuperscript{st} trimester; 50\% have GERD by 3\textsuperscript{rd} trimester.
• Most GETA is emergent; difficult intubation is more common in pregnancy and increases aspiration risk.
ORAL INTAKE (cont)

• No benefits have been shown to solid food intake over drinking clear liquids, although maternal satisfaction may ↓.

• Both ASA and ACOG guidelines state consumption of solid food in active labor should be avoided.

• However strict NPO policies can cause patient distress.

• Conclusions: 1) Offer clear liquids during labor 2) High risk patients or labors may require further restrictions on intake 3) No conclusions can be made on pre-labor intake, i.e. IOL 4) Do not deny neuraxial regardless of NPO status.
STATEMENT ON QUALITY METRICS

ASA Committee on Obstetric Anesthesia (approved 10/22)
The Institute of Medicine has outlined 6 domains of quality, and these were used to develop relevant and quantifiable quality metrics for obstetric anesthesia care.

1. Mode of anesthesia for CD: avoid GA when possible
2. Neuraxial-induced hypotension during CD: monitor, prevent with pressors, and treat when below baseline
3. Post-cesarean opioid use: ↓ with multi-modal therapies
QUALITY METRICS (cont)

4. Responsiveness to the request for labor analgesia: avoid delays (defined by the institution) or failure to provide.

5. Post dural puncture headache: monitor rates, response time for evaluation, and treatments.

6. Labor epidural replacements: time to adequate analgesia, regular assessments, and replacements.

www.asahq.org
STATEMENT ON ANESTHESIOLOGISTS’ ROLE IN REDUCING MATERNAL M&M

• Should be an active member of each state’s MMRC.
• Should be an active member of institutional-, regional-, state-level Obstetric Quality Committees and provide reviews of in-hospital cases involving acute care.
• Antenatal consultations should be sought on high-risk patients.
• Should lead in implementation of the elements in ACOG’s Levels of Maternal Care related to anesthesiology practice.
• Simulations should include teaching and planning by anesthesiologists and should include all anesthesia providers.

ASAhq.org / ASA Committee on Obstetric Anesthesia
The ACOG Levels of Maternal Care: The Anesthesiologist’s Role in Reducing Maternal Mortality

ASA Monitor, July 2022, pp 34-5

<table>
<thead>
<tr>
<th>Levels of Maternal Care</th>
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</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td>- Anesthesiologist, nurse anesthetist, or anesthesiologist assistant with anesthesiologist readily available at all times</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
</tr>
<tr>
<td>- Anesthesiologist readily available at all times</td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
</tr>
<tr>
<td>- Board-certified or board-eligible anesthesiologist physically present at all times</td>
</tr>
<tr>
<td>- Director of obstetric anesthesia is board-certified anesthesiologist with obstetric anesthesia fellowship training or obstetric anesthesia experience</td>
</tr>
<tr>
<td><strong>Level 4</strong></td>
</tr>
<tr>
<td>- Board-certified anesthesiologist with obstetric anesthesia fellowship training or obstetric anesthesia experience physically present at all times</td>
</tr>
<tr>
<td>- Same criteria as Level 3 for director of obstetric anesthesia</td>
</tr>
</tbody>
</table>
ASA PHYSICAL STATUS FOR OBSTETRICS

The 2020 ASA Physical Status Classification System update now includes Pediatric and Obstetric examples:

• ASA II: Normal pregnancy (due to physiologic changes) and also well-controlled HTN, PEC without severe features, gestational diabetes

• ASA III: preeclampsia with severe features, DM requiring insulin, thrombophilia requiring anti-coagulation

• ASA IV: HELLP syndrome, cardiomyopathy with ↓ EF

Anesthesiology 2021; 135: 904-19
MATERNAL MORTALITY

New CDC data from 2017-9 in 36 states with MMRCs found:

• > 80% of maternal deaths were preventable; > 90% in American Indian and Alaska Native women.
• 25% were due to suicide or overdose, the largest cause.
• Over half occurred after 1st postpartum week when patients have been discharged and are home.
• Black women died most often of cardiac causes, white and Hispanic of mental health conditions, Asian of hemorrhage.

Trost SL, CDCP and HHS, 2022
MATERNAL MORTALITY

A review of 237 maternal deaths due to suicide or drug overdose in Michigan from 2008-2018:

• 71% had a documented psychiatric illness; 48% had ≥ 2 dx, but only 34.5% had documentation of taking medication for their mental illness.

• Of those who died of drug overdose 71% had a known history of substance use disorder, but only 27.4% of those received medication-assisted treatment.

• Conclusions: few who died received proper treatment - why?

Am J Obstet Gynecol MFM 2023;5:100811
MATERNAL MORTALITY IN THE UK

Results from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2017-19 (a triennial publication):

• Cardiac disease is the largest cause of indirect maternal death; neurologic causes (epilepsy and stroke) were 2nd.
• Indirect = pre-existing but made worse by pregnancy; Direct=caused by the pregnancy itself.
• Thromboembolism is the largest direct cause up to 6 weeks postpartum; hemorrhage and sepsis the next most common.
• Suicide is the leading cause of direct deaths occurring within a year after pregnancy.

MBRRACE-UK Saving Lives, Improving Mothers’ Care 2021
LABOR ANALGESIA
NOCEBO EFFECT

Nocebo = using negative words that predispose patients to expect adverse events. Consider positive alternatives.

Anaesthesia 2022;77: 1113 and 11 (suppl.)

<table>
<thead>
<tr>
<th>Nocebo terms</th>
<th>Alternative wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>Here comes a big bee sting.</td>
<td>This medicine will make you numb and comfortable for the block.</td>
</tr>
<tr>
<td>This is the worst part.</td>
<td>Most people find this is easier than they thought.</td>
</tr>
<tr>
<td>Let me know if you feel pain or nausea.</td>
<td>If you need anything at all I’m right here, just let me know.</td>
</tr>
</tbody>
</table>
VIRTUAL REALITY

Is immersive virtual reality effective as a distractive tool on patient satisfaction and pain relief? Does it benefit patients with pre-existing anxiety and depression?

• Used an Oculus Quest All-in-one VR Gaming Headset and patient selected the environment they preferred.
• Satisfaction was high (88/100) and 95% would use again.
• VR improved pain scores in early labor.
• Anxiety and depression scores were similar to control.

BMC Pregnancy and Childbirth 2022;22:354
SAFETY AND UTILITY OF N₂O

Nitrous oxide is safe for mother, neonate and those who work on L&D. Conversion to epidural occurs in 40-60%. Rate of neuraxial utilization does not change if nitrous is available.

*APSF newsletter, June 2020, pp 60-1*

18% will use nitrous as their only pain med; 82% will transition to other modalities; 3% discontinue for side effects.

*J Obstet Gynecol Neonatal Nurs 2021; PMID 33493464*

50% nitrous is effective at high and low altitudes although there are fewer side effects at high altitude.

*Anesth Analg 2022; 134: 294*
Use of Nitrous Oxide for Labor Analgesia in High-Altitude Clinical Settings

N\textsubscript{2}O is a labor analgesic option with increasing use in the United States

**Multi-center retrospective data analysis**

From 4 institutions:
- University of Colorado Hospital
- Mount Sinai West
- University of North Carolina
- Vanderbilt Medical Center

Comparison of impact of altitude on:
- Conversion rates from N\textsubscript{2}O to another analgesic modality
- Conversion predictors
- Side effect frequencies
- Estimation of adjusted odds ratio (aOR)

**No significant difference between odds of converting to N\textsubscript{2}O from other modalities due to altitude**
(aOR = 1.13, CI = 0.90–1.42)

**High altitude group**
- Neuraxial analgesia (aOR = 3.03, CI = 1.59–5.88)
- Inadequate pain relief
  (aOR = 2.19, CI = 1.14–4.21)
- Reason for conversion
  (compared to low altitude group)

**Low altitude group**
- Choice of analgesia after conversion
  (compared to high altitude group)
- High side effects
  (aOR = 2.13, CI = 1.45–3.12)
- Likelihood of side effects
  (compared to high altitude group)

**Administration of N\textsubscript{2}O as a labor analgesic at higher altitude has lower side effects, but no effect on conversion to another analgesic modality**

What is the impact of higher altitude-associated reduction in partial pressure of N\textsubscript{2}O on labor analgesia?

Multi-center study evaluating nitrous oxide use for labor analgesia at high and low-altitude institutions

Wood et al. (2021)
BENEFITS OF NEURAXIAL ANALGESIA

Is labor neuraxial analgesia (epidural or CSE) associated with ↓ risk of severe maternal morbidity. YES

• 575K women with vaginal delivery in NY hospitals 2010-17
• Neuraxial was associated with 14% ↓ risk of morbidity.
• ↓ risk was similar between white and minority women.
• 21% of the risk reduction was ↓ risk of hemorrhage.
• Increasing access and utilization of neuraxial may help reduce maternal morbidity and improve health outcomes.

JAMA Network Open 2022; 5: e220137
OPTIMIZING NEURAXIAL: DPE

“To puncture or not to puncture: DPE vs standard epidural”

• Benefits of DPE in the general pregnant population are modest and inconsistent. Need at least a 25g spinal.

• When used in obese parturients, there was no difference in quality of analgesia compared to epidural without DPE.

• Editorial: “Dural puncture seems to be a clever idea in search of an indication….individual clinician judgment will probably guide the development of a home, if any, for the dural puncture epidural technique.”

Anesthesiology 2022; 136: 667, 678 + infographic
OPTIMIZING NEURAXIAL: DPE

Are labor epidural catheter replacement rates lower if DPE is used for placement?

• Retrospective trial compared DPE to standard epidural procedures for labor analgesia.
• DPE was associated with fewer catheter failures (OR 0.64).
• DPE had longer mean time to catheter replacement and required supplementation significantly later (like CSE).
• No difference in PDPH or blood patch.

Int J Obstet Anesth 2022; 52: 103590
PROGRAMMED INTERMITTENT BOLUS

What is the optimal interval between boluses using PIEB?

• 100 women in labor were randomized to varying time intervals between 10 ml boluses after DPE.

• The ED50 interval was 37 minutes and the ED90 interval was 52.5 minutes.

• The trend for PIEB maintenance is for larger boluses (8-10 ml) and longer intervals ~ 45 minutes.

Anesth Analg 2022; September PAP
GASTRIC EMPTYING IN LABOR

Is gastric emptying in labor affected by epidural analgesia?

• 4 groups: nonpregnant women, term pregnant women, laboring women without analgesia, laboring with CLE

• Gastric ultrasound was performed before and at 15, 60, 90, and 120 minutes after a light meal.

• Gastric emptying was delayed in laboring women compared to nonpregnant and term pregnant women

• Epidural analgesia facilitates gastric emptying during labor

Anesthesiology 2022; 136: 542
# GASTRIC EMPTYING

<table>
<thead>
<tr>
<th></th>
<th>Non-pregnant</th>
<th>Term pregnant</th>
<th>Labor + epidural</th>
<th>Labor no analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastric emptying at 90 min</td>
<td>52%</td>
<td>45%</td>
<td>31%</td>
<td>7%</td>
</tr>
</tbody>
</table>

With modern obstetric anesthesia practices, risk of aspiration is 1 per million but practice hasn’t changed.
ANESTHESIA FOR CERCLAGE

We do not have an optimal spinal anesthetic for short ambulatory procedures such as cervical cerclage placement.

What is the ED90 of intrathecal chloroprocaine for cerclage?

- ED90 of 3% chloroprocaine + fentanyl was 49.5 mg.
- Median duration of surgery was 15 minutes.
- Median time to block resolution was 60 minutes for motor and 90 minutes for sensory.
- Time to PACU discharge readiness was 150 minutes.

Anesth Analg 2022; 134: 834
How do spinal 3% 2-chloroprocaine and 0.75% hyperbaric bupivacaine compare for cervical cerclage?

- Randomized to 50 mg 3% CP or 9 mg bupivacaine + fentanyl
- No difference for time to motor block resolution (110 min)
- But sensory block resolution: 143 CP vs 198 min bupivacaine
- PACU discharge criteria were met 76 minutes earlier in the CP group. No TNS. Similar need for adjuncts (~ 10%).

Anesth Analg 2022; 134: 624
SURGICAL ISSUES

Azithromycin is effective at ↓ SSI after unplanned cesarean when given within 1 hour before or even after skin incision.

*Obstet Gynecol* 2022; 139: 1043

A meta analysis of maternal outcomes associated with uterine exteriorization found ↑ risk of IONV but no ↓ Hgb compared to uterine repair in situ.

*Can J Anesth* 2022; 69: 216

A meta analysis found skin closure with absorbable sutures ↓ wound complications by 50% compared to staples.

*Obstet Gynecol* 2022; 140: 293
OPTIMAL PRE-OXYGENATION

Does low-flow nasal oxygen + face mask pre-oxygenation extend safe apnea time? YES

- Physiologic model comparing BMIs 24-50
- Low-flow nasal oxygen was started after optimal face mask pre-oxygenation; it extended time to reach 90% saturation similar to high-flow nasal oxygen.
- For low BMI extended 25 min; for BMI 50, extended 10 min
- Low flow cannula is readily available in all operating rooms.

Br J Anaesth 2022; 129: 581 and 468 (editorial)
PARTNER PRESENCE DURING GA

Scoping review of the literature on partner presence in the OR during emergency cesarean using regional or general:

- Most parents preferred to have the partner present.
- Most staff are reluctant to allow partners during GA.
- Most arguments against presence are personal opinion.
- Most arguments in favor are clinical findings.

Eur J Anaesthesiol 2022; 39: 939
LEFT UTERINE DISPLACEMENT?

75 women having elective cesarean under spinal anesthesia were randomized into 3 groups: supine, $15^0$ tilt, or $30^0$ tilt from spinal placement until delivery.

- There was no difference in umbilical arterial pH between groups (7.31 vs 7.30 vs 7.31).
- But, the 30 degree group required significantly less phenylephrine and ephedrine.

*Anesth Analg 2021; 133: 1235-43*

*Eur J Anaesthesiol 2022; 39: 236-43 (review)*
LEFT UTERINE DISPLACEMENT

Review of current knowledge on supine hypotensive syndrome

• We don’t tilt correctly: you need an angle of at least 30°
• We underestimate the angle by visually judging
• Surgical conditions are impaired with tilt, slowing delivery
• It causes patient discomfort; feelings of sliding, postoperative sciatic neuropathy
• All women have IVC compression but very few have sx
• Fetal acid-base status is not affected if BP is maintained.

Eur J Anaesthesiol 2022; 39: 236
ISOBARIC vs HYPERBARIC BUPIVACAINE

Randomized comparison of isobaric vs hyperbaric 0.5% bupivacaine for lower limb surgeries (extrapolate to cesarean!):

• Found 73% efficacy of hyperbaric compared to 100% efficacy of isobaric bupivacaine when administered intrathecally in equal volumes and amounts.

• Longest postoperative analgesia with isobaric bupivacaine.

• Consider substituting when/if drug shortages occur again.

Scientific Reports 2023;13:2736
Are low doses (< 12.5 mcg) or higher doses (> 12.5 mcg) of intrathecal fentanyl preferable during cesarean delivery?

- Meta analysis of 11 RCTs with 1350 patients
- Higher doses result in reduced need for intraoperative analgesic supplementation and prolonged time to first request for analgesia postoperatively.
- Higher doses associated with more pruritus.
- Doses > 12.5 mcg should be used for optimal benefit.

Int J Obstet Anesthesia 2022; 50: 103270
Need for conversion to GA is rare but more common with emergencies and when lower bupivacaine dose is used.

*Acta Anaesth Scand 2023; 67: 29*

Low-dose ketamine (0.5 mg/kg infused over 40 minutes after cord clamp) during cesarean did not ↓ depression scores at 2 days in women with prenatal depression. But it did reduce IONV and ↓ postop pain at 4 hours.

*Front Surg 2022; 9: 1050232*

IT morphine does not prevent chronic post-cesarean pain.

*Br J Anaesth 2022; 128: 700*
NOREPINEPHRINE DURING CESAREAN

A comparison of infusions of phenylephrine 100 mcg/min or norepinephrine (NE) 5 mcg/min after spinal for cesarean found no difference in fetal acidosis, but base excess was significantly ↑ in the NE group and there was less maternal bradycardia.

_Eur J Anaesthesiol_ 2022; 39: 269

A comparison of phenylephrine or norepinephrine titrated to keep maternal BP at baseline after spinal for cesarean found equivalent prevention of hypotension but higher maternal cardiac index with NE.

_Anesth Analg_ 2022: October PAP
OXYTOCIN

Patients receiving magnesium prior to delivery (e.g. preeclampsia) require ↑ oxytocin dose during cesarean.

Anesth Analg 2022; 134: 303

Patients with twin pregnancy require higher oxytocin dosing than those with singleton pregnancy.

Anesth Analg 2022; December PAP
NEURAXIAL MORPHINE

Neuraxial morphine is the “gold standard”. How concerned should we be about respiratory depression?

- ~5000 patients received spinal (100-450 mcg) or epidural (3-5 mg) morphine after cesarean in a single center.
- There were no RRT events for respiratory depression and no oxygen desaturation events, no initiation of oxygen therapy, and no naloxone administration.
- The risk of clinically significant respiratory depression after neuraxial morphine for cesarean (even high doses) is low.

Int J Obstet Anesthesia 2022; 52: 103592
MULTI-MODAL ANALGESIA

What is the best timing for scheduled NSAIDs and acetaminophen after cesarean delivery, simultaneously q 6 hours of alternating q 3 hours?

• Ketorolac 30 mg IV or PO NSAIDs + acetaminophen 1 gram ordered q 6 hours → alternate q 3 hrs or give both q 6 hrs?
• Combined administration resulted in significantly less opioid consumption: 26.3 MME vs 105 MME in total.
• Mothers get fewer interruptions and (hopefully more rest).

J Clin Anesth 2022;80:110847
BENEFITS OF DEXAMETHASONE

Intraoperative dexamethasone (D) is an effective anti-emetic after cesarean. Does it also provide opioid-sparing effects?

• Systematic review and meta-analysis of D’s effect on early resting pain scores and time to first rescue analgesia.

• D was associated with significant reduction in resting pain scores at all times, ↑ time to first request for analgesia (mean 2.64 hrs), and a small but significant reduction in opioid consumption at 24 hrs.

Eur J Anaesthesiol 2022; 39: 498
RCT: Efficacy of Single Wound Infiltration With Bupivacaine and Adrenaline During Cesarean Delivery for Reduction of Postoperative Pain

POPULATION
288 Women

Pregnant women undergoing planned cesarean delivery at full term
Mean age, 32.5 y

INTERVENTION
288 Participants randomized

143 Bupivacaine and adrenaline
Single intraoperative administration of subcutaneous bupivacaine and adrenaline before wound closure

145 Usual care
Usual intra- and postoperative care without intervention

FINDINGS
A single subcutaneous administration of bupivacaine and adrenaline during cesarean delivery significantly reduced postoperative pain compared with usual intra- and postoperative care.

Primary Outcome
Mean pain intensity during the 24-h postoperative period after cesarean delivery as measured by a visual analog scale (VAS) score (range, 0-10, with a higher score indicating more pain)

Mean between-group difference in VAS score, intervention vs control: -0.20 (95% CI, -0.35 to -0.05)

© AMA

DELAYED CORD CLAMPING

A review of high quality evidence that supports delayed (1-3 minutes) umbilical cord clamping to promote placental transfusion for both preterm and term neonates:

• No effect on maternal blood loss during C/S
• Preterm benefits: ↓ mortality, less surfactant use, more stable hemodynamics and less need for inotropic support, ↓ PVR and PDA shunt, ↑ Hct so ↓ need for transfusion
• Huge benefits from a simple and no-cost strategy.

Obstet Gynecol 2022;139:121
ANESTHETIC MORBIDITY
ADVERSE EVENTS

Canadian hospitalization database was reviewed for serious complications related to anesthesia in obstetric patients.

- 2.6M hospitalizations & 8361 adverse events; 9% were serious
- Adverse events declined significantly over the 13 years.
- PDPH was most common → 83% of events
- Rate of difficult or failed intubations was low; 2% of events
- Events were more common in cesarean deliveries, OR 1.12
- Also more common with general than neuraxial, OR 1.71
- There was a positive association with cardiomyopathy (OR 8.34), eclampsia (OR 3.11), and OSA (OR 1.91)

Can J Anesth 2022;69:72
DIFFICULT AND FAILED INTUBATION

Review of MPOG data on almost 15,000 intubations during general anesthesia for cesarean between 2004 and 2019:

• 1:49 were difficult intubations; 88% based on the view and 16% who required ≥ 3 attempts.

• 1:808 were failed intubations (defined as any attempt without successful ETT placement). All 18 were rescued using a supraglottic airway. There was 1 arrest, no deaths.

• Risk factors: MP 3 or 4, BMI ≥ 40, and maternal age ≥ 35.

Anesthesiology 2022; 136: 697-708
GETA AND PREECLAMPSIA

How often to preeclamptic women receive general anesthesia just due to thrombocytopenia or unavailable platelet count?

- South African registry of obstetric airway management
- Thrombocytopenia < 75K was the reason for GA in 17%; half were confirmed counts and half had unavailable results.
- Of the unavailable group, 89% were subsequently found to have platelets > 75K, so GA was unnecessary.
- Consider the risk-benefit ratio when count unavailable.

Anesth Analg 2022; October PAP
PDPH: LONGTERM OUTCOMES

What is the risk of chronic health problems after wet tap and PDPH? Does blood patch ↓ these morbidities?

• Systematic review and meta analysis with 1M parturients and 1M controls
• Wet tap and/or PDPH were associated with ↑ risk of chronic headache, backache, neckache, and depression.
• Blood patch did not ↓ the risk.
• What should our follow-up be? Can we prevent these?

J Clin Anesth 2022;79:110787
What factors are associated with a failed epidural blood patch?

- Prospective, multi-center trial of 643 women
- EBP failed in 28%, was completely successful in 33% and partially successful in 39%
- 20% required a 2\textsuperscript{nd} EBP
- Factors associated with failure: interval < 48 hours since dural puncture and wet tap at a higher level (L1-3 vs 3-5)
- History of migraine also associated with needing 2\textsuperscript{nd} EBP

Pain 2022; 129: 758
Healthy G3P2 with normal BMI requested epidural at 6 cm. Two attempts were unsuccessful at L2-3, then placed at L3-4. Aspiration and test dose negative. Because of unilateral sensory block on the right, the catheter was withdrawn 1 cm and re-bloused. She complained of shortness of breath and numbness of her right face and arm, followed by headache, ptosis, miosis and anhidrosis on the right side = Horner’s Syndrome. Full resolution after 24 hours.

Anesthesiology News, February 2022, p. 38
SUBDURAL CATHETER: DIAGNOSIS

Major criteria:
• Negative aspiration of CSF
• Disproportionately extensive sensory block

Minor criteria:
• Delayed onset of sensory and motor block
• Variable extent of the motor block
• Disproportionate sympathetic block
TXA MEDICATION ERROR

IT administration of TXA has been reported from a wide range of hospitals worldwide. It has a 50% risk of mortality or life-changing neurologic disability. It is the most common neuraxial drug administration error in recent reports.

*J Clin Anesthesia 2022;82:110889*

If accidental epidural administration of TXA occurs, treat with saline lavage.

*Can J Anesth 2022;69:1169*
TXA DRUG-ERROR DEATHS

Recent cases of inadvertent intrathecal administration of TXA instead of local anesthetic for spinal anesthesia, with convulsions and 50% mortality. A list of recommendations for preventing intrathecal TXA administration includes:

- Store separately from anesthetic drugs in the OR.
- Never put on the cart used for opening the spinal tray.
- Check the label of spinal drugs multiple times.
- Utilize barcode scanning if possible.

Am J Obstet Gynecol 2023;228:January
PAIN DURING SURGERY: GUIDELINES

“Litigation arising from pain during caesarean section under neuraxial anaesthesia has replaced accidental awareness under general anaesthesia as the most common successful medicolegal claim against obstetric anaesthetists.”

• Approved by the Obstetric Anaesthetists’ Association (OAA)
• 11 recommendations with emphasis on consent, adequate testing of the block, and management of intraoperative pain
• Any woman who experiences pain should receive follow-up.

Anaesthesia 2022; 77: 588
PAIN DURING SURGERY: REVIEW

What is the prevalence of inadequate neuraxial for elective cesarean and conversion to general anesthesia?

• Review of 54 RCT, 3497 patients
• 14.6% required supplemental analgesia or conversion to general anesthesia
• 0.06% were converted to GETA (is this too few?!)  
• Combined spinal-epidural less likely than epidural to be inadequate: 10% vs 30% (no spinal comparison).

Anaesthesia 2022; 77: 598
PAIN DURING SURGERY: DEFINITION

*Editorial:* “If a mother reports being in pain, the anesthesiologist must believe her and take appropriate action. She is the only one who knows. Failure to do so compounds her distress.”

- Severity of reported harm after awareness under regional is equivalent to that after awareness under general.
- Anesthetic complications such as pain during surgery were a significant predictor of postpartum PTSD - more than emergency situations or newborn complications.

Anaesthesia 2022; 77: 523
HYPOXIC ISCHEMIC ENCEPHALOPATHY (HIE)

Review of 21 years of litigation in the UK for anesthetic negligence resulting in HIE. Examples from actual cases.

• #1: Anesthetic delay due to delayed response time, availability, waiting to dose the epidural until in the OR, choosing to place a spinal rather than GETA.

• #2: Communication – not understanding the urgency of the case or continuing with task while FHT deteriorate

• #3: Hypotension after neuraxial with delayed treatment.

• #4: Documentation: explain your thoughts, accurate times
EPIDURAL-RELATED FEVER

Epidural analgesia in labor is associated with ↑ rates of maternal fever. How can it be prevented?

• Systematic review of 37 studies found no cause and no effective preventive strategies.

• Interventions included: reduced epidural dose, prophylactic steroids, prophylactic paracetamol, prophylactic antibiotics. None worked.

• Why do we care? Intrapartum fever of any cause is associated with neonatal brain injury.

Br J Anaesth 2022;129:567
EPIDURAL-RELATED FEVER

Does the rate of fever differ between continuous epidural vs continuous spinal labor analgesia (CSA)?

- Retrospective study of 81 CSA and 162 matched controls who received epidural analgesia.
- No difference in the rates of fever between the modalities.
- Since epidural uses 10x the dose of LA as CSA, a dose-dependent effect of bupivacaine or fentanyl doesn’t mediate fever.

Anesth Analg 2022;135:1153, 1151 (editorial)
SURGICAL OR MEDICAL MANAGEMENT?

How do the outcomes of operative and non-operative management (NOM) of appendicitis compare during pregnancy?

• Immediate surgery is associated with lower odds of amniotic infection and sepsis than NOM.
• There was no difference in preterm labor, preterm delivery or other maternal complications between surgery and NOM.
• Immediate operation had lower hospital charges.
• Failed NOM requiring surgery had the worst clinical outcomes.

JAMA Network Open 2022; 5: e227555
SURGICAL OR MEDICAL MANAGEMENT?

A review of acute cholecystitis from the surgical literature encourages early surgical intervention for acute cholecystitis.

- Compared to medical management during pregnancy, surgery patients had less preterm labor, fewer premature deliveries, and fewer days in-hospital.

- “During pregnancy, early laparoscopic cholecystectomy, compared with delayed operative management, is associated with a lower risk of maternal-fetal complications (1.6% vs 18.4%) and is recommended in all trimesters.”

  JAMA 2022; 327: 96575
ANESTHETIC NEUROTOXICITY

Excellent review: Long-term cognitive and behavioral outcomes following early exposure to general anesthetics.

Summary:

...the findings of deficits in some neurodevelopmental domains (e.g., behavioral problems, ADHD) and not others (e.g., intelligence) will help guide the selection of appropriate outcomes in future studies that can further evaluate whether anesthetics have an impact on neurodevelopment in children.

Current Opinion Anaesth 2022;35:442
OBSTETRIC & MEDICAL COMPLICATIONS

"I'm going to give it to you straight, Mr Watson, for a 27 year old you're in pretty bad shape."
MATERNAL CARDIAC ARREST

Are survival rates different between maternal in-hospital cardiac arrest vs nonpregnant in-hospital arrest?

- Resuscitation database compared outcomes of women ages 18-50, pregnant or not
- No difference in ROSC or survival to discharge
- Pregnant women were more likely to survive with a good neurologic outcome (OR 1.57)

Am J Obstet Gynecol 2022;226:401
UTERINE ATONY

To risk-stratify patients, what are the greatest risk factors for postpartum hemorrhage due to uterine atony?

- A meta-analysis of 27 studies found 15 risk factors
- A large proportion of PPH have no risk factors!
- Prior PPH, placenta previa, abruption, uterine rupture and multiple gestation were highest risk. Also, IOL, oxytocin exposure and chorioamnionitis.
- New factors: HTN, diabetes, Hispanic and Asian race
- Obesity and magnesium were NOT associated with atony.

Obstet Gynecol 2021;137:305
PLACENTA ACCRETA SPECTRUM

• Review of the prenatal diagnosis and management:
  Obstet Gynecol Clin N Am 2022;49:423

• Two studies found the association of placenta previa with PAS ↑ the risk of worse maternal outcome and higher resource use including transfusion, ICU admission, hysterectomy and intraop bowel/bladder injuries.
  JAMA Network Open 2022;5:e2228002
  Obstet Gynecol 2022;140:599
PLACENTA ACCRETA SPECTRUM

What is typical RBC use during PAS surgery?

- Meta-analysis found 5 studies reporting mean transfusion data on 221 patients → 6.6 units PRBC transfused. They recommend a minimum of 6 PRBC be prepared.
  
  *Obstet Gynecol* 2022; PAP (Miller)

- How should we select patients for whom the REBOA or vascular control device will provide the greatest benefit? Intraop “staging” was better than using for everyone or deciding whether to use based on prenatal imaging.
  
  *Am J Obstet Gynecol MFM* 2022;4:100498
AMNIOTIC FLUID EMBOLISM: DIAGNOSIS

AFE is often over-diagnosed. SMFM and the AFE Foundation propose strict criteria for diagnosis of AFE. There must be:

• Sudden onset cardio-respiratory arrest or hypotension + respiratory compromise (cyanosis, oxygen sat < 90%).
• Overt DIC prior to EBL-related coagulopathy.
• Clinical onset during labor or within 30 minutes of delivering the placenta.
• No fever > 38°C during labor.
• Triad: hypotension + hypoxia + coagulopathy

APSF Newsletter 2022;37:83
AMNIOTIC FLUID EMBOLISM

• Demographics of AFE: incidence of 6 per 100K, PAS ↑ the risk 10-fold, and mortality was up to 46% if associated with cardiac arrest and coagulopathy.  
  
  JAMA Network Open 2022;5:e2242842

• Excellent review of AFE and pulmonary embolism.  
  Obstet Gynecol 2022;49:439

• Biologic plausibility of AOK therapy for AFE?  
  Case Rep Obstet Gynecol 2017;8458375 / PMID 29430313
TREATMENT OF PPH: OXYTOCICS

Does prophylactic methylergonovine during intrapartum C/S vs oxytocin alone reduce the need for add’l uterotonic?

• Yes: fewer uterotonic (20% vs 55%), better tone, ↓ incidence PPH (RR 0.6), ↓ QBL, and ↓ need for transfusion.

*Obstet Gynecol 2022;140:181*

In Niger, maternal deaths due to hemorrhage were halved using 3 steps: 1) patients were given a dose of misoprostol during prenatal visit to take if birth occurs at home, 2) uterine tamponade balloon placed at hospital if still bleeding after 30 min, then 3) shock garment used to give time to get to surgery and transfusion.

*Lancet Global Health 2023;11:e287*
A pilot study gave 1 gm calcium chloride or placebo to women with at least 2 risk factors for PPH.

- Administered over 10 minutes after cord clamping.
- Uterine atony occurred in 20% of calcium recipients versus 50% of placebo recipients (RR 0.38).
- Peak ionized calcium was 1.6 mmol/L and the CaCl was tolerated well by recipients.

J Clin Anesth 2022; 110796
TREATMENT OF PPH: TXA

What is appropriate TXA dosing? At least 1 gm IV was needed to inhibit activation fibrinolysis, but higher BMI correlated inversely with plasma TXA levels. Higher dosing?


Prophylactic TXA did *not* reduce blood loss in women with multiple gestation (primarily twins).

*Am J Obstet Gynecol* 2022;227:889
TREATMENT OF PPH: TXA

Is early administration of TXA a cost-effective strategy for reducing maternal M&M due to PPH in the U.S.?

• Based on a decision-analytical mode
• Early administration (within 3 hours of diagnosis of PPH) of TXA to 100K women would prevent 16 maternal deaths, 9 laparotomies and 155 re-operations with an annual cost savings of $23.15 million.

Am J Obstet Gynecol MFM 2022;4:100588
TREATMENT OF PPH: TXA

Review article on TXA: Current known and unknowns

• Prophylactic TXA does not reduce PPH to a meaningful degree after vaginal or cesarean delivery.

• The WOMAN trial found TXA was associated with a 37% reduction in death if given within 3 hours of PPH, but it is unclear whether TXA reduces the risk of morbidity from PPH in well-resourced countries – “can be considered”.

• Catastrophic neurologic damage can occur after accidental IT administration.

Anesth Analg 2022;135:460 and 459 (infographic)
POC COAGULATION TESTING ON L&D

Clinical Expert Series: Obstetrics & Gynecology

- Laboratory assessment is essential in PPH.
- Both ROTEM and TEG provide results within 10-20 min.
- Normal ranges are now available for pregnancy.
- Correct blood products can be given early, limiting use of unnecessary transfusion of other blood products.
- Some studies have shown shorter hospital stays, lower costs and less need for re-operation.

Obstet Gynecol 2022;139:463
Both ACOG and the American Heart Association published updated guidelines on hypertension in pregnancy.

*Obstet Gynecol* 2020; 135: 1492

*Hypertension* 2022; 79: e21-e41

**Common themes:** 1) The main therapeutic options for preeclampsia are treatment of HTN, prevention of seizures, and timed delivery. 2) Ensure more aggressive treatment of HTN to reduce maternal morbidity and mortality due to cardiovascular complications and stroke.
PREECLAMPSIA: PREVENTION

The incidence of HTN in pregnancy ↑ from 13-16% from 2017-9. Risk was 1 in 5 for mothers 35-44 and 1 in 3 for mothers 45-55 years old. Also higher in Black and American Indian/Alaska Native mothers and in the Midwest, South and lower income communities.

*MMWR 2022;71:585*

How often do at-risk women receive aspirin therapy to prevent preeclampsia? < half of women with DM, obesity, and/or chronic HTN receive the recommended prophylaxis.

*JAMA 2022;327:388*
Should mild chronic HTN be treated during pregnancy? Does keeping < 140/90 reduce adverse pregnancy outcomes?

- 2408 women randomized when < 23 weeks gestation to receive treatment when BP >140/90 or >160/105.
- Targeting < 140/90 was associated with better pregnancy outcomes: ↓ in preeclampsia with severe features, indicated preterm birth, placental abruption, or fetal/neonatal death.
- No ↑ in risk of small for gestational age birth weight.

N Engl J Med 2022; 386: 1781-92 (CHAP Trial)
MANAGEMENT OF ECLAMPSIA

What are the expected fetal heart rate changes associated with an eclamptic seizure and what should management be?

- Decelerations occurred in 79% of cases for 2-15 minutes followed by tachycardia. 48% also had minimal variability.
- Maternal support and stabilization were prioritized.
- Other than C/S for abruption, 2/3 did not have immediate operative intervention and outcomes were good for mother and newborn. Don’t run to the OR!

Am J Obstet Gynecol 2022;227:622
PREVENTION OF ECLAMPSIA

Given that 30% of eclamptic seizures occur postpartum, what is the optimal duration of postpartum magnesium?

• Treatment for ≤ 12 hours vs 24 hours was not associated with increased risk of eclampsia.

• Benefits of shorter treatment: less flushing, shorter Foley catheter insertion, less time to ambulation and shorter hospital stay.

Obstet Gynecol 2022;139:521
Is there an association between a history of adverse pregnancy outcomes (i.e., preeclampsia, gestational HTN or diabetes, preterm delivery, SGA baby) and coronary artery disease by CT angiography screening? Yes

- 10,528 women in Sweden with deliveries in 1973 or later had CT at age 50-65 years.
- There was a significant association between those with adverse pregnancy outcomes and image-identified CAD, including those women estimated to be at low risk.

JAMA 2023;329:393
“The choice of neuraxial anesthesia is ultimately in the hands of anesthesiologists. However, a wide spectrum of practice exists, even within departments, particularly when platelet counts are 50-100K, so it is important that maternity care providers have confidence to advocate for women in their care....platelet counts in women with preeclampsia may decrease rapidly and unpredictably.”

CARDIOMYOPATHY IN PREGNANCY

What is the risk of pregnancy in women with cardiomyopathy of any type?

- All major adverse CV complications are more likely including a 7-fold greater risk of severe CV events and a 4-fold greater risk of dying in hospital than other forms of heart disease during pregnancy.
- A multi-disciplinary team should manage their care.
- No data was found to assist with detailed risk stratification.

Am J Obstet Gynecol 2022;227:582
ECMO IN PREGNANCY

What is ECMO utilization during pregnancy and outcomes?
• Data from the Nationwide Inpatient Sample, 1999 – 2014
• ECMO utilization increased significantly from 1 to 11 per million obstetric discharges
• In-hospital mortality decreased significantly from 74 to 32 per 100 women who received ECMO
• ECMO during pregnancy had ↑ risk of venous thromboembolism (OR 1.83) and non-traumatic hemoperitoneum (OR 4.32)

Anesth Analg 2022;135:268
ECMO IN PREGNANCY

What are the indications for using ECMO during pregnancy?

- Review of the Nationwide Inpatient Sample 2010-16
- Respiratory failure (80%), cardiogenic shock (64%), and circulatory arrest (25%) were the most common but most had more than one indication (58%).
- Mortality was 30.5% overall, but 30% with respiratory failure, 40% with cardiogenic shock, 47% with cardiac arrest, and 42% for combined diagnoses.
- Cardiogenic shock had the highest mortality rate (OR 5).

Anesth Analg 2022;135:1172
ECMO IN PREGNANCY

**Review Article:** ECMO is an effective peripartum rescue therapy. Pregnant physiology including uteroplacental perfusion and thrombophilia must be considered.

*Anesth Analg* 2022;135:277

**Editorial:** There were widespread reports of ECMO for obstetric patients during COVID. ECMO has the potential to reduce maternal mortality for a variety of catastrophic indications, including future pandemics.

*Anesth Analg* 2022;135:264
When cancer is diagnosed in pregnancy, what are the effects on the child, with or without chemotherapy?

- Danish database of liveborn children over a 40 year span
- Fetuses exposed to cancer in utero had no higher mortality, no increased risk of malformations, no ↑ risk of somatic or psychiatric disease.
- Of those exposed to chemotherapy, there were no health consequences; no ↑ risk of malformations or disease.

J Clin Oncology 2022; 40:3975
HIV IN PREGNANCY

Women who conceived on antiretroviral therapy (ART) and had a suppressed viral load at time of delivery, had no perinatal HIV transmissions.

Clin Infect Dis 2022 (Sibiude et al)

What is the best ART to use pre-conception and during pregnancy for women with HIV infection?

• Highest viral suppression was with dolutegravir (96.7%).
• There was no differences in adverse birth outcomes between regimens.

N Engl J Med 2022;387:799
OBESITY IN PREGNANCY

Excellent review: *N Engl J Med* 2022;387:248

What is the risk-benefit of bariatric surgery in women for their obstetric, neonatal and child outcomes?

• Less gestational HTN, gestational diabetes, birth injuries, and large-for-gestation neonates.

• More small-for-gestation neonates

• Surgery is highly favorable for pregnancies & newborns but requires collaboration with OB, dietician, surgeon and PCP.

*JAMA Surgery* 2022 (Rives-Lange et al)

*JAMA* 2023; PAP 2/10 (Fisher et al)
OSA IN PREGNANCY

• Snoring is common, increasing as pregnancy progresses.
• ↑ upper airway edema and nasal congestion and ↓ FRC are predisposing factors.
• OSA found in 10% 1\textsuperscript{st} trimester and 26% in 3\textsuperscript{rd} trimester.
• Risk factors: self-reported snoring, ↑ BMI, older age, and presence of chronic HTN.
• OSA is associated with HTN, DM, PEC, preterm birth, cardiomyopathy, CHF, and 5x ↑ risk of dying before D/C.

Obstet Gynecol 2022;140:321
Clinical Expert Series: an excellent review of maternal, fetal and child effects of tobacco, alcohol, cannabis, opioids, stimulants and benzodiazepines and their respective treatments.

Obstet Gynecol 2022;139:317

SUD in pregnancy (cannabis, alcohol, opioid, other) has ↑ dramatically and is associated with adverse outcomes such as HTN, preterm delivery, abruption and antepartum hemorrhage.

Am J Obstet Gyneco 2022;July:100
Substance use disorder diagnoses during pregnancy have increased substantially from 2000-18 in the Nationwide Inpatient Sample.

Am J Obstet Gynecol 2022;227:100
PERINATAL SUBSTANCE USE DISORDER

What Obstetrician-Gynecologists Should Know About Substance Use Disorders in the Perinatal Period (Review)

*Obstet Gynecol* 2022;139:317

- MAT should be continued at the same dose throughout the birthing hospitalization, and pain management should be multimodal, using nonopioid medications, regional anesthesia, and opioid agonists if needed.

- Undertreated pain is a greater risk for SUD recurrence than use of an opioid agonist for postoperative pain.
What is the best MAT for opioid use disorder in pregnancy – buprenorphine or methadone?

• Cohort study of 10.7K buprenorphine and 4.3K methadone
• Buprenorphine had lower risk of adverse neonatal outcomes: abstinence syndrome (RR 0.73), preterm birth, SGA, and low birth weight.
• No difference maternal outcomes: delivery by cesarean or severe maternal complications.

N Engl J Med 2022;387:2033 & editorial
What are the characteristics associated with opioid use during pregnancy?

- Opioid use was present in 2.8% of pregnancies.
- Majority of users were: non-Hispanic white (67%), had some college education (69%), of higher parity, and had high rates of alcohol use (32%) and smoking (39%) during the pregnancy. Maternal depression $\rightarrow$ OR 2.42.
- 86% of the opioid use came from a prescription

J Women’s Health 2022;PAP (Nguyen)
CANNABIS USE IN PREGNANCY: MATERNAL

Cannabis use in pregnancy has ↑ substantially and potency has tripled. Use is associated with maternal nausea, depression and anxiety. Prenatal exposure is associated with ↑ autism, SGA, preterm birth, NICU admit.

Am J Obstet Gynecol 2022;227:571 / JAMA Network Open 2022

In a large multicenter cohort, cannabis use was associated with a higher likelihood of moderate-to-severe nausea and vomiting in early pregnancy.

Obstet Gynecol 2022;140:266
CANNABIS IN PREGNANCY

Kaiser Permanente Northern California held focus groups with women who self-reported daily or weekly cannabis use.

- White and non-Hispanic black women had highest use.
- They perceived legalization was done to allow better access and exposure to cannabis. It gave them greater willingness to discuss use during pregnancy with their OB provider.
- They believed that cannabis retail staff are knowledgeable and view them as experts on the benefits of use in pregnancy.

JAMA Network Open 2022;
SEPSIS AFTER VAGINAL DELIVERY

Can a single dose of azithromycin reduce maternal infection after vaginal delivery as it does after cesarean? Yes

- 29,278 women randomized in labor to AZ or placebo.
- Maternal death or sepsis was less after AZ: RR 0.67
- Incidence of sepsis was 1.5% after AZ vs 2.4% after placebo
- No difference in neonatal sepsis, death or stillbirth did not differ between groups.

COVID: MATERNAL OUTCOMES

Data from the CDC & others has shown that pregnant women have ↑ risks of ICU admission, intubation, need for ECMO, and death from COVID infection.

- COVID also ↑ risk for maternal death and morbidity due to OB causes: HTN, hemorrhage, other infections: 13% vs. 9%.
- Preterm delivery and NICU admission were more common.
- Risks were ↑ in women with moderate or severe COVID; asymptomatic cases had similar outcomes to non-infected.

JAMA 2022; 327: 748-59 and 790 (patient info)
COVID: PERINATAL OUTCOMES

Results of an individual participant data meta-analysis of 13,136 pregnant women to evaluate risks of COVID infection:

• ↑ risk of maternal mortality; RR 7.68
• ↑ risk of ICU admission or any critical care; RR 3.81 / 5.48
• ↑ risk of mechanical ventilation; RR 15.23
• ↑ risk of neonatal admission to ICU; RR 1.86
• ↑ risk of preterm birth; RR 1.71
• No increased risk of stillbirth.

BMJ Global Health 2023; 8: e009495
PRO: MATERNAL COVID VACCINATION

• 2 studies found breast milk from women vaccinated with mRNA vaccines contains specific IgA and IgG antibodies, and after a second dose the breast milk antibody levels increased. These antibodies showed strong neutralizing effects which should protect the infant.

  JAMA Network Open 2021; 4: e2120575 & JAMA online 4/12/21

• Population-based studies in Sweden, Norway and Canada found that vaccination in pregnancy was not associated with an increased risk of adverse peripartum outcomes.

  JAMA 2022; 327: 1451 (editorial), 1469, 1478
THE FETUS AND NEONATE
Benzodiazepine exposure during pregnancy was not associated with ↑ risks of neurodevelopmental disorders.

JAMA Network Open 2022;5:e2243282

Maternal marijuana exposure was associated with ↑ preterm delivery, NICU admission, low birth weight, low 1-minute Apgar score and head circumference.

JAMA Network Open 2022;5:e2145653

Maternal anti-psychotic prescription was not associated with ↓ standardized test scores or ↑ malformations / teratogenicity.

JAMA Intern Med 2022 / JAMA Psychiatry 2023;80:156
CANNABIS USE IN PREGNANCY: NEWBORN

Are adverse neonatal outcomes associated with marijuana-exposed pregnancies?

- Meta-analysis of 16 studies and 59K patients showed significant ↑ in 7 adverse neonatal outcomes.

- Birth weight < 2500 gm (RR 2.06), SGA, preterm delivery (RR 1.28), NICU admission (RR 1.38), ↓ mean birth weight, Apgar score at 1 minute, and infant head circumference.

JAMA Network Open 2022;5:e2145653 & editorial
HOME BIRTH RATES

• During the pandemic, planned home birth rates rose from 23% (from 1.03% in 2019 to 1.41% in 2021) and birth center deliveries rose 13%.

• The largest increases were in Black and Hispanic women.

• 1 in 50 U.S. births occurred in one of these settings.

• Fear of being infected with COVID or fear of receiving poor care in overwhelmed hospitals may have made women reluctant to delivery in a hospital.

JAMA 2022;328:2389
BIRTH OUTCOMES & SITE OF DELIVERY

What are neonatal outcomes if delivered outside hospitals?

• 9.8 million births were studied; 88% in hospitals with physician coverage, 11.4% in hospitals with midwives, 0.75% in freestanding birth centers

• BC deliveries had 4-fold ↑ in neonatal deaths; 7-fold if G1, 2-fold ↑ neonatal seizures, 7-fold ↑ 5-min Apgar score < 4

• Compared with hospital midwife deliveries, physician deliveries had significantly ↑ adverse neonatal outcomes.

Am J Obstet Gynecol 2022;226:116
AAP GUIDELINES ON BIRTHING PRACTICES

In 2022, AAP advised against the following birthing practices which may be associated with ↑ rates of neonatal morbidity/mortality, and have no clear benefits:

- Water birth
- Vaginal seeding
- Placentophagy
- Umbilical cord nonseverance
- Non-medical deferral of Hep B vax and ocular prophylaxis
- Delayed bathing of newborns exposed to active genital HSV or maternal history of HIV, hepatitis B or C

Pediatrics 2022;e2021055554
KANGAROO CARE

15M preterm babies yearly; leading cause of death < 5 years.

- New WHO guidelines for preterm babies advise immediate “kangaroo care” i.e., skin-to-skin contact with a caregiver, starting immediately after birth, no initial time in incubator.

- Combined with exclusive breast feeding, it saves lives, ↓ infections, prevents hypothermia and improves feeding.

- The guidelines are especially relevant in low resource countries where preterm mortality can be 90%.

- Consider during C/S if your Neonatologists approve.

 ASAmonitor.pub/30VbPpf
PERIVIABLE RESUSCITATION

Has active treatment of live-born neonates 22-25 weeks changes over time (2014-2020)?

• Yes – frequency of active resuscitation significantly ↑ but rates of active treatment varied by race and ethnicity. JAMA 2022;328:652, 624 (editorial)

• NEJM Clinical Decision article: a pro/con to recommend resuscitation for ALL neonates born at 22 weeks vs selective resuscitation; anesthesiologists will be involved with these cases for analgesia or cesarean delivery. N Engl J Med 2022;386:391
AND WE’LL SEE WHAT’S NEW IN 2023!

THE END
Ambulatory Surgery
what could go wrong?

Alison Brainard MD
Associate Professor
Director Cherry Creek North Ambulatory Surgery Center
Conflicts of Interest

- None
Learning Objectives

At the conclusion of this talk, attendees will be able to:

1. Analyze best practices on patient selection for free standing ambulatory surgery centers (ASCs)
2. Discuss keeping the ORs full – what are the national trends for block release, block utilization, and case cancellations
3. Describe best practices around risk management, safety huddles and peer reviews
4. Create a recipe for creating a culture of psychological safety
   a. Dealing with the difficult surgeon
   b. Dealing with the difficult patient
Ambulatory Surgery

- Definition: From ASAHQ: “Outpatient surgery, also called same-day, ambulatory, or office-based surgery, provides patients with the convenience and comfort of recovering at home, and can cost less. It might also help lower your risk of infection.”

- Types of Centers: Free-standing ASC, In-Office or Hospital based

- Facts:
  - According to the CDC, two-thirds of cases are ambulatory
  - Benefits: reductions in waiting times, decreases hospital costs, and the risk of nosocomial infection
  - Large retrospective database studies of ambulatory surgeries have estimated serious complication rates of less than 1% [3,4] and mortality rates of 1 in 50 000 to 1 in 100 000 [5,6].
Must be licensed by CMS if they are taking care of Medicaid or Medicare patients

Patients must be expected to stay 23 hours or less. Unanticipated longer admission MUST be rare*

American Recovery and Reinvestment Act (Recovery Act) appropriated $50 million to the Department of Health and Human Services (HHS) with $10 million devoted to the state level to increase state-level regulation
Stand up if...

- You’ve ever worked done anesthesia for outpatient surgery
- You’ve ever worked at an ASC
- You currently work at an ASC
- You have a leadership role for an ASC
Predicting an Unanticipated Admission
Identifying Those at High Risk for Major Complications

**Hypothesis:** Specific patient history and surgical characteristics place patients scheduled for common day case-eligible surgeries at a greater risk of major morbidity and mortality within 72h after such procedures.

**Method:** Data mining using the American College of Surgeons’ National Surgical Quality Improvement Program (ACS-NSQIP) from 2005 to 2010.

**Results:** 241,600 outpatient cases; 232 cases experiencing an event; 21 mortalities and 234 perioperative morbidities (multiple morbidities in some cases) within 72h postoperatively

- Incidence of 0.095%, or approximately 1 in 1,053 cases
- Of the 232 cases experiencing an event, 195 (84%) were discharged within 23h of surgery.
- No intraoperative deaths; 9 deaths on the day of surgery, 7 on POD #1, and 5 on POD #2.
Secondary Outcomes Analysis Showed

- 2,797 patients (1.1%) required an unplanned admission.
- The most common events included:
  - Pneumonia (46)
  - Unplanned postoperative intubation (37)
  - Wound disruption (25)
  - Postoperative bleeding (21)
  - Sepsis (19).
**Patient Selection for Day Case-eligible Surgery: Identifying Those at High Risk for Major Complications**

- Authors used the American College of Surgeons’ National Surgical Quality Improvement Program Database to analyze common day case surgeries from 2005-2010

- Primary outcome morbidity or mortality within 72 hours
Reasons for admission

- Surgical: 40%
- Anesthetic: 20%
- Medical: 19%

Monitored anesthesia care when compared with general anesthesia (OR 0.17; 95% CI 0.04 to 0.68).

BMI 30-35 (OR 2.81; 95% CI 1.31 to 6.04).

Advanced age (> 80 yr) (OR 5.41; 95% CI 1.54 to 19.01);

ASA III (OR 4.60; 95% CI 1.81 to 11.68); ASA class IV (OR 6.51; 95% CI 1.66 to 25.59);

Length of surgery of one to three hours (odds ratio [OR] 16.70; 95% confidence interval [CI] 4.10 to 67.99) and length of surgery more than three hours (OR 4.26; 95% CI 2.40 to 7.55);

Patient Selection...
Outpatient Surgery Admission Index from Independent Predictors of Immediate Hospital Admission

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| • 65 years or older
  • OR time longer than 120 min | • Cardiac Diagnoses
  • Peripheral Vascular Disease
  • Regional Anesthesia | • Cerebrovascular Disease
  • Malignancy
  • HIV | • General Anesthesia |
Never have I ever...

- 54 yo patient with a BMI of 54 coming in for a lap chole. PMHx significant for Type 2 DM (Hgb A1C 7.5), GERD and well controlled HTN
  - Hospital with planned admission
  - Hospital with planned discharge to home
  - Free-standing ASC
Obesity – A GROWING PROBLEM

- Systematic review of published studies also showed that BMI alone did not increase perioperative complications or unplanned admissions after ambulatory surgery.

- National Survey of Ambulatory Surgery found that morbidly obese patients had a similar incidence of adverse postoperative outcomes, delayed discharge, and unplanned hospital admission, when compared with nonobese patients.

- In Lopez and Byers study looking at patients presenting for weight loss surgery, looking to see the prevalence of OSA in obese patients:
  - Severely obese group (BMI 35-39.9 kg/m2) had a prevalence of 70%.
  - Morbidly obese group (BMI 40-40.9 kg/m2), the prevalence was 74%.
  - Superobese group (BMI 50-59.9 kg/m2) 77 per cent.
  - BMI 60 kg/m2 or greater, the prevalence of OSA rose to 95 per cent.

- Probably needs individualized decision based on type of surgery, anesthesia and comorbid conditions.

190
Never have I ever

- 45 yo Male presenting for distal radius fracture ORIF. PMHx significant for obesity (BMI 39), HTN (well controlled on Lisinopril and Metoprolol). On his preop call, it is reported that his STOP-BANG questions put him at high risk of Obstructive Sleep Apnea.
  - Proceed with the case as planned with GA and a supraclavicular PNB
  - Proceed with case under PNB and very little sedation
  - Move case to hospital based OR
Undiagnosed Sleep Apnea: A Hidden Health Crisis

In the U.S. the estimated economic cost of undiagnosed obstructive sleep apnea was nearly $150 billion in 2015.

Workplace Accidents
$6.5 billion

Motor Vehicle Accidents
$26.2 billion

Comorbid Diseases
$30 billion

Lost Productivity
$86.9 billion

TOTAL
$149.6 billion

Source: American Academy of Sleep Medicine, 2016 | www.sleepeducation.org
Patient Selection for Adult Ambulatory Surgery: A Narrative Review

Rajan, Niraja MD*; Rosero, Eric B. MD, MSc†; Joshi, Girish P. MBBS, MD, FFARCSI†
SAMBA CONSENSUS STATEMENT - Decision making in preoperative selection of a patient with OSA

Preoperative Considerations:
- Comorbid conditions include hypertension, arrhythmias, heart failure, cerebrovascular disease, and metabolic syndrome.
- If OSA is suspected during the preoperative evaluation, one could proceed with a presumptive diagnosis of OSA albeit with caution.
- Educate surgeon, patient and family (see the text for details)

Intraoperative Considerations:
- Non-opioid analgesic techniques, when possible.

Postoperative Considerations:
- Exercise caution in OSA patients who develop prolonged and frequent severe respiratory events (e.g., sedation analgesic withdrawal, desaturation, and apneic episodes) in the postoperative period.

Joshi, Girish P.; Ankichetty, Saravanan P.; Gan, Tong J.; Chung, Frances
STOP-BANG

<table>
<thead>
<tr>
<th>Question</th>
<th>No</th>
<th>Yes +1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you snore loudly? Louder than talking or loud enough to be heard through closed doors</td>
<td>No 0</td>
<td>Yes +1</td>
</tr>
<tr>
<td>Do you often feel tired, fatigued, or sleepy during the daytime?</td>
<td>No 0</td>
<td>Yes +1</td>
</tr>
<tr>
<td>Has anyone observed you stop breathing during sleep?</td>
<td>No 0</td>
<td>Yes +1</td>
</tr>
<tr>
<td>Do you have (or are you being treated for) high blood pressure?</td>
<td>No 0</td>
<td>Yes +1</td>
</tr>
</tbody>
</table>

Objective measures:

<table>
<thead>
<tr>
<th>Measure</th>
<th>≤35 kg/m²</th>
<th>&gt;35 kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>0</td>
<td>+1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>≤50 years</th>
<th>&gt;50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 points</td>
<td>High risk of OSA</td>
<td></td>
</tr>
</tbody>
</table>

STOP-BANG 6 points | High risk of OSA
Copy Results | Next Steps
STOP-Bang = Snoring, Tiredness, Observed apnea, High BP, BMI, Age, Neck circumference, and Male gender

<table>
<thead>
<tr>
<th>STOP-Bang Score</th>
<th>Any OSA (AHI &gt; 5)</th>
<th>Moderate/Severe OSA (AHI &gt; 15)</th>
<th>Severe OSA (AHI &gt; 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>0.46 (0.39-0.53)</td>
<td>0.18 (0.13-0.24)</td>
<td>0.04 (0.02-0.08)</td>
</tr>
<tr>
<td>3</td>
<td>0.72 (0.65-0.78)</td>
<td>0.36 (0.29-0.43)</td>
<td>0.13 (0.09-0.19)</td>
</tr>
<tr>
<td>4</td>
<td>0.73 (0.66-0.79)</td>
<td>0.42 (0.34-0.49)</td>
<td>0.18 (0.13-0.25)</td>
</tr>
<tr>
<td>5</td>
<td>0.77 (0.69-0.84)</td>
<td>0.50 (0.42-0.59)</td>
<td>0.30 (0.23-0.39)</td>
</tr>
<tr>
<td>6</td>
<td>0.79 (0.68-0.87)</td>
<td>0.57 (0.45-0.69)</td>
<td>0.32 (0.22-0.44)</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.86 (0.72-0.93)</td>
<td>0.60 (0.44-0.73)</td>
<td>0.38 (0.29-0.53)</td>
</tr>
</tbody>
</table>

Data are given as probability (95% CI).

Never have I ever

- 82 yo F presenting for cysto and bladder sling procedure. PMHx significant for 50 pack year smoking history, COPD (on 2 inhalers), HTN (well controlled). Wears 2 LPM O2 at night. RA saturation in PreOp 91%
  - Proceed with case at ASC
  - Postpone until able to reschedule at hospital in case admission is necessary postop
  - Postpone until she agrees to quit smoking
## Risk of Post-op Pulmonary Complications

### ARISCAT

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years</strong></td>
<td></td>
</tr>
<tr>
<td>≤50</td>
<td>0</td>
</tr>
<tr>
<td>51-80</td>
<td>3</td>
</tr>
<tr>
<td>&gt;80</td>
<td>16</td>
</tr>
<tr>
<td><strong>Preoperative SpO₂</strong></td>
<td></td>
</tr>
<tr>
<td>≥96%</td>
<td>0</td>
</tr>
<tr>
<td>91-95%</td>
<td>8</td>
</tr>
<tr>
<td>≤90%</td>
<td>24</td>
</tr>
<tr>
<td><strong>Respiratory infection in the last month</strong>*</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>17</td>
</tr>
<tr>
<td><strong>Preoperative anemia (Hgb ≤10 g/dL)</strong></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
</tr>
<tr>
<td><strong>Surgical incision</strong></td>
<td></td>
</tr>
<tr>
<td>Peripheral</td>
<td>0</td>
</tr>
<tr>
<td>Upper abdominal</td>
<td>15</td>
</tr>
<tr>
<td>Intrathoracic</td>
<td>24</td>
</tr>
<tr>
<td><strong>Duration of surgery</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;2 hrs</td>
<td>0</td>
</tr>
<tr>
<td>2-3 hrs</td>
<td>16</td>
</tr>
<tr>
<td>&gt;3 hrs</td>
<td>23</td>
</tr>
<tr>
<td><strong>Emergency procedure</strong></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>ARISCAT Score</td>
<td>Risk group</td>
</tr>
<tr>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td>&lt;26</td>
<td>Low</td>
</tr>
<tr>
<td>26-44</td>
<td>Intermediate</td>
</tr>
<tr>
<td>≥45</td>
<td>High</td>
</tr>
</tbody>
</table>

*Complications were defined as a composite including respiratory failure, respiratory infection, pleural effusion, atelectasis on chest x-ray, pneumothorax, bronchospasm treated with bronchodilators, and aspiration pneumonitis.
How does our patient score?

► IF surgery is less than 2 hours...
  ► 24 points = LOW RISK 1.6% risk of in-hospital post-op pulmonary complications (composite including respiratory failure, respiratory infection, pleural effusion, atelectasis, pneumothorax, bronchospasm, aspiration pneumonitis)

► IF Surgery is 3 hours....
  ► 40 points = INTERMEDIATE RISK 13.3% risk of in-hospital post-op pulmonary complications

► IF Surgery is 4 hours ....
  ► 47 points = HIGH RISK 42.1% risk of in-hospital post-op pulmonary complications
Never have I ever

- 45 yo M presenting for an inguinal hernia repair. PMHx of HTN (poorly controlled with home BPs of 150’s/90’s), obesity (BMI 31), daily marijuana use, NIDDM (HgbA1C 6.2% last month). Reports able to mow yard weekly and vacuum house
  - Proceed with GA and ETT
  - Insist on a stress test prior to surgery at an ASC
  - Needs to go to a hospital
Ways to Assess Cardiac Risk

- **GUPTA** - Assesses Cardiac risk looking at:
  
  Cardiac risk % = \( e^{-5.25 + \text{sum of values of selected variables}} \)

Where \( x = -5.25 + \text{sum of values of selected variables} \)

- Age
- ASA Status
- Creatinine (< 1.5 or > 1.5)
- Type of Procedure

- **Revised Cardiac Risk Index** - Series of yes/no questions looking at:
  
  - If surgery is considered “elevated risk”
  - Patient has a h/o ischemic heart disease
  - Patient has a h/o CHF
  - Patient has a h/o TIA/Stroke
  - Pre-op treatment w insulin
  - Pre-op Creatinine > 2 mg/dL
How does our patient score?

- Does he need a pre-op stress test?
  - Yes
  - No

- Is it this case safe to do at an ASC?
  - Yes
  - No
62 yo F presenting for ORIF distal tibia. She got tangled in her puppy’s leash and fell to the ground. The puppy had been purchased to celebrate her survival of her heart attack 5 weeks ago for which 2 DES were placed. Echo at her 4 week cards appointment the shows EF 45% with no regional wall motion abnormalities, normal valve function. Letter from cardiology says “cleared for surgery”

- Proceed under regional anesthesia with little to no sedation at ASC
- Postpone until it can be done at a hospital setting
- Postpone until a cardiac anesthesiologist is available
The current US and European guidelines recommend DAPT for at least 12 months in acute coronary syndrome and for at least 6 months in stable coronary artery disease without high bleeding risk.

In a meta-analyses of randomized trials comparing short (≤6 months) vs prolonged (≥12 months) DAPT duration, short DAPT was associated with lower bleeding risk without a significant increase in ischemic risk.

Delay surgery after PCI during the re-endothelialization period, which would be 14 days after ballooning, 30 days after bare metal stent placement, and at least 3 months (preferentially 6 months) after DES placement.
For our patient...

Emergent or urgent surgery during the re-endothelialization period

Consider continuation of dual antiplatelet therapy

In surgeries with serious bleeding risk, consider continuation of aspirin (or 3-4 days of cessation, if necessary) and discontinuation of oral P2Y₁₂ inhibitors with bridge therapy using cangrelor, tirofiban, or eptifibatide

In cases of non-surgical bleeding, platelet function test may be performed to guide platelet transfusion

Restart dual antiplatelet therapy as soon as possible following surgery for the intended duration after percutaneous coronary intervention

Never have I ever

- 28 yo F presenting for a full body lift. She had a gastric bypass 3 years ago and has lost 250 lbs. Current BMI is 27 and patient has excess skin that is causing pain and interferes with ADLs. Surgeon estimates it will take 6-7 hours to complete the procedure, but promises "these patients always go home. I have a great pain regiment for them. My old institution always let me do these at the ASC. She’s totally healthy now."
  - Proceed with case at ASC, but insist on a first case start
  - Insist the case must be done in segments, with no segment lasting more than 4 hours
  - Move to hospital setting so patient can be admitted
Length of Case

- Cosmetic procedure complication rates range from 0.33% to 1.9% at ASCs
- State dependent limits:
  - Pennsylvania limits surgery length to 4 hours
  - Connecticut limits surgery length to 1.5 hours with a 4-hour recovery time.
- 2009 – Evidence-based safety advisory on safety selection for ASCs
  - American Society of Plastic Surgery recommended a 6-hour maximum surgery length at ASCs.
- Meta-analysis looking at facial plastic surgery
  - No increased morbidity or mortality based on case length
Discuss keeping the ORs full – what are the national trends for block release, block utilization, and case cancellations
WE CAN REMOVE IT... BUT IT'LL COST A FORTUNE.
Block time

“Each 1% of room utilization equates to $100,000 of net revenue,” says Steve Hess, chief information officer for UCHealth in Colorado, which recently implemented an app to facilitate block scheduling. “We were able to increase overall block utilization by 4%.” That increase resulted in an additional $15 million in revenue annually. UCHealth has 10 hospitals and more than 80 ORs.

- Review utilization of assigned block time quarterly
- Make changes accordingly
Blocks must be released 30 days before planned vacations.

Creativity = increased volume. Utilization increased by 28% in 1 year
CMS Requirements:

- The ASC must comply with State licensure requirements.
- The ASC must have a governing body that assumes full legal responsibility for determining, implementing, and monitoring policies governing the ASC’s total operation. The governing body has oversight and accountability for the quality assessment and performance improvement program, ensures that facility policies and programs are administered so as to provide quality health care in a safe environment, and develops and maintains a disaster preparedness plan.
- Surgical procedures must be performed in a safe manner by qualified physicians who have been granted clinical privileges by the governing body of the ASC.
- The ASC must develop, implement, and maintain an ongoing, data-driven quality assessment and performance improvement (QAPI) program.
- The ASC must have a safe and sanitary environment, properly constructed, equipped, and maintained to protect the health and safety of patients.
- The medical staff of the ASC must be accountable to the governing body.
- The nursing services of the ASC must be directed and staffed to assure that the nursing needs of all patients are met.
- The ASC must maintain complete, comprehensive, and accurate medical records to ensure adequate patient care.
- The ASC must provide drugs and biologicals in a safe and effective manner, in accordance with accepted professional practice, and under the direction of an individual designated responsible for pharmaceutical services.
- must inform the patient or the patient’s representative or surrogate of the patient’s rights and must protect and promote the exercise of these rights, as set forth in this section.
- The ASC must maintain an infection control program that seeks to minimize infections and communicable diseases.
- The ASC must ensure each patient has the appropriate pre-surgical and post-surgical assessments completed and that all elements of the discharge requirements are complete.
- The ASC must comply with all applicable Federal, State, and local emergency preparedness requirements. The ASC must establish and maintain an emergency preparedness program that meets the requirements of this section.
Measures for the CY 2021 Reporting Period/CY 2023 Payment Determination

• ASC-9 Endoscopy/Polyp Surveillance: Appropriate Follow-Up Interval for Normal Colonoscopy in Average Risk Patients
• ASC-11 Cataracts: Improvement in Patient’s Visual Function within 90 Days Following Cataract Surgery*
• ASC-12 Facility 7-Day Risk-Standardized Hospital Visit Rate after Outpatient Colonoscopy**
• ASC-13 Normothermia
• ASC-14 Unplanned Anterior Vitrectomy
• ASC-17 Hospital Visits After Orthopedic Ambulatory Surgical Center Procedures**
• ASC-18 Hospital Visits After Urology Ambulatory Surgical Center Procedures**

* ASCs may voluntarily submit data for CY 2021 but will not be subject to a payment reduction with respect to this measure during the voluntary reporting period.
The Ambulatory Surgical Center Quality Reporting (ASCQR) Program

- Goal of program is to promote “higher quality, more efficient health care in the ASC setting for Medicare beneficiaries through quality of care measurement, quality improvement, and information transparency through public reporting.”

- Mandatory reporting of Measures ASC-9, -13, and -14- (endoscopy/polyp surveillance, normothermia and unplanned anterior vitrectomy) with data submitted annually via the Hospital Quality Reporting (HQR) system; and

- Measure ASC-20 Coverage for Healthcare Personnel (HCP) with data submitted quarterly via the Centers for Disease Control and Prevention (CDC)

- ASCs that do not meet reporting requirements, including allowing the data to be publicly available, may incur a 2.0 percentage point reduction to any payment update provided under the revised ASC payment system for that year.
Describe best practices around risk management, safety huddles and peer reviews
Psychological Safety -
An individual’s “sense of being able to show and employ oneself without fear of negative consequences to self-image, status or career”

- Originally defined in 1990

- 2015 report on malpractice claims in the US [2] implicated communication failure in 30% of all malpractice claims and 37% of high severity injury cases).

- improves the health of the workforce by promoting job satisfaction & well-being
I DON'T ALWAYS BLAME ANESTHESIA
WHO AM I KIDDING, YES I DO

Past medical history of heart stuff and blah, blah, blah. Plan OR tonight.

--An orthopedic surgeon's H&P

Humble enough to know I'm replaceable.

Cocky enough to know it's a downgrade.
Anesthesia for patients with ischemic heart disease for non-cardiac surgery

Breandan L. Sullivan MD
Associate Professor, University of Colorado School of Medicine
Co-Medical Director Cardiopulmonary Intensive Care Unit

Panelists

Dr. Andropoulos, MD, MHCM
Dr. Brown, MD, PhD

Dean Andropoulos MD, MHCM
- Burdett S. Dunbar Chair in Pediatric Anesthesiology
- Texas Children’s Hospital Houston
- Professor of Anesthesiology and Pediatrics
- Medical Officer SmartTots
- Public-private partnership of the US Food and Drug administration and NHTS

Nathaniel Brown MD PhD
- Assistant Professor Anesthesiology
- University of Colorado
- Cardiac Anesthesiologist Rocky Mountain Regional VA Hospital
- MD/PhD St. Louis University
- PhD Health Care Ethics

No Disclosures

Outline
- Introduction
- Case 1
- Intermission
- Case 2
- Case 3
- Wrap-up Questions
**SCOPE OF THE ISSUE**

- Every year 100 million adults inpatient, noncardiac surgery globally.
- 2% develop major cardiac complications.
- 13% develop prognostically important myocardial injury.
- Both negatively impact patients' short- and long-term outcomes.

**Ischemic Heart Disease and Perioperative outcomes**

- Controversies
  - Beta blockers?
  - Timing Issue
  - CAB vs PCI
  - Anticoagulant Therapy
  - Pre-operative testing
    - Test strategy
    - Anticipation management of unplanned coronary artery disease prior to surgery
    - Delay surgery?
    - Impact on quality of life
    - Cardiac surgery in long security retention

**In the old days...**

- Easy peasy lemon squeezy!

**Fancy Algorithms**

- Didn’t pan out
- Traded in decisions from “must do” to “consider if justified”
- Individualized Medicine...
- Modern Problems...

**One part of the story**

*SAGA OF BETABLOCKERS*
New Data/Old Data/Same Data...

- Perioperative Beta Blockers
  - Don't cause increased risk of stroke...
    - Massive retrospective paper
- Long Convoluted History
- Slightly difficult to interpret
- Polderman/Hangero
- DECREASE IV
- POISE trials
  1,2,3

<table>
<thead>
<tr>
<th>NEJM 1999</th>
<th>Polderman et al</th>
<th>Bisoprolol</th>
<th>1 week before Vascular Surgery</th>
<th>Decreased MI’s and cardiac deaths</th>
<th>3.4% vs 34%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEJM 2005</td>
<td>Lindenauer et al</td>
<td>Bisoprolol</td>
<td>2 days before major vascular surgery</td>
<td>Decreased MI’s in high risk patients, increased MI’s in low risk patients</td>
<td>3.4% vs 34%</td>
</tr>
<tr>
<td>J Am Coll Cardiol 2007</td>
<td>Reeder et al</td>
<td>Bisoprolol</td>
<td>Coronary Re’s perioperative &amp; blocker</td>
<td>Don’t stop beta blocker in high risk patients should be on them</td>
<td>3.4% vs 34%</td>
</tr>
<tr>
<td>Lancet 2008</td>
<td>Devereaux et al</td>
<td>Bisoprolol</td>
<td>1 week pre Vascular surgery</td>
<td>Decreased MI, increased EBL and death</td>
<td>3.4% vs 34%</td>
</tr>
<tr>
<td>Circulation 2014</td>
<td>Reeder et al</td>
<td>Periop rec</td>
<td>Consider high risk</td>
<td>Consider, maybe, possibly, set us some...</td>
<td>3.4% vs 34%</td>
</tr>
</tbody>
</table>

CASE #1

"I would rather die then go on with the pain..."

CASE #1

- 37 y/o female
  - Referred for lumbar fusion surgery
  - Heart Transplant evaluation on hold secondary to functional status
  - Limited by pain with ambulation
  - Pain has been refractory to medications/injections/physical therapy
  - Multidisciplinary spine team recommending surgical intervention
  - 4 level fusion with hardware
  - Potential EBL 3

Past Medical History/Cardiac Work-up

- Chronic debilitating back pain
- Cardiomyopathy diagnosed 12/20
- Suspicion past viral myocarditis
- PET scan w/a negative for myocarditis
- Chest CT scan notable for diffuse calcium in LAD, RCA distribution
- EF has improved with GDT
  15% (12/20) - 31% (12/22)
- Global biventricular dysfunction
- No regional wall motion abnormalities

Physical exam

- Vital signs
  - HR 45 sinus
  - BP 100/55
- Airway Exam unremarkable
  - Anterior 1, good neck extention
  - Base 15
- Pulmonary/Cardiac Exam unremarkable
  - No edema, murmurs
Dr. Andropoulos

- Does this patient need additional work-up?
  - Medication titration (beta blockers, statins)
  - Optimization (laboratory assessment)
  - How do you risk assess this patient?
  - "what are my anesthetic risks?"
  - What invasive monitors do you use for this patient if any?

Preoperative Workup and Other Considerations

- Ensure that this patient must have this extensive high-risk procedure now
  - Neurologic function compromised?
  - Pain?
  - Is a more limited procedure possible?
- Assuming the answer is that the procedure should proceed as planned, in order to make this patient a cardiac transplant candidate
  - Major risk factors:
    - Cardiac function
    - High BMI (equivalent of 5’ 6”, 217 lbs)

Dr. Andropoulos

Additional Preoperative Workup/Optimization

- Cardiac catheterization
  - Document the true extent of CAD, intervene when indicated, i.e. stents
  - Pulmonary hypertension with heart failure
- Exercise testing
  - Biomarkers: NT-pro-BNP
  - Weight loss/diet optimization
    - Greatly reduce cardiac risk
    - Insufficient time and functional status
- Assuming surgery will proceed
  - Operative setting:
    - Cardiac center with full expertise available
    - TEE, Impella® or balloon pump, We, full cardiac ICU capability
    - Extensive multidisciplinary cardiac planning for monitoring, low CO events, postoperative care
- Patient and family discussion:
  - Extremely high-risk procedure
  - Significant risk of death, stroke, end-organ damage: cardiac, renal

Assessment of functional capacity before major non-cardiac surgery: an international, prospective cohort study

Implications of all the available evidence
Subjective assessment of functional capacity should not be used for preoperative risk assessment. This commonly used practice does not accurately identify patients with poor fitness or those at increased risk for postoperative morbidity and mortality. As alternatives, clinicians could consider more objective measures, such as Duke Activity Status Index, questionnaires and NT-pro-BNP testing to assess perioperative cardiac risk, and perhaps even ETT to predict complications after major elective non-cardiac surgery.

“DASI scores showed significant adjusted associations with the primary outcome of death or myocardial infarction by 30 days after surgery and with death or myocardial injury by 30 days after surgery. Additionally, DASI scores showed significant risk reclassification with death or myocardial injury by 30 days.”

Lancet 2018; 391: 2633–40
Intraoperative Monitoring

- Arterial line
- Central venous pressure: right internal jugular catheter
- Oxygen saturation
- PiCCO® system: continuous CO
- Percutaneous PA catheter
  - Cardiac output, PA wedge pressure
  - Pulmonary artery pressure
  - Mixed venous O₂ saturation
- Transesophageal echo
- Cardiac function
- Left ventricular volume/filling

All of these modalities are complicated by prone positioning.

Perioperative Cardiac Support Modalities

- Inotropic and vasodilator support: dobutamine, epinephrine, milrinone, vasopressin, inhaled nitric oxide (phenylephrine, epinephrine, calcium chloride), inhaling nitric oxide if pulmonary hypertension
- Impella®: percutaneous placement in cath lab; needs anticoagulation
  - Suitable for postoperative support
- Frequent ABGs, electrolytes
- Coagulation monitoring: ROTEM®, TEG®
- Cell saver and goal-directed therapy for reinfusion: blood transfusion, platelets, coagulation factors
  - SvO₂, Hgb, platelets, prothrombin complex factor, fibrinogen, red cells, cell saver blood
- Planning for cardiac arrest
  - Cover wound, turn supine, ACLS, mechanical support

Postoperative Care

- Admission to ICU ventilated; extubate only when certain that cardiac function is adequate
- Continue the intraoperative monitoring
- Consider Impella® for LCCS

Integration of the Duke Activity Status Index into preoperative risk evaluation: a multicentre prospective cohort study


Dimitra K. Vlachou-Cheney1,2,3##, W. Scott Beeler4, Graham A. Hills5,##, Tim E. Allen5,##
Mark A. Shih2,##, Gareth L. Acheson2,3, C. David Mann2,##, Paul O. Nyman2,##, Robert M. Payne2,##, Helen M. Cuthbertson2,## on behalf of the Measurement of Exercise Tolerance before Surgery Study Investigators

Editor’s key points

- The Duke Activity Status Index (DASI) questionnaire is a valid measure of preoperative cardiopulmonary function, but it is unclear what threshold score defines an elevated preoperative risk.
- A central cohort analysis of the Measurement of Exercise Tolerance before Surgery Study sample was conducted to characterize the association of preoperative DASI scores with postoperative outcome complications and mortality-to-severe complications.
- A DASI score of 25 was identified as a threshold for identifying patients at risk for repeat revascularization, mortality, severe morbidity, and new disability in sagittal motions, and new disability in sagittal motions.
- The use of the DASI should help the preoperative identification of patients at an elevated risk of postoperative morbidity.
PiCCO® System Display

Advantages (no disclosures)
- Standard arterial line/CVP catheter placement
- Good accuracy
- No PA catheter or anticoagulation
- Displays CO and other parameters continuously

Disadvantages
- Training required
- Careful calibration

https://clinicalview.gehealthcare.com

Impella® System

Advantages (no disclosures):
- Can be placed in cath lab
- Mostly percutaneous insertion, especially for temporary support
- Relatively easily removed

Disadvantages:
- Anticoagulation required
- May require axillary artery cutdown

https://www.heartrecovery.com/

Case #2

“But doc, its not my heart I worried about, its the cancer!”

65 y/o male prostate cancer
- Robotic prostatectomy possible open PMH
  - CAD: STEMI 1 year ago
  - Prior DVT, bilateral PE
  - Recent ECG show ischaemia
  - Automatic internal defibrillation
  - ASA, Clopidogrel for his stents
  - PVD
  - Stroke in left arm, complication of cancer
  - Diabetes on insulin
  - HbA1c 7
  - CVI
  - Weakness in left arm and slight speech deficit
  - Endocarditis

How do you risk assess this patient?
What do you recommend for this patient’s anticoagulation?
Do you recommend any changes to their defibrillator/biventricular pacing prior to the surgery?

Dr. Brown
Dr. Brown

The good news: other than that, he's healthy!

- The major assessment is, on the one hand, quite easy to make:
  - He has a sick heart
  - He has other markers of poor health
  - But, the question is perhaps not "is his risk is high?" but rather "how high is his risk?"

RCRI

- Several tools can guide risk assessment.
- HESQUIP / NASQUIP are very granular and require a lot of data.
- The most blunt, but perhaps the most ubiquitous: RCRI

- RCRI consists of 6 binary variables:
  - Elevated risk surgery
  - H/o ischemic heart disease
  - H/o CHF
  - H/o cerebrovascular disease (including TIA)
  - Pre-op insulin therapy
  - Preop creatinine >2 (mg/dL)

RCRI, cont

- RCRI yields a risk from 3.9% to 15% based on "yes" answers.
- Answering yes to 3 questions gets you to 15%.
- Our patient scores well, or poorly, depending on your outlook with 5/6 and that's assuming no CKD.

Anticoagulation

- Drug eluting stents (DES) require dual anti-platelet therapy (DAPT).
- ACC/AHA give a Class 1 recommendation of 6-12 months of DAPT after modern DES deployment.
  - Clopidogrel can probably stop.
  - ASA can stay.
AICD management

- The patient has a Bi-V AICD.
- Even modern AICDs often need to be made "dumber" for surgery. Why?
  - Electrocautery can confound them.
  - Magnets and an AICD:
    - Usually turns off all anti-tachycardia therapies and puts pacing in asynchronous mode (DDD or VOO)
    - Guide in references

AICD and EM interference risk

- The farther away the electrocautery circuit, the better.
- The electrocautery return pad should be on a lower extremity, and certainly not on the left shoulder or over the precordium!

AICD Management, cont.

- Is pt paced? If so, how much?
  - The pacemaker keeps track of this and
  - Use of anti-tachycardia therapies.
  - The patient will generally be able to tell you if a shock was delivered...

It hurts!

- It hurts!

What if something goes wrong?

- Place external defibrillator pads on patient prior to going to surgery.
- Have magnet available.
  - If magnet placed, and pt needs defib, remove it, or use external pads.
- Communicate this to surgery, unless you don't especially like them, in which case ensure that they're standing in a puddle of saline.

Case #3

"My heart is fine, I had the CABG, now I need the aorta fixed!"
Case #3

- 78 y/o with abdominal aortic aneurysm
- Infra-renal endovascular repair
- PMH: CAD s/p CABG 4 years ago, COPD 4L NC, CKD creatinine 3, obstructive sleep apnea
- PSH: CABG complicated by cardiogenic shock (Perioperative ECMO), tracheostomy, temporary dialysis, prolonged rehab

How important is this patient’s functional status in deciding his preoperative work-up?

The cardiologist says the patient is “cleared” if the anesthesia is done under regional or with sedation?

8.6% overall conversion rate to open

However, our patient has advanced age, CHF, chronic kidney disease, prior CABG, all of which increase risk of conversion to open surgery.

If his conversion rate risk is actually much higher, i.e., 20-30%, what would you tell the Cardiologist and Patient about anesthetic and surgical risk?

How would this effect your anesthetic planning?

The surgeons are unable to complete the procedure endovascularly

Upon opening there are inferior ST depressions on the patients 5 lead EKG

- How do you proceed?
- Transfusion goals/Hemodynamic goals/Discussion with care team
If converting to open, anesthetic and surgical risk both increase with conversion to GA.
I would favor tracheal intubation (over LMA, e.g.) to preserve the ability to use TEE should complications arise in this critically ill person.

Bad News
There is active ischemia.
Management goals are directed toward cardiac perfusion
Are there guidelines? Yes, but they vary quite a bit.

Lene Boker 1, 2, Lily Park 1, Richard Dutton 1, Holleah Amay 1, Andre Marlier 1, , Bert Lewi 3, 5, Alexandre Carvalho 4, 5, Joao Semproni 3, 4, 5, Guido A. Vanguestaine 4, 5, Guillaume Marlier 1, 2

Summary
MACE is a common problem
Risks should be guided by the surgery, patient risk factors, timing
Case 1
Functional status important
NISQUIP / VASQUIP data bases give strong evidence based outcomes data
Helpful for discussion when alternative treatments are available
Case 2
Case 3
Cardiac Support devices/Post operative expert care

Case #3 management, cont.
If available, place TEE for intraop monitoring.
Discuss urgency with surgery.
If evolution to ST elevations, plaque rupture may have occurred, and patient may need trip to cath lab for revascularization.
Alert cardiology, discuss with them. Again, discuss with surgery.

Summary
Case 2
NISQUIP / VASQUIP data bases give strong evidence based outcomes data
Helpful for discussion when alternative treatments are available
Chemotherapy

Case 3
Summary
Case 3
References

- RCRI tool (at MDCalc): https://www.mdcalc.com/calc/1739/revised-cardiac-risk-index-
  pre-operative-risk
  and management of patients undergoing noncardiac surgery: executive summary: a report
  of the American College of Cardiology/American Heart Association Task Force on Practice
  Antiplatelet Therapy in Patients With Coronary Artery Disease: A Report of the
  American College of Cardiology/American Heart Association Task Force on Clinical Practice
- Friedman H, et al. Prediction of intraoperative electrosurgery-induced implantable
  PMID: 27665098.
- Guide to AICDs/PPMs here.
- Thomas H, et al. “Guidelines for the peri-operative management of people with cardia
  implanta ble electronic devices. Guidelines from the British Heart Rhythm Society.”

Questions for our Panelists

- Special thanks:
  - Dr. Brown
  - Dr. Andropoulos
  - Dr. Ing
  - Chrissie Butz
Point of Care Ultrasound

Marianne Wallis, M.D.
University of Colorado Hospital
Department of Emergency Medicine
Department of Anesthesiology, Critical Care Section

Disclosures

- None

Faculty

- Marianne Wallis, MD
- Jason Brainard, MD
- Kenji Tenabe, MD
- Hans Tregear, MD
- Nicholas Houska, MD
- Samuel Gilliland, MD

Objectives

- Obtain the following cardiac views: parasternal long axis, parasternal short axis, apical four chamber, and subxiphoid.
- Identify basic cardiac structures in these four views.
- Understand basic lung ultrasound and identify lung sliding and pleural effusions.

Overall Flow

- 6 Rotations: ~ 18 minutes at each station
  - Parasternal long and short axis (Dr. Wallis)
  - Subxiphoid view (Dr. Gilliland)
  - Apical view (Dr. Houska)
  - Cardiac function (Dr. Tenabe)
  - Lung Ultrasound (Dr. Brainard)
  - Volume responsiveness/Pathology (Dr. Tregear)
- Hands-on time for each learner to obtain the view

Where to go from here?

- American Society of Anesthesiologists now has a certification process
- POCUS ACGME requirements now in place
- PRACTICE PRACTICE PRACTICE!
- DON'T MAKE SIGNIFICANT CLINICAL DECISIONS YET!
Question and Answer Session

- Please see me or any of my colleagues after the session for further questions
- Feel free to contact me if you think of additional questions
  - Marianne.Wallis@cuanschutz.edu
Wednesday, March 1st
Perioperative Implications of Cannabis Use

Rachael Rzasa Lynn, MD
Associate Professor, Department of Anesthesiology
University of Colorado Anschu

Objectives

- Understand the cardiovascular effects of cannabis administration
- Discuss pulmonary effects of cannabis use
- List common drug interactions with cannabis
- Describe the effects of cannabis on post-operative pain

Disclosures

- Grant/research support from the Colorado Department of Public Health & Environment, National Institutes of Health and US Department of Defense

What is cannabis?

Marijuana = Cannabis sativa (also indica, ruderalis, afghanica)

- First evidence of medicinal use (analgesic) in 4,000 BC
- High degree of inbreeding or hybridization → CANNOT predict the biochemical content based upon strain name or physical appearance
- "Chemovar"

What is cannabis?

Numerous active components

- Psychoactive:
  - Δ⁹-tetrahydrocannabinol (THC)
    - Non-psychoactive: A synthetic cannabinoid
  - Cannabidiol (CBD)
- Anti-inflammatory and other:
  - CBD
  - Numerous other minor cannabinoids
  - Cannabichromene, cannabigerol, cannabinol

- Terpenoids (eg myrcene, limonene)
  - Anti-inflammatory & modulate THC effects

State policies and demographics

- Cannabis is the most commonly used federally illegal drug in the US
- Nearly a fifth of people aged 12 or older reported use in 2021

As of May 2022

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6901475/

References

Cannabis Risks

- About 30% of people who use cannabis have cannabis use disorder.
- Risk increased for people who begin using marijuana before age 18.
- Long-term or frequent cannabis use linked to increased risk of psychosis.
- Cannabis use increases the risk of suicidal ideation and attempts in adults and adolescents.
- Increased risk of pregnancy complications: decreased birth weight, preterm delivery.
- May affect fetal brain development leading to attentional deficits, behavioral problems, psychopathology and lowered cognition.

Not your parents’ grass: THC Content

- NIDA Cannabis “High THC” concentration is 5-10%.
- Average retail flower in Colorado is over 19%.
- Concentrates (inhaled, edible, etc.) allow for even higher THC consumption.
- Average concentrate products sold by the gram were 68% THC in 2020.
- Vape cartridge potency increased from 69% THC in 2019 to 80% in 2020.
- MMJ Edible average THC content increased from 540 to 737 milligrams from 2019 to 2020.
- Package labeling may be wildly inaccurate.

Marketed cannabinoids

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Cannabinoid</th>
<th>FDA Indication</th>
<th>Dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>dronabinol</td>
<td>synthetic THC</td>
<td>n/v 2/2 chemotherapy, also anorexia in HIV/AIDS</td>
<td>start 2.5mg PO BID, max dose 10mg PO BID</td>
</tr>
<tr>
<td>nabilone</td>
<td>synthetic THC analog</td>
<td>n/v 2/2 chemotherapy</td>
<td>1-2mg PO BID</td>
</tr>
<tr>
<td>Epidiolex (cannabidiol)</td>
<td>CBD extract</td>
<td>seizures in Lennox-Gastaut or Dravet syndrome</td>
<td>start 2.5mg/kg BID up to 10mg/kg BID</td>
</tr>
<tr>
<td>nabiximols</td>
<td>THC and CBD extract</td>
<td>none: not approved in US. Use in Canada, Europe for MS spasticity</td>
<td>oromucosal spray: titration from 1/day up to 12/day divided BID</td>
</tr>
</tbody>
</table>

Cannabis Pharmacology
Cannabis pharmacology

**Endocannabinoid System**

- **Endogenous cannabinoids**
  - Chemically similar to arachidonic acid
  - Sulfidophosphatidylethanolamine (SPEA) aka anandamide
  - 2-arachidonoylglycerol (2-AG)
- Enzymes and proteins for EC synthesis, degradation and re-uptake
  - Different enzymes for AEA and 2-AG synthesis
  - Degradation: oxygenation or hydrolysis
    - AEA: Fatty-acid amide hydrolase (FAAH)
    - 2-AG: Monoacylglycerol lipase
    - Both: oxygenation by COX-2, lipoxygenases or CYP450 enzymes
- **G-protein-coupled receptors**
  - CB1: Expressed in CNS (and PNS)
    - Nerve axons and presynaptic terminals
    - Also in thyroid, adrenals, liver, adipose tissue, GI tract, reproductive organs and immune cells
  - CB2: "Peripheral" cannabinoid receptor
    - Expresses on immune cells
    - Also chondrocytes, osteocytes, fibroblasts, and DRG as well as microglia
- **Non-cannabinoid receptors:**
  - TRPV1 (ligand-gated cation channel), "CB3" aka G protein-coupled receptor 55, Peroxisome proliferator-activated receptor-β, etc.

**THC vs CBD**

- **THC**
  - "Psychoactive" = psychotomimetic
  - Agonist at CB1 and CB2 receptors
  - "Psychoactive" = psychotomimetic
  - Agonist at CB1 and CB2 receptors
- **CBD**
  - Anti-inflammatory analgesic
  - Relatively low affinity for CB1
  - Partial agonist at CB1
  - May activate both indirectly by increasing AEA and 2-AG
  - Modulates and activates glycine receptors (so do THC and AEA)

Hemp products (by definition <0.3% THC) widely available, NOT regulated

**Drug-drug interactions**

<table>
<thead>
<tr>
<th>Drug levels possibly increased by THC/CBD:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acenocoumarol (2C9)</td>
</tr>
<tr>
<td>Aemetin (2C9)</td>
</tr>
<tr>
<td>Buprenorphine (2C9)</td>
</tr>
<tr>
<td>Clopidogrel (2C19)</td>
</tr>
<tr>
<td>Diltiazem (2C9)</td>
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<tr>
<td>Diclofenac (2C9)</td>
</tr>
<tr>
<td>Domperidone (2C19)</td>
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<td>Flurbiprofen (2C9)</td>
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<td>Furosemide (2C9)</td>
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<td>Perhexiline (2C9)</td>
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<td>Propranolol (2C9)</td>
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<td>Rabeprazole (2C9)</td>
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<td>Sildenafil (2C9)</td>
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<td>Simvastatin (2C9)</td>
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<td>Tamsulosin (2C9)</td>
</tr>
<tr>
<td>Theophylline (2C9)</td>
</tr>
<tr>
<td>Tolcapone (2C9)</td>
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<tr>
<td>Verapamil (2C9)</td>
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<tr>
<td>Warfarin (2C9)</td>
</tr>
</tbody>
</table>

**Cannabis pharmacology**

- Inhaled exposure → peak 15-30 minutes, effects can last > 8 hrs
- Oral exposure → onset 30 minutes to 3 hrs, lasts up to 12 hrs
- Extensive first-pass metabolism, oral bioavailability is 10-20%
- Frequent dosing leads to accumulation (long terminal half life)
- ASRA guidelines (2022) recommend screening for cannabis use, inquiring further about dose & frequency, route of administration, and time of last use

Shah S (2023) Reg Anesth Pain Med 2023;0:1–21

Cannabis Cannabinoid Res 2:274-81
Cannabis and anesthetics

- Propofol affects endocannabinoid system in mouse models
- Propofol activates CB1 indirectly via increase in brain AEA (also inhibits FAAH)
- Propofol effect requires CB1 activation
- Patients using cannabis require more propofol for induction and LMA insertion
- Significantly more additional Propofol required for LMA insertion for cannabis users (314±109.3mg) than non-users (263.2±69.5mg)
- BIS <60 achieved in 57% of cannabis users, 73% of non-users (p=0.18) with fixed mg/kg propofol doses


Cannabis and Pain

 Patients using cannabis may require greater doses for procedural sedation
In a retrospective analysis of 118 patients undergoing tibial fracture repair, cannabis use was associated with greater ml administration of sevoflurane
No difference in desflurane, no difference in propofol, no controlling for FGF, etc.

Cannabis for chronic non-cancer pain

- Pain is the number one indication for medical cannabis use
- Majority of studies evaluated neuropathic pain and MS-related spasticity
- Commonly used nabiximols (THC-CBD oromucosal spray, not approved in US)
- Also cannabis flower, dronabinol (synthetic THC), nabilone (synthetic THC analog), very few CBD


- 39 patients with heterogeneous neuropathic pain disorders
- Randomized, double-blind, placebo-controlled crossover design
- Compared vaporized medium (3.53%) vs low- (1.29%) THC vs placebo cannabis
- Flexible dosing: 4-8 puffs at 2nd admin


- Crossover RCT in 16 patients with painful diabetic neuropathy
- Single exposure, vaporized
- Placebo vs low (1% THC), medium (4% THC) and high (7% THC) doses
- Spontaneous pain and Evoked pain

Dose  | Avg Pain Intensity Score Difference from Placebo
Low   | -0.44 (p<0.05)
Med    | -0.42 (p<0.001)
High   | -1.2 (p<0.001)

Cannabis for chronic non-cancer pain

- Decreasing effect size with increasing study duration: greatest effect seen with intervention <4 weeks
  - Single administration provides significant relief of chronic neuropathic pain
  - Smaller and more inconsistent outcomes with ongoing cannabis use

Observational studies report significant effects, while RCTs find very small effect sizes (<3mm on 100mm VAS vs placebo)

Cannabinoid Analgesic Effects: Opioid Sparing in Pre-Clinical Models

- Numerous studies show opioid sparing effects when cannabinoids are co-administered with opioids in animal models of acute and chronic pain.
- Meta-analysis of pre-clinical animal models:
  - Median effective dose (ED50) of morphine is 3.6 times lower when administered in combination with THC than alone.
  - The ED50 for codeine administered with THC is 9.5 times lower than the ED50 for codeine alone.

Cannabinoid Analgesic Effects: Opioid Sparing in Clinical Trials

- States with MCC laws saw decrease in opioid prescriptions filled in Medicare database from 2010-2015.
  - Most significant for hydrocodone and morphine (7.1% and 20% reductions)
  - MCC laws were associated with a 3.8% lower rate of opioid prescribing in Medicare claims.
- In a sample of patients with commercial insurance (n=8,840,562) 2006-2014, MCC legalization was associated with lower odds of:
  - Any opioid use (OR 0.95; 0.94-0.96)
  - Chronic opioid use (OR 0.91; 0.90-0.92)
  - High risk opioid use (OR 0.96; 0.94-0.98)

Cannabis and Opioids - Population Data

- Opioid analgesic overdose death rates from 1999-2010 were lower in states with medical cannabis (MCC) laws.
- Reduction increased over time following MCC legislation:
  - States with MCC saw decrease in opioid prescriptions filled in Medicare database from 2010-2015.
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  - High risk opioid use (OR 0.96; 0.94-0.98)

Cannabis and Opioids: Clinical Data

- 2021 meta-analysis found only 18 publications (RCTs or observational studies) reporting the impact of medical cannabis initiation on opioid use for chronic pain.
  - 5 RCTs, 13 observational
  - All 5 RCTs and 3 observational enrolled only cancer pain
  - All RCTs administered isolated or synthetic cannabinoids
  - All RCTs instructed patients to maintain prescribed pain med doses

Cannabis and Opioid Use for Pain (Noori):

- Minimal change in opioid use in RCTs (WMD -3.4MME, 95% CI -12.7 – 5.9)
- Data from 8 observational studies suggests adding cannabis may reduce opioid use in CNCP (WMD -22.5 MME, 95% CI -43.06 – -1.97)
  - 1 study found >1/2 of patients with low back pain stopped all opioid use at median follow-up of 6.4 years

Cannabis opioid-sparing effects: chronic opioid use

- Cannabis use results in self-reported reductions in opioid use for pain in observational studies
  - Low quality evidence of reduced opioid requirement after initiation of short-term smoked/vaporized cannabis
  - Higher quality studies have not found an opioid sparing effect
THC and opioids: safety concerns

- Few studies report on vital signs when opioids and cannabinoids combined
  - No evidence of respiratory depression or CV complications when CBD given prior to IV fentanyl (0.5 or 1mcg/kg)
  - Dronabinol 20mg + morphine 30mg PO resulted in statistically significant change in SBP and DBP, as well as SpO2 (magnitude not reported)
  - Dronabinol alone increased HR
  - IV THC after anesthetics:
    - Further decreased ventilation
    - At highest THC dose (134mcg/kg), HR and Cardiac Index increased while TPR decreased

Post-op pain in patients who use cannabis

- Mixed findings regarding differences in post-op or opioid use between cannabis users and non-users
  - Many studies under-powered
  - Cannabis use by diagnosis code (database analyses) vs patient history
  - Poor quantification of post-op opioid use following discharge
  - Confounder of co-morbid pre-operative opioid use
  - Several studies have found that patients using cannabis preoperatively were significantly more likely to also use opioids and BZDs preoperatively

Post-op pain and opioid use in patients who use cannabis

- retrospective multi-institutional pilot study from 3 trauma centers in CO and 1 in TX
  - 215 (54/261) of patients reported marijuana use and 35% of those reported chronic use (daily or almost daily use or >1oz over past month)
  - Opioid use was greater in marijuana users, both chronic and episodic, vs non-users (7.1 and 7.8, respectively vs 3.7, p<0.05)
  - No difference in post-op pain scores at 12 or 36 hours post-op (did not control for intra-op medications like ketamine)
  - Pain scores were significantly greater throughout the duration of hospitalization for marijuana users

Post-op pain and opioid use in patients who use cannabis: orthopedic surgery

- Liu (2018): Internal database retrospective matched cohort analysis of major orthopedic surgery patients; patients who had previously used cannabis, both chronic and episodic, vs non-users (7.1 and 7.8, respectively vs 3.7, p<0.05)
  - Nearly all patients with marijuana use were chronic users
  - Most patients with marijuana use were chronic users

Cannabis for post-op pain

- Adding dronabinol reduces opioid use and improves pain control in retrospective analysis (regardless of pre-admission cannabis use history)
  - Clinical trials have investigated the post-operative analgesic (or antiemetic) effect of several cannabinoids
    - Dronabinol
    - Nabuline
    - Levonantradol
    - Other novel cannabinoid agonists
    - CBD (buccal)

  - 2020 meta-analysis of 6 trials found a significant reduction in pain vs placebo only for IM cannabinoids (1 trial), not for oral administration

Table 4. Pain Scores

<table>
<thead>
<tr>
<th>Route</th>
<th>No. of Patients</th>
<th>Mean difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intravenous</td>
<td>69</td>
<td>-0.32 [-0.48, -0.16]</td>
</tr>
<tr>
<td>Oral</td>
<td>25</td>
<td>-0.21 [-0.38, -0.04]</td>
</tr>
</tbody>
</table>

- Post-op pain and opioid use in patients who use cannabis
  - McAfee 2021 - cannabis users reported more pain day of surgery, greater functional impairment, more symptoms of anxiety and depression versus non-users
    - 6% patients reported cannabis use (state where only medical cannabis was legal), over half for medical use only
    - No difference in surgical site pain at 3 or 6 months post-op
    - Users more likely to continue opioid use at 3 and 6 months but no significant difference in OME at either time

- Post-op pain and opioid use in patients who use cannabis
  - Ong (2022): single institution matched cohort of patients undergoing THA, inpatient opioid use, opioid refills
  - 21% (54/261) of patients reported marijuana use and 30% of those reported chronic use (daily or almost daily use or >1oz over past month)
  - Those who used cannabis (almost 10%) had significantly higher pain and opioid use at both 12 and 36 hours post-op (did not control for intra-op medications like ketamine)

- Post-op pain and opioid use in patients who use cannabis: orthopedic surgery
  - Wood 2022 retrospective claims analysis of patients who underwent hip arthroscopy with or without cannabis use, dependence or abuse in the 5 years prior, matched cohort, no difference in prescription opioid use within 60 days after surgery
    - Queried 50,458 patients, found 360-with cannabis history (0.71%)

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    - Queried 50,458 patients, found 360-with cannabis history (0.71%)
Marijuana use and Post-operative Pain

- Retrospective survey of 500 patients with musculoskeletal injury
- Never user, prior user (but not during recovery) and user during recovery
- Latter group: more total opioids and longer duration of use (but not persistent use)
- 89% reported that marijuana helped their pain, and 81.1% said they used less opioids
- BUT still significantly greater total MME rx and duration
- Less effective coping strategies (more catastrophizing, greater anxiety at baseline)

Cannabis-opioid interactions: cardiovascular and pulmonary effects

- THC administration alone does not affect ventilation or O2 saturation, however co-administration with opioids may further decrease ventilation and CO2 response
- does not change respiratory rate
- No evidence that CBD + opioid affects respiratory or cardiovascular parameters

Pulmonary effects of cannabis use

Effects of cannabis use on lung function difficult to discern
- Cannabis smoke contains similar chemicals and particulates found in tobacco smoke, some in even greater quantities
- Co-morbid tobacco use
  - Use of cannabis + tobacco worse than tobacco or cannabis alone
- Results in obstructive pulmonary disease
  - Increased sputum, cough, wheezing among young cannabis users
- Cannabis smoking reduces FEV1/FVC ratio
  - Lung volumes may be altered by breathing practices associated with cannabis smoking
  - Increased total lung capacity
  - Increased FVC

Pulmonary effects of acute cannabis use

- THC induces bronchodilation (oral or inhaled)
- But inhalation of combustion products may irritate airways and cause bronchoconstriction in patients with RAD
- Case reports
  - Several reports of hemoptysis shortly after cannabis use
  - Case report of alveolar hemorrhage after GA
- EVALI
  - Dyspnea, fatigue, hypoxemia
  - acute eosinophilic pneumonia, diffuse alveolar hemorrhage, lipoid pneumonia, and respiratory-bronchiolitis interstitial lung disease

Cardiovascular implications of cannabis use
Acute cardiovascular effects of cannabis use

- Tachycardia
  - Peaks 10-30 minutes after inhalation of cannabis smoke
  - Bradycardia possible with repeated use
- Hypertension vs Hypotension - dose and chronicity
  - THC: tachycardia + hypertension from beta-adrenergic activation and parasympathetic inhibition in naïve users
  - With high doses or chronic usage → hypotension (diastolic)
  - Reduced cardiac output following THC administration in animals (reduced venous return)
- Possibly dysrhythmias

- Cannabis smoke increases carboxyhemoglobin, thus decreasing O₂ carrying capacity
- Unclear effects on coagulability
  - In a very small study of trauma patients, +THC associated with hypercoagulability on TEG
  - Most studies find platelet function impaired with chronic THC administration
    - One in vitro study found enhanced irreversible platelet aggregation with high but not low THC
- Possibly dysrhythmias

Acute cannabis use and Myocardial Infarction

- Nearly 5-fold increased risk of MI in the first hour after smoking cannabis
  - MI onset within 5 hours of use in the majority of cases
- Frequency of cannabis use associated with risk of mortality after MI
  - 2.5-fold if use >1x weekly
  - 4-fold risk if more frequent use
- Adjusted odds of postoperative myocardial infarction after major elective surgery was 1.88 times higher for patients with vs without active cannabis use disorder in a large retrospective analysis
- CUD also associated with greater risk of post-operative cerebrovascular event

Recommendations

- Screen for cannabis use, including dosage & frequency, route of administration, and time of last use
- Counsel patients on the risks of cannabis use
- Delay elective surgery at least 2 hours after cannabis use
- If possible, consider avoidance of cannabis use for 72 hours before surgery
  - Cannabis withdrawal: measure on cannabis withdrawal scale
    - Consider use of nabilone or dronabinol, also data for gabapentin
- Be aware of possible obstructive lung disease pathology and manage ventilation accordingly
- Adjust anesthetic and analgesic doses as clinically indicated
A complex multifaceted construct

Hilary P. Grocott, MD, FRCP
Professor, Department of Anesthesiology, Pharmacology & Therapeutics
University of British Columbia

Outline: shared decision making

• Definition
• Historical perspectives
• Why we should do it
• How to do it
• Challenges to SDM

Case Study

• 56 year old female with severe aortic stenosis
• NYHA II-III symptoms
• AVA = 0.8 cm²
• normal LVEF
• "otherwise healthy"
• referred to cardiac surgeon for AVR

AVR: which option?

transcatheter surgical

TAVR SAVR

The Evidence

Nishimura et al. JACC 2017;70:252-89

The Evidence

Eur J Cardio-Thorac Surg 2017;52:656-664
SAVR vs TAVR?

- **SAVR** vs **TAVR**
- **High-Risk**
- **Palliate**
- **12 mos**
- **Life Expectancy**

Which valve strategy should she pursue?

- **A) TAVR**
- **B) SAVR**

If SAVR, which valve option do you recommend?

- **A) Mechanical**
- **B) Bioprosthetic**

The Evidence

- **Clinical Practice Guideline: Focused Update**
- **2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease**
- **A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines**

What do the guidelines say?

- **Mechanical**
- **Bioprosthetic**
- **Guidance**

Nishimura et al. JACC 2017;70:252-89

Otto CM et al. Circulation 2021;143:e72-e227
Mechanical vs Bioprosthetic AVR?

> 65 years

>50 years

Risks: Bioprosthetic vs Mechanical?

1) Thromboembolism
2) Major Bleeding
3) Reoperation
4) Survival

Bioprosthetic vs Mechanical: embolism

Hazard Ratio (95% CI) = 0.54 (0.35 to 0.84)

Studies = 12; n = 8,661

Bioprosthetic vs Mechanical: bleeding

Major Bleeding
Hazard Ratio (95% CI) = 0.48 (0.39 to 0.59)

Reoperation for Valve Deterioration

N = 24,410 bioprosthesis
N = 14,789 mechanical
Reoperation for Valve Deterioration

Bioprosthesis vs Mechanical: survival

Re-do AVR: valve-in-valve TAVR?

Re-do AVR: expanding options for TAVR?

Which valve do you recommend?

A) Mechanical

B) Bioprosthetic

Do we have enough information to make a recommendation?

What does she want?

What are her concerns?

What are her values?
Shared Decision Making (SDM)

**Shared Decision Making: definition**

The process of using the best available evidence to support patients in making healthcare decisions based on the patient’s own values, preferences, and beliefs.

**Historical Considerations**

“the obedience of a patient to the prescriptions of his physician should be prompt and implicit. The patient should never permit his own crude opinions as to their fitness to influence his attention to them”

1847 Code of Medical Ethics (American Medical Association)

**Decision Making Types**

- Paternalistic
- Informed
- Shared
- Patient-Centricity
SHAREd Decision Making: Steps

1. Seek patient participation
2. Help explore treatment options
3. Assess patient values and preferences
4.达 to a decision with your patient together
5. Evaluate your patient’s decision

Why SDM?

SDM as Ethical Imperative

“The imperative for SDM must rest on the principles of good clinical practice, respecting patients’ right to know; that their informed preferences should be the basis for professional actions”


Perioperative Risk

“Healthcare is an intrinsically hazardous business”

Irwin M. Anesthesia 2014;69:1299

Anesthesia-related Mortality

87 studies
21.4 million anesthetics

Bainbridge D et al. Lancet; 2012;380:1075-81

Anesthesia-related Mortality

Bainbridge D et al. Lancet; 2012;380:1075-81

250
Anesthesia-related Mortality

What Risks to Consider

1) Anesthetic risk (deaths within 24 hours)
2) Surgical complications
3) Procedural (perioperative) risk
4) Loss of independence

Risk: problems/challenges

- No reciprocal consideration of the facts (surgeon or anesthesiologist)
- No one clinician has access to all the data
- Uncertainty:
  - Risk
  - Understanding
  - Communication

SDM and Communication

SDM: importance of communication

the single biggest problem with communication is the illusion that it has taken place

- George Bernard Shaw*

Roadblocks to Communication

<table>
<thead>
<tr>
<th>Physician</th>
<th>Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient time</td>
<td>Education level</td>
</tr>
<tr>
<td>Poor prognostic accuracy</td>
<td>Inadequate numeracy</td>
</tr>
<tr>
<td>Lack of confidence/skill in communication</td>
<td>Statistical literacy</td>
</tr>
</tbody>
</table>
Inadequate Numeracy

“inability to understand the meaning of numbers”

2% vs. 5%
which is higher risk?

Communicating Risk of Low Probability Events

Doctor: I’ve done this operation 100 times and have never seen a problem
Patient: Great, I’ve got nothing to worry about then

“Is the risk really 0%?”

How large does a study need to be to understand risk?

the rule of “three”

3/n

How large does a study need to be to understand risk?

I’ve done this type of case on 100 patients and have never seen a stroke

True risk = 3/n = 3/100 = up to 3%
Statistical Illiteracy

“Inability to understand and reason with statistics and data”
- probability
- Risk (absolute and relative)

Solutions to Improve Statistical Understanding

**Absolute Risk** rather than **Relative Risk**

“risk of DVT is reduced from 10% to 8%”
vs.
“risk of DVT is 20% less”

Communicating Risk: pictograph

Bilateral mammography reduces the risk of breast cancer mortality by 20%

“Doctor, 20% is a very large reduction, I think I should proceed”
Threats to SDM implementation

“we don’t have the right tools”

Warner DO et al. Anesthesiology 2015;123:18-28

• Improve decision quality
• Improves patient satisfaction
• Cost-effective (improves efficiency)
• Higher level conversation
• Increased confidence that patient understood
### SDM: future directions

- Barriers to implementing it
- Tools to facilitate it
- Promoting SDM policy and accountability
- Can it change use/misuse of procedures
- Can it reduce variability in use of resources
- Cost effectiveness?
- Optimize patient outcomes?

### Case Study: epilogue

- 55 year old female with severe aortic stenosis
- Active lifestyle (hiking, skiing)
- Her concerns:
  - will warfarin impact activities?
  - friend had SAH on warfarin
  - regular INR testing (lives remotely)
  - worried about repeat operation

---

When/if needed

![Image](example.com/image.png)
Pediatric Anesthesia Emergencies

Debnath Chatterjee, MD, FAAP
Megan A. Brockel, MD
Richard J. Ing, MBBCh, FCA (SA)

Disclosures
- None

Learning Objectives
Upon completion of the presentation, participants will be able to:

1. Explain the rationale for using honey or sucralfate following button battery ingestions in children.
2. Discuss the diagnosis and anesthetic management of a child with an airway foreign body.
3. Compare the risks and benefits of rapid sequence versus modified rapid sequence induction techniques in a pediatric patient with a full stomach presenting for emergency surgery.
4. Describe the pathophysiology and anesthetic considerations in blunt thoracic trauma in children and adolescents.

Scenario 2: FB in Esophagus
- A 2-year-old boy presents to ED with irritability, drooling, and refusing to eat. He was playing with his brother’s toy car remote earlier today.

Two Changes
- Larger diameter batteries (20-25 mm)
- Stronger lithium batteries
  - 3 volt (vs 1.5 volt)
  - Longer shelf life
  - Better stability at cool temperature
  - Lighter weight
Mechanism of Injury

It's not leakage!

- Entrapped BB
- Mucosa bridges + & - terminals
- Circuit completed
- Generation of hydroxide radicals
- Alkaline caustic injury

Higher the voltage, faster the process

- Visible injury within 15 minutes
- Serious injury as soon as 2 hours
- New vs. spent - 3.2 times higher risk

Orientation of Button Battery

Three Ns
- Negative
- Narrow
- Necrotic

Extent of Damage

- Size
- Duration
- Location
- Orientation
- Voltage
- Esophageal pathology

If a Child Swallows a Button Battery

Call the National Battery Ingestion Hotline 800-498-8666

Proceed immediately to hospital
Do not induce vomiting

1. Patient >12 months old
2. Suspected lithium battery
3. Ingested within 12 hours

10 mL of honey every 10 minutes
Max 6 doses

National Capital Poison Control Treatment Algorithm

Button Battery in esophagus

Goal: endoscopic removal within 2 hours of ingestion

Consider: Sucralfate 10 mL every 10 mins (max 3 doses)
After BB Removal

Inspect esophageal mucosa for extent of damage
Note orientation of negative pole

If no evidence of perforation, irrigate esophagus with **0.25% acetic acid** (50-150 mL)

Anesthetic Concerns

- Do not delay
- Bronchoscopy
- Trach perforation
- Rapid sequence induction
- Additional IV access
- Endotracheal intubation


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Anesthetic Implications of the New Guidelines for Button Battery Ingestion in Children

Monica A. Hoagland, MD; Richard J. Ing, MRCPCH, FCO(A.GL; Kris R. Jatana, MD, FACS, FAAP; Ian N. Jacobs, MD, MSc and Debrah Chatterjee, MD, FAAP

Anesthesia and Analgesia 2020

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Current management of button battery injuries

Rishabh Sethia MD; Hannah Gibbs BS; Ian N. Jacobs MD; James S. Reilly MD; Keith Rhodes BS; Kris R. Jatana MD

Laryngoscope Investigative Otolaryngology 2021
Summary
- Halo sign on CXR
- Negative/Narrow/Necrotic
- Emergent endoscopic removal
- Active surveillance after removal
- Recognition of sentinel bleed
- Mitigation with honey/sucralfate

Scenario 3: FB Aspiration
- A 1-year-old girl was sitting in her highchair eating chicken. As her father prepared to leave, she inspired deeply to cry and choked.

FB Aspiration
- A leading cause of death in children younger than 3 years old
- Peak age is 1-2 years
- In this age group, the most commonly retrieved AFBs are food products
- Older children are more likely to aspirate nonorganic products
- Retrieval is essential

Presenting Symptoms
- Vary depending on type of object, size, location, chronicity
- Coughing, wheezing, shortness of breath, fever, recurrent pneumonia
- Parents may or may not recall an event
Clinical Findings

- High index of suspicion and careful history and physical exam
- Nonspecific
  - Decreased breath sounds, wheezing, dullness to percussion, crackles
  - Initially abnormal exam may become normal
  - Lung auscultation may be clear
- 14-45% of patients with abnormal bronchoscopic exam had a normal physical exam preoperatively

Diagnostic Modalities

- Chest radiograph may help
  - May see hyperinflation or collapse or normal image
  - More definitive diagnosis when object is radiopaque
- Neck x-rays are commonly used to look for upper aerodigestive FBs
- Chest computed tomography (CT) can also be performed
- Diagnosis relies on bronchoscopy

Anesthetic Considerations

- History
  - Both related and unrelated to current illness
  - Previous anesthetic history
- Physical examination
  - Upper airway exam
  - Lung auscultation, work of breathing, distress
  - Vital signs and radiographic images
  - Consider preoperative nebulized bronchodilator
- Preoperative peripheral IV access is preferred
- Consider risks and benefits of preoperative anxiolysis
- Consider atropine or glycopyrrolate
- Induction can be inhaled or intravenous
  - Total intravenous anesthesia is preferred for maintenance
- Ventilation can be spontaneous or controlled
Anesthetic Considerations

Spontaneous
- Allows for continuous ventilation
- Must maintain adequate depth of anesthesia to obliterate airway reflexes yet maintain sufficient ventilatory function

Controlled
- Ability to provide optimal oxygenation and ventilation during the breathing phase
- Assurance of patient immobility
- Limited time before desaturation occurs
- Lack of assurance that positive-pressure ventilation will be successful
- Movement of the object distally


Anesthesia for Tracheal or Bronchial Foreign Body Removal in Children: An Analysis of Ninety-Four Cases
Ronald S. Litman, MD, L. Stephen, MD, and Igor Tugaj, MD
Department of Anesthesiology, University of Rochester School of Medicine, Rochester, New York

No increased incidence of adverse events related to either spontaneous or controlled ventilation
Summary

- FB aspiration is a potentially life-threatening event in young children.
- A detailed history and physical examination and a high index of clinical suspicion is critical to diagnose FB aspiration.
- Both spontaneous and controlled ventilation techniques can be used during bronchoscopy for removal of airway FBs.

Scenario 4: Full Stomach

- A 3-year-old boy presents with testicular torsion for emergent orchiopexy. He had apple juice one hour ago and a full breakfast six hours ago.
- New European guidelines favor a 6, 4, 3, 1 regimen
  - 6 h for solids
  - 4 h for formula and nonhuman milk
  - 3 h for breast milk
  - 1 h for clear fluids

Classic RSI vs. Modified RSI

- Classic RSI:
  - Positive pressure ventilation is strictly avoided.
  - Concern for gastric insufflation and pulmonary aspiration.
- Surveys have revealed that there are many clinical situations in which clinicians will opt for a modified RSI (mRSI) technique.

Modified RSI

► Low pressure, positive pressure ventilation after induction and prior to intubation
► Current (albeit limited) evidence supports the safety of mRSI to reduce hypoxemia without increasing the risk of aspiration


RSI vs. mRSI: Pyloromyotomy

► 296 neonates and infants
► 30% hypoxemia with RSI, 17% with mRSI
► AOR for hypoxemia for all patients 2.8
► In subgroup analysis of neonatal patients, AOR 6.5
► No indication that mRSI increased incidence of aspiration


Cricoid Pressure

► Controversial in both adult and pediatric practice
► Reliability and feasibility of CP questioned by pediatric anesthesiologists
  ► Force?
  ► Potential airway obstruction
  ► Associated technical problems
► Release or adjustment of the cricoid force is justified if pressure interferes with ventilation or intubation
► More than half have abandoned the maneuver


Scenario 4: Full Stomach

► A 3-year-old boy presents with testicular torsion for emergent orchiopexy. He had apple juice one hour ago and a full breakfast six hours ago.

Summary

► Preoperative fasting should be minimized in pediatric patients
► Current evidence supports the safety of mRSI
► Use of cricoid pressure in pediatric patients is controversial

Case 3
CASE 3.

15-year-old boy 75 kg
Motorcycle injury
Wearing a helmet and no LOC
Abrasions front lower abdomen
Fractured R humerus
Neck collar
Pale
Hb 9.8 g/dl
2 peripheral 20-gauge IVs

Anesthetic Approach

Prepare for a lengthy Anesthetic 3:45 am -10:45am.
Radiology Suite- cold, exposed extremities + thoracotomy / laparotomy
Airway considerations: Neck collar
Appropriate vascular access and invasive monitoring (Arterial line CVP)
Serial Hb/ ABG: Associated abdominal injury ongoing bleeding
Heparinization
Urinary catheter (Contrast enhanced diuresis + length of procedure)
Blood products / Air convection warmer
Antibiotic prophylaxis and redose

Within a week, he underwent bilateral carotid-subclavian bypass and a second TEVAR
Outline for Blunt Chest Trauma

- Discuss the mechanisms of injury
- Understand the pathophysiology
- Develop an approach to exclude cardiac injuries
- Anesthetic considerations

Epidemiology of Blunt Chest Trauma

- Blunt thoracic aortic injuries (BTAI)
- USA and Canada: 7500-8000 deaths annually
- 80% of patients die before hospital arrival
- 15-23% of those who reach hospital: Succumb to associated injuries within 24 hrs

Medial Aspect Aortic Isthmus
90% reaching hospital
80% autopsy fatal cases

False aneurysm 58%
Dissection 25%
Intimal tear 20%


B Pillar of Car Frames

Force of the B Pillar of the car frame impact has on the human body in car accidents determines the extent of injuries

Lateral impact motor vehicle accidents impart 46,051 to 313,502 Joules Energy to the chest.
Force > 1,000 mmHg
Intra-aortic pressure needed to rupture the aorta


Neschis DG NEJM 2008; 359:1708-16
Blunt diaphragmatic and thoracic aortic rupture: An emerging injury complex

In one study of 3,886 pts
69 (1.8%) had BDR
44 (1.1%) TAR
7/69 (10%): both injuries


Massive Blunt Chest Compression

Vascular Injuries to ascending/descending aorta, innominate artery

Heart End-diastole (Distended Ventricle) most
Susceptible time of high intraventricular cavity volume

Lungs Contusion, hemothorax, pneumothorax, laceration

Airway

Skeletal Fractures of sternum/thoracic vertebrae/ribs

Diagnostics: A clinical chameleon

Prepare for Rapidly Changing Clinical Condition

Individual Signs Symptoms Prompt Investigations

No Gold-Standard Diagnostic Test (ATLS Protocol)

Complex Cardiac Angina-like chest pain
Arrhythmia Dyspnea
Heart Murmurs Distended jugular veins
Hypotension Pneumothorax

Cardiac Tamponade

Diagnostic Approach

Physical examination

Chest X-Ray (14% may be normal)
Serial 12 lead ECG
Cardiac enzymes CK-MB and troponin
Cardiac echo

Chest X-Ray: rib, sternum, spine scapula, clavicle fracture
Widened mediastinum >8 cm
Tracheal deviation, NG tube R
Loss of aorto-pulmonary window

Contrast CT scan
Suspected Coronary Artery Injury: Coronary Angiogram

Treatment Options

1997, Kato and colleagues first reported endovascular stent grafting in 10 patients all alive at 15 months follow-up.

However not all ruptured aortas amenable to this therapy:
Ongoing bleeding, greater than 1 liter blood loss hemodynamically unstable patient: Surgery


Endovascular Repair

- Performed under sedation
- Local anesthesia
- Minimizes blood loss
- Well tolerated in high-risk pts
- Minimizes paraplegia
- Reduces mortality

Disadvantages

- Endoleak 14%
- Groin access vascular damage
- Stent migration
- Subclavian/ carotid occlusion

- We still don’t know the extent of medium and long-term durability of these stents
- High volume centers better outcomes

Heart Injuries

- Commotio Cordis Ventricular fibrillation with no structural damage
- 10 to 30 ms before the peak of the T wave
- Contusio Cordis Myocardium, valves, conduction system
- Isolated coronary injuries / Rupture / Dissection

Blunt Cardiac Injury: Spectrum

- Minor ECG or Enzyme Abnormality
- Complex Arrhythmia
- Coronary Artery thrombosis
- Free Wall Rupture
- Septal Rupture
- Cardiac Failure

Categories of Force Causing
- Myocardial Injury
- Direct
- Indirect
- Compressive
- Decelerate
- Blast

Physical Examination

- Thoracic trauma
- Hypotension
- Jugular venous distention
- Tachyypnea
- Wheezing/rhonchi
- Chest abrasion/ tenderness/ palpable crepitus/ fial chest
- Fractured clavicle/ sternum/ ribs
- Distant heart sounds/ tachycardia/ rub/ murmurs/ pulsus paradoxus
Diagnostics: Cardiac Enzymes

CK-MB not recommended:
Skeletal muscle, Lung, Stomach, Pancreas, Liver, Small intestine

Troponin I: Heart specific. If elevated > 2.0 ng/ml : Significant

Normal ECG and no rise in troponin at 8 hours:
No other injuries
Negative predictive value 100% : Discharge the patient

Velmahos GC et al. Normal electrocardiography and serum troponin I levels preclude the presence of clinically significant blunt cardiac injury. J Trauma. 2003 Jan;54(1):45-50

Diagnostics: Point of Care Echo

Up to 30% of BCI patients have abnormal cardiac echo
Pericardial effusion and tamponade are common

Focused Assessment with Sonography for Trauma (FAST)
Rapid screening 1.30 +/- 0.08 mins vs. X-ray; 14.18 +/- 0.91 mins, p < 0.0001
Indications: Heart failure, hypotension, arrhythmia


2 Patients: June and July 2013, ATV accidents

Case 1

35 kg 11-yr-old
LOD at scene brief CPB lacerated liver: Debridement at outside hospital under GA
Post op CT found large heart: Cardiac Echo
Troponin 38.9 (0-0.119 ng/ml)
CPB at CHOC
Tricuspid valve papillary muscle
Aneurysm repaired.
Home POD 5


Case 2

68 kg 13 yr old: No LOC
ECG wide complex tachycardia
Cardiac Echo: TR, MR, VSD.
CPB repair:
Received porcine TV, MV
VSD Patch necrotic septum.
3rd degree Heart block:
Epicardial pacemaker
Home POD 6 warfarin aspirin

Other Important Injuries

Tracheobronchial injuries
Usually 2 cm from carina (R)
Signs:
Dyspnea cough, stridor
Subcutaneous emphysema, hemoptysis
Pneumothorax.
May need rigid Bronch for ETT

Pulmonary injury
Hypoxia,
Intraparenchymal hemorrhage,
Atelectasis,
Acute respiratory distress syndrome (ARDS),
Mechanical Ventilation

Chest injuries

Hemothorax
Pneumothorax

Tension
Flail chest:
Three or more adjacent ribs are each fractured in two places, creating a floating segment and unstable chest wall.
The flail segment moves paradoxically with respiration.

Velmahos GC et al. Cardiac, and Gabriel Pollock MD,
Cedars – Sinai Medical Center, Los Angeles, CA
(December 13)
Summary

Blunt thoracic trauma in children can be very severe and the clinical picture can change rapidly. These injuries require considerable force applied to the thorax.

Additional injuries to lungs, trachea, and airways, spine and head injuries must always be considered.

Anesthetic planning requires attention to detail and potential for massive transfusion.
Ultrasound-Guided Regional Anesthesia Workshops
Kyle Marshall, MD
CRASH 2023

DISCLOSURE
- There are NO disclosures for any faculty participating.

Upper Extremity/Thoracic Workshop
- Superior Trunk/Interscalene
- Supra & Infraclavicular
- Selective Root/Forearm
  - Radial, Ulnar, Median
- Paravertebral
- PECs I&II/Serratus Anterior
- Erector Spinae

Thank you to our Vendors!!
- Mindray: Rob Kimbrough
- Sonosite: Kristi Howe

Thank you to our Models!!

BEER & WINE - END @ 1630!

I'm really just in it for the apres ski beers and outdoor hot tub.
Thursday, March 2nd
What’s the best blood pressure under anesthesia?

The implications of perioperative hypotension

Hilary P. Grocott, MD, FRCPC
Professor, Department of Anesthesiology, Pharmacology & Therapeutics
University of British Columbia

Outline

- Case presentation
- Blood pressure definition
- Hypotension: Incidence and Consequences
- Where do we go from here?
- What can we do to personalize blood pressure?

Hypotension: how common is it?

Incidence of Intraoperative Hypotension as a Function of the Chosen Definition

Literature Definitions Applied to a Retrospective Cohort Using Automated Data Collection

1) Systematic review to define hypotension
2) N= 15,509, consecutive patients undergoing non-cardiac surgery


48 definitions in the literature

Hypotension: how common is it?

12

N = 18, day surgery cases
24 hour blood pressure monitoring


Incidence

- Systolic > 90-100 mmHg 64-82%
- MAP > 90-100 mmHg 51-78%
- MAP > 20-30% mmHg 80-84%

Soo JCL et al. Anesthesiology 2007;107:213-20
Defining Hypotension: methodology

Saugel B et al. Anesthesiology 2019;131:74-83
“Keep the MAP within 20-30% of baseline”

What is baseline?

- Preop holding area
- Pre-induction
- In surgeon’s office/Preop clinic
- At home (awake vs. asleep)

Where does the “20%” come from?

Prospective observational trial
N = 278, vascular and GI surgery
“high risk” = DM, HTN

Intraoperative Blood Pressure
What Patterns Identify Patients at Risk for Postoperative Complications?

P < 0.05
N = 278
21% had MI or renal insufficiency

MAP < 20% baseline
(in-hospital pre-op BP)

What are the Consequences of “hypotension”?

Intraoperative Hypotension and Perioperative Ischemic Stroke after General Surgery
A Nested Case-control Study

N = 48,241
Non-cardiac, non-neurologic surgery
41 strokes = 0.09%

Adjusted Odds Ratio
MAP threshold from baseline (%)

1.01 OR per min MAP < 30%

Post-op Stroke
Mean blood pressures

MAP threshold from baseline (%)

Mean of pre-op clinic and all pre-induction BPs


Adjusted Odds Ratio
MAP threshold from baseline (%)

Mean of pre-op clinic and all pre-induction BPs


Hypotension and CV Outcome


Roshanov PS et al. Anesthesiology 2019;130:756

Roshanov PS et al. Anesthesiology 2019;130:756

Roshanov PS et al. Anesthesiology 2019;130:756


Mean Arterial Pressure (mmHg)

Secondary Outcomes
- 30-day mortality
- Acute MI
- Stroke
- Acute Kidney Injury
- Dialysis
- Delirium
- 90-day mortality
- Sepsis

Dual-center Retrospective Study
N = 316,717 non-cardiac surgery patients
Delirium within 30 days post-op

Can we individualize blood pressure/hypotension?

Is there a role for cerebral oximetry?

Cerebral Blood Flow Determinants
Critical closing pressure

Cerebral Blood Flow Determinants

Cerebral Blood Flow Determinants

Widely variable lower limit of autoregulation (LLA)

Cerebral Autoregulation

Defining the Lower Limit of Autoregulation

Blood Pressure Excursions Below the Cerebral Autoregulation Threshold During Cardiac Surgery are Associated With Acute Kidney Injury*

N = 410

observational study
cardiac surgery with CPB

Non-Cerebral Outcome: AKI
Non-Cerebral Outcome: AKI

Cerebral Oximetry

What does it measure?

What does it measure?

Oxygen Saturation of Hemoglobin Transiting Brain

Defining the Lower Limit of Autoregulation

Predicting the Limits of Cerebral Autoregulation During Cardiopulmonary Bypass

N = 410
Observational Study in Cardiac Surgery
Primary outcome: autoregulatory thresholds using cerebral oximetry

Brady K et al. Stroke 2010;41:1951-1956
Lower Limit of Autoregulation: optimizing blood pressure


Circulation

Autoregulation of cerebral blood flow in hypertensive patients: The modifying influence of prolonged antihypertensive treatment on the tolerance to acute, drug-induced hypotension

Strandgaard S. Circulation 1976;53:720-727

n = 13 hypertensive patients vs. n = 10 controls

CBF measurements/autoregulatory curves

BP where neurologic symptoms occurred

Strandgaard S. Circulation 1976;53:720-727

Lower Limit of Autoregulation: optimizing blood pressure


The risks of too high a blood pressure: delirium

Arterial pressure above the upper cerebral autoregulation limit during cardiopulmonary bypass is associated with postoperative delirium


N = 401, cardiac surgery

Oximetry > Clinical Predictors (HTN, age, stroke, DM)
The risks of too high a blood pressure: delirium

Magnitude/Duration
Above Autoregulatory
Threshold (mmHg x min/hr)

Adverse Clinical Outcomes Reduced with **Cerebral Oximetry**

Brain as the “index organ”

Organ Specific Hierarchy for Blood Flow
Organ Specific Hierarchy for Blood Flow

The brain as the “canary in a coal mine”?

What not just run everyone’s blood pressure higher?

The risks of too high a blood pressure

The risks of too high a blood pressure

The Goldilocks Principle
Summary

• Defining baseline blood pressure
• Blood pressure and outcome relationships
• Using cerebral monitoring to guide blood pressure management
• No single unifying optimal blood pressure
• Importance of individualizing care
Pushing Boundaries and Ancef: Anesthesia for Total Joints
Katelyn McLaughlin, MD
“Medicine Woman”

Learning Objectives
1) Identify appropriate patients for same day total joints
2) Describe the role of neuraxial vs general anesthesia for THA and TKAs
3) Recognize the benefit and limitations of peripheral nerve blocks and/or periarticular injections for analgesia in total joints

Disclosures
No disclosures

Prevalence of Total Joints
- In the US annually
  - ~790,000 Total Knee Arthroplasties (TKA)
  - ~450,000 Total Hip Arthroplasties (THA)
  - ~130,000 Total Shoulder Arthroplasties (TSA)
- Projections for 2030:
  - ~1.28 million primary TKA
  - ~635,000 primary THA

Same Day Discharge? That’s Unpossible!
- Dr. Benchmore wants to start same-day joints at their surgery center
- Wants to know which patients qualify for same-day discharge (SDD)

Hx of Discharge Timing for Total Joints

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Benefits of Same Day Discharge

- **Money**
  - THA: ~$4000-7000/case in hospital-based setting
  - If even only 30% were eligible for SDD, that’s ~$945 million per year for THA alone!
- **Similar outcomes compared to inpatient**
  - 2017 NSQIP data matched cohort studies between SDD and inpatient TJA: showed no difference in overall adverse events or readmission rates

Complications from SDD/Readmissions

- **8 studies evaluated, 7 retrospective and 1 prospective**
- 212,632 patients undergoing TKA
  - 6,607 were outpatient
  - 206,025 were inpatient
- Higher rate of complications in outpatient TKA (16.1% vs 10.5%, p=0.003)
- Complications: ranged from cutaneous rashes to heart attacks...
- Similar readmission rates between outpatient and inpatient (4.9% vs 5.9%)

Barriers to Discharge

- **Most common barriers:**
  - Patient concerns
  - Function
  - Pain
  - Orthostatic hypotension
  - Bleeding
  - Nausea/Vomiting
  - Urinary retention
- **Surveyed patients who underwent primary TKA from March-September 2017**
  - Prior knowledge of SDD
  - Perceived ability to undergo procedure as outpatient
  - Perceived risk and benefits to outpatient TKA
  - 72.1% believed they definitely or probably could not go home the same day
    - Pain control (54.8%)
    - Bathroom (39.6%)
    - Fear of falling (39.6%)
  - Perceived benefits of SDD
    - Avoidance of infection (57.3%)
    - Getting better sleep (46.9%)
    - Quieter recovery at home (42.7%)

Patient Selection for SDD Total Joints

- **Common Inclusion Criteria**
  - Patient willingness
  - Social support system, home care for 24 hrs/day for several days
  - Preoperative independent ambulation
  - Primary, unilateral joint replacement
Patient Selection for SDD Total Joints

- Common Exclusion Criteria
  - Age > 70-80 yrs
  - Significant cardiopulmonary disease
  - Cirrhosis
  - Bleeding disorders
  - CHF Stage 3-5
  - High TG
  - Poorly controlled DM
  - BMI > 40
  - Chronic pain/preoperative opioid use

Patient Selection for SDD Total Joints (RAPT)

- Risk Assessment and Prediction Tool (RAPT)
  - Developed in 2003
  - Attempts to predict patient’s postoperative rehabilitation needs via 6 items
  - Accurately predicts discharge destination after TKA 62-89%

Moore et al in 2020 assessed utility of RAPT score and found that it can be used but may be suboptimal for SDD when compared with the institutional variables they selected, including BMI and number of allergies.

Patient Selection for SDD Total Joints (OARA)

- Outpatient Arthroplasty Risk Assessment (OARA)
  - Developed to predict which patients could safely undergo SDD
  - Stratifies patients by 9 separate comorbidity areas
  - Assigns scores based on presence, severity, and medical optimization
  - Score < 80 = More precisely predicted SDD than ASA score or Charlson Comorbidity Index for TKA and TJA
  - Score < 110 = Effectively screened for SDD TSA with low rates of 90 day ED visits and readmissions

*** This assessment tool is provided by a third party company and requires subscription

** QUESTION **

- Dr. Curls has patient who wants to undergo SDD TKA
  - 65 y/o F
  - COPD on scheduled inhalers, no O2
  - BMI 36
  - Hx of DVT not on AC
  - Lives alone, no family support

- Is this patient eligible for SDD?
Developing Clinical Pathway for SDD

- Enhanced Recovery After Surgery (ERAS) Protocols
- Multidisciplinary Approach:
  - Patients and care givers
  - Surgeons
  - Anesthesia
  - PACU RNs
  - Physical Therapy

Perioperative Management for SDD

- Needs to Address Barriers to Discharge:
  - Pain control
  - Bleeding
  - Function
  - PONV
  - Urinary retention

Preoperative Management

- Counseling, patient education and expectation setting
- Optimize comorbidities, decrease risk factors
- Multimodal analgesia
- Peripheral Nerve Blocks - more later

Preoperative Management

- Counseling/Pre-Surgical Education
  - Require extensive preoperative education regarding postoperative expectations
  - Pain control
  - Physical Therapy
  - Home care (support 24 hrs/day for several days)
- Medical Optimization
  - Need for further workup prior to surgery
  - Clearance from PCP or Cardiologist
  - Smoking cessation
  - Controlling DM
  - Correct anemia (fex, B12)

Preoperative Management

- Multimodal Analgesia
  - NSAIDS
  - APAP
  - +/- Gabapentinoids
  - Anesthesiology 2020 - Systematic and meta-analysis
    - No additional analgesic benefit
    - No prevention of chronic pain
    - Decreased PDH
    - Greater risk of adverse events (sedation, dizziness, visual disturbances)
  - Peripheral Nerve Blocks

Intraoperative Management

- Medications - antifibrinolytics
  - Neuraxial vs General
Tranexamic Acid (TXA)

- Antifibrinolytic agent
- Binds to plasminogen and prevents fibrin degradation
- Can be given PO, IV, or topically
- Used to reduce overall blood loss
- Typically given as a bolus prior to incision in TJA

Complications from TXA:
- Venous thromboembolism
- Renal failure
- MI, ischemic stroke, TIA
- Confirmed to be non-anticoagulant

TXA: Anesthesiology 2021 (Poeran et al)

- Retrospective cohort study of TKA and THA from 2013-2016
- Evaluated TXA administration in patients with 'high-risk' comorbidities
  Group 1: History of VTE, MI, or ischemic stroke
  Group 2: Renal disease
  Group 3: Atrial fibrillation
- TXA use was associated with decreased blood transfusion in all 3 groups with no increased risk of new-onset composite complications (VTE, MI, ischemic stroke)

"If they can't receive TXA, they are probably too sick to undergo this surgery"
Neuraxial Local Anesthetic Choice

- Ambulation at 3-3.5 hrs post injection:
  - 70% of Mepi (35 of 50)
  - 37.7% of Hyper Bupi (20 of 53)
  - 17.6% of Iso Bupi (9 of 51)
- Pain and Opioid consumption higher in Mepi group but only in early postoperative period
- Same Day Discharge:
  - 46% of Mepi
  - 24.5% of Hyper Bupi
  - 21.5% of Iso Bupi
- Transient Neurological Symptoms, Urinary Retention, Hypotension: no difference

Postoperative Management

- Early Ambulation
  - FAD2 Discharge Criteria
  - Physical Therapy/physiotherapy before discharge
  - Walk on and down stairs
  - Demonstrated understanding of home equipment
  - Perform bathroom transfers
  - Stand from a supine position in bed
  - No incontinence of stool or urine
  - Clothing, shoes, socks, etc.

Postoperative Management

- Postoperative Urinary Retention (POUR)
  - Incidence ranges from 5.5–46.3%
  - POUR increases rates of UTIs, can increase risk of PJI
- Risk factors:
  - Age, sex, certain comorbidities (ex BPH, renal disease)
  - IT morphine
  - Bupi > Mepi
  - IV fluids (>1000 mL)
  - Urinary catheter placement

Prosthetic Joint Infection (PJI)

- Incidence:
  - ~0.5% within first year after THA/TKA
  - ~1.4% within first ten years after THA/TKA
  - PJI most common cause of TKA failure
  - Study of 11,134 THA, the incidence of revision at 15 years was 4.5% with 2.9% of the 4.5% done for PJI
  - PJI is the third most common indication for revision THA
  - Risk of PJI following TSA is less than both TKA and THA
Infections in TJA

Risk Factors
- Patient Risk Factors:
  - Rheumatoid Arthritis
  - Immunosuppression
  - DM, CKD
  - Smoking
  - Obesity
  - Medications (MTX, Prednisone, TNF-alpha inhibitors etc)
- Surgical Risk Factors:
  - Duration of surgery
  - Location
  - Blood transfusion

Prevention
- Antibiotic prophylaxis
- Pre-incision Cefazolin
- Treat hyperglycemia (glucose <200)
- Decreased OR traffic
- Surgical hoods

Peripheral Nerve Blocks for TJA
- Considered ‘Gold Standard’ for TSA

Peripheral Nerve Blocks for TSA
- Interscalene Nerve Block
- Superior Trunk Nerve Block
Peripheral Nerve Blocks for THA

PENG Block

Erector Spinae Plane Block (ESP)

Fascia Iliaca Nerve Block

Peripheral Nerve Blocks for TKA

Adductor Canal vs Femoral Nerve Block for TKA
Infiltration between the Popliteal Artery and Capsule of the Knee (IPACK)

IPACK Block

Periarticular Injection

- Direct periarticular injection of the operative field
- Numerous small injections of the posterior capsule, periosteum, arthrotomy, and subcutaneous tissues for TKA, and pericapsular tissues for THA
- Often involves a "cocktail"
  - Local Anesthetic
  - Ketorolac
  - Epinephrine
  - Clonidine
  - Opioid

Periarticular Injection


Periarticular Injection

Periarticular Injection

Periarticular Injection

Does Periarticular Injection reduce pain after knee arthroplasty among patients receiving peripheral nerve blocks?

Question

Which of the following nerve blocks can cause footdrop?
A) IPACK
B) Adductor Canal
C) Fascia Iliaca
D) Superior Trunk

“I don’t like Adductor Canal blocks because I don’t want the patients to have foot drop” - someone who scored highly on Step 1

Summary

- Identify appropriate patients for SDD
- Counsel patients thoroughly regarding postop expectations
- Multimodal analgesia
- TIA for almost everyone
- Hemostatic and general are both safe, Hept + Buip
- Early ambulation
- Cefazolin
- Nerve blocks and PAI are good adjuncts

Thank You
Cancer Outcomes and Anesthetic Management: An Introduction
Roland Flores, MD
University of Colorado Anschutz Medical Campus
@TheRolandFlores

Objectives

• To review (very briefly!) the proposed mechanisms of cancer metastasis and recurrence and the immune system’s role in limiting cancer spread
• To illustrate the effects of the perioperative period on these mechanisms and defenses
• To introduce the implications of anesthetic management choices in cancer outcomes

Anesthesiologists: The Physicians of the Perioperative Period

Metastasis, in a nutshell: The seed and soil hypothesis

Why is surgery so problematic for cancer recurrence?

- Handling and disruption of the tumor may release cells into circulation
- Removal of primary tumor may lead to decrease of circulating anti-angiogenic factors
- Increase in local and systemic release of growth factors after surgery
- And probably most importantly…perioperative Immunosuppression

The immune system and cancer

<table>
<thead>
<tr>
<th>Powers for good</th>
<th>Forces of evil</th>
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<tbody>
<tr>
<td>CD4 Th1 cells</td>
<td>CD4 Th2 cells</td>
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<tr>
<td>IL-2</td>
<td>IL-4</td>
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<tr>
<td>IL-12</td>
<td>IL-10</td>
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<td>IFN-γ</td>
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<tr>
<td>CD8+ cytotoxic lymphocytes</td>
<td>CD4 Th17 cells</td>
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<tr>
<td>Natural killer cells</td>
<td>CD4 regulatory T (T-reg) cells</td>
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<tr>
<td></td>
<td>Myeloid-derived suppressor cells (MDSCs)</td>
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<td>Tumor-associated Macrophages</td>
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</table>
How does surgery affect this balance?

- Most significant factor: The surgical stress response
  - Sympathetic nervous system activation resulting in catecholamine release
    - Interferes with NK activity & increases IL-6 levels
    - Shifts the immune response to Th2 (immunosuppressor) predominance
  - Catecholamines promote angiogenesis
  - These actions are primarily via β2 receptors.
  - Hypothalamic-pituitary-adrenal axis activation
    - Increased ACTH production leads to increased glucocorticoid release
    - Glucocorticoids kill immature T cells and shift the immune response to favor Th2

How does surgery affect this balance?

- Anesthetic consequences
  - Hypotension
  - Hypothermia
  - Transfusion
  - Medication effects
  - Immunosuppression response is biochemically evident within hours of surgery and lasts for several days, with a peak around the third postoperative day.

Inhaled Agents vs. TIVA

<table>
<thead>
<tr>
<th>Drug</th>
<th>Adverse effect</th>
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<tbody>
<tr>
<td>Volatile agents</td>
<td>Inhibit NK cell cytotoxicity</td>
</tr>
<tr>
<td></td>
<td>Reduce NK cell number</td>
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<tr>
<td>Propofol</td>
<td>Reduces NK cell number</td>
</tr>
<tr>
<td>Thioental</td>
<td>Increases number of viable tumor cells in animal models</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Reduces NK cell number and activity</td>
</tr>
<tr>
<td></td>
<td>Increases number of viable tumor cells in animal models</td>
</tr>
<tr>
<td>Midazolam</td>
<td>Reduces IL-8 levels</td>
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Surgery is a bad thing...

How can we ameliorate these negative influences and give our patients the best chances for survival?

- Anesthesia technique?
- Analgesic technique?
- Blood transfusion management
- Are the cardiologists right? SHOULD we avoid hypotension and hypoxemia? The answer may SHOCK you.
Inhaled agents

- Inhaled agents are associated with pro-cancer effects
- Mechanisms are unclear but clearly complex and multifactorial, and include immunomodulation and effect on tumor stem cells
- Halothane, isoflurane, and sevoflurane have all been long demonstrated to suppress NK cell activity and lymphocyte function, but recent research has revealed much more wide-ranging and complex effects on the immune system

Direct immunomodulating effects of volatile anesthetics

- Halothane, isoflurane, and sevoflurane have all been long demonstrated to suppress NK cell activity and lymphocyte function, but recent research has revealed much more wide-ranging and complex effects on the immune system

Immunomodulating pathways

- Exposure to isoflurane has been shown to increase the resistance of colon cancer cells to the effects of anticancer drugs
- Isoflurane exposure increases melanoma metastasis in mice
- Isoflurane has been demonstrated to enhance the malignancy of head and neck squamous cell carcinoma cell lines
- Isoflurane enhances ovarian and renal cell tumor growth and malignant potential
- Nitrous oxide is associated with acceleration of lung and liver metastasis in animal models
- Sevoflurane has been demonstrated to promote the proliferation of glioma stem cells

Sevoflurane and Glioma Stem Cells

- Does suppress NK activity in vitro, BUT...
- Probably does not do so significantly in vivo at clinically relevant concentrations (whereas ketamine and thiopental appear to be significant)
- Mouse studies suggest that propofol increases CTL activity against tumor cells
- Increases Th1/Th2 ratio, which is good
- Has some COX-2 inhibitory activity, which is also good
- In humans, propofol/remifentanil anesthesia was associated with increased IL-10 activity in patients undergoing open cholecystectomy
- In patients undergoing supratentorial tumor excision, patients has less immunosuppression under propofol anesthesia compared to isoflurane.

Propofol: An anesthesiologist’s friend?
Is TIVA superior to inhaled agents?

Very possibly.

Wigmore et al.

- Retrospective cohort study of more than 7,000 patients who had general anesthesia for cancer surgery over 3 year period
- Patients who received both techniques, were under 16 yo, or who were having emergent surgery were excluded
- 3316 patients received inhalational agents; 3714 received propofol/remifentanil TIVAs
- Statistical analysis used 2607 matched pairs

Overall Group and Matched Group

<table>
<thead>
<tr>
<th>Overall Group</th>
<th>Matched Group</th>
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<tr>
<td>TIVA/PVB</td>
<td>Volatile &amp; Opioids</td>
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Overall survival

Recurrence of breast cancer after regional or general anaesthesia: a randomised controlled trial

TIVA/PVB vs Volatile & Opioids

Comparison of recurrence rates for patients who received either TIVA/PVB or volatile agents.
Role of pain in cancer recurrence

Acute pain activates the stress response via the SNS and the HPA axis; these responses can exacerbate or maintain pain. This stress response can decrease NK cells and their activity.

Pain may have additional immunosuppressive effects, possibly mediated via endogenous opioids' effect on the \( \mu \) receptor.

Pain management and tumor growth

Morphine has been shown to influence immunomodulation & immune cell function:

- Negative dose dependent action on NK cytotoxicity
- Inhibits IL-2 and CD8+ and CD4+ cells
- Synthetic opioids appear to have less immunomodulating effects than morphine

Opioids

- Morphine may be problematic:
  - Inhibits spontaneous and cytokine-enhanced NK cell cytotoxicity; appears to be mediated by the \( \mu \) opioid receptor
  - Animal data suggest that morphine is prosurviving and promotes breast cancer and non-small cell lung tumor growth
  - However, a few studies have shown protective effects

- Fentanyl and possibly other synthetic opioids have similarly contradictory data:
  - Doesn’t bind to \( \mu \); actually appears to increase NK activity
  - Several studies show no significant immunosuppressive effects
  - On the other hand, rat studies again show tumor-promoting effects
Are All Opioids Bad?

- Not Necessarily ...
- "Tramadol use is associated with enhanced postoperative outcomes in breast cancer patients: a retrospective clinical study with in vitro confirmation"
- Enhanced NK activity after uterine cancer surgery

Neuraxial or regional anesthesia

Overall and recurrence-free survival

Colon cancer and epidurals

Survival Benefit

- Five-year survival was 61% in the epidural group and 56% in the traditional pain management group.
- Median survival was 7.34 years in the epidural group versus 6.09 years.

Adjusted data

<table>
<thead>
<tr>
<th>Table 2. Association between Epidural Use and All-cause Mortality</th>
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<tr>
<td>Models</td>
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<td>Model 1A</td>
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<td>Model 2A</td>
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<td>Model 2B</td>
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<td>Model 2C</td>
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Peripheral nerve blocks

- Exadaktylos and colleagues retrospectively studied 129 consecutive patients who underwent mastectomy and axillary clearance in an Irish hospital.
- 50 patients received paravertebral blocks in addition to general anesthesia, while the remaining 79 received general anesthesia and postoperative morphine analgesia.
- No significant difference between the groups in terms of patient factors, surgical details, tumor presentation, or prognostic factors.
- The median pain scores were less in the paravertebral group.

Paravertebral block for breast cancer surgery

Other modalities

- Local anesthetics: Possible tumor inhibiting effect via direct effects on EGF receptors or via inhibition of the voltage-gated sodium channels on cancer cells.
- COX-2 Inhibitors: Promising in animal models.
  - COX is over-expressed in many cancers.
  - Prostaglandins inhibit NK cytotoxicity.
  - Long-term use is associated with reduced incidence of cancer.

How about toradol?

- If COX-2 blockers are promising, what about our intraoperative NSAIDs?
- Somewhat new area of interest.
- Theory: May reduce tumor adhesion to endothelial cells and invasive potential. But mainly...
Does Ketorolac Increase Disease Free Survival in High Risk Breast Cancer?

Blood transfusions
- More than 200 studies have described an association between perioperative blood transfusion and increased risk of cancer recurrence.
- The implications of transfusion have been investigated for many cancer types, including colorectal, bladder, breast, head and neck, endometrial, esophageal, hepatocellular, prostate, and kidney.
- Why? Same story -- immunosuppression.

Blood transfusions and immunosuppression
- Historical fun fact: Perioperative transfusions were observed to enhance the survival of transplanted kidneys, thus tipping us off that transfusion might suppress the immune system.
- Transfusion-related Immunomodulation (TRIM).
- Mechanism is not totally clear.
  - Leukocyte mediated? Probably not, since removal of white cells doesn’t fix it.
  - Seems to involve induction of Treg cells, which suppress CD4 and CD8 cells.
  - May also be related to arginine depletion, which suppresses T-cell function.

Bladder cancer
- Linder et al recently published a retrospective study of 2060 patients undergoing radical cystectomy for bladder cancer at the Mayo Clinic.
- 62% (1279 patients) received transfusion with a median of 2 transfused units.
- Results were complicated, but showed an increased risk of both recurrence and mortality for transfused patients.

Outcomes
Bladder cancer

Multivariate Analysis

Cochrane Review: Transfusions and colorectal cancer

- 2006 meta analysis of 36 studies with a total of over 12,000 patients undergoing curative resection of colorectal cancer
- Twenty-three of the studies showed a detrimental effect of perioperative transfusion on cancer recurrence
- Pooled data estimated that transfusion yielded an overall odds ratio of 1.42 (95% CI 1.2-1.67)
- Effect appeared to be dose-related; patients receiving 3 or more units had double the risk of recurrence compared to patients receiving 1 or 2 units
- Timing of the transfusion (pre-, intra-, or post-operative) did not seem to make a significant difference

Hypotension and hypoxemia: Shockingly not helpful in cancer patients

Okay, but why particularly?

Hypotension study

- 1991 retrospective study of 116 patients who had undergone complete hepatic resection for colorectal metastasis
- "Baseline" MAP was defined as the MAP at surgery start.
- Hypotension was defined as any value less than 80% of baseline MAP
- Of all the variables analyzed, the single most predictive factor for future recurrence was the number of hypotensive episodes during surgery. (p = <0.00001)
Hypotensive episodes and recurrence-free survival

2012 retrospective study of 53 patients who had undergone complete resection of esophageal cancer
- Defined hypotension as SBP<70 for all patients
- Found significant difference in 1-year cancer-specific survival for patients who had one or more hypotensive episodes (p=0.0002)

Esophageal cancer and hypotension

2012 retrospective study of 53 patients who had undergone complete resection of esophageal cancer
- Defined hypotension as SBP<70 for all patients
- Found significant difference in 1-year cancer-specific survival for patients who had one or more hypotensive episodes (p=0.0002)

Beta blockers and Cancer

- 2018 Retrospective Meta-analysis of over 300K patients
- The administration of BB was not associated with increased overall survival, all cause mortality, disease free survival, progression free survival, recurrence free survival
- Associated with improved survival in patients with ovarian CA, pancreatic CA, and melanoma

Conclusions

- Cancer is complicated. Anesthesiology is complicated. The interplay between the two is significant, but in general incompletely understood. Ongoing research is critical
- The perioperative period is a critical time for cancer patients due to the attendant immunosuppression
- Many of our anesthetic drugs, particularly volatile agents and opioids, likely significantly contribute to this immunosuppression
- Pain is bad. Treat it aggressively, but consider avoiding opioids (particularly morphine) if possible. Consider NSAIDs and lidocaine
- Blood transfusions should be avoided when possible
- Hypoxia and hypotension continue to be bad ideas.
- Beta blockers MAY be helpful in certain subgroups

Disclosures

- I have no financial conflict of interest in relation to this program/presentation.
- I am a member of the educational board of the Society for Head and Neck Anesthesia (SHANA).
- I am a co-author on the “Expert consensus statement on the perioperative management of adult patients undergoing head and neck surgery and free tissue reconstruction from the Society for Head and Neck Anesthesia,” which was published in Anesthesia & Analgesia.
You may have been taught differently or seen and done things another way before. These patients and problems often require adaptable, individualized plans, but a baseline plan for regular and/or emergency management can be established.

Objectives

Following this lecture, a participant should be able to:

- Describe the preoperative assessment and preparation for patients undergoing head & neck surgery.
- Outline anesthetic management goals in patients undergoing head and neck flap reconstructive surgery.
- Define the steps necessary to evaluate a tracheostomy and emergently manage it.
- Outline the preparation and performance of an awake fiberoptic intubation.

Head & Neck Cancer Statistics

- In the United States, the incidence of oral and pharyngeal cancers is over 54,000 cases per year, resulting in over 11,000 yearly deaths.
- Although smoking and alcohol consumption are traditional risk factors for head and neck cancer, they are declining in many countries.
- There is a steady increase in diagnoses of human papillomavirus (HPV)-related cancers, frequently affecting the oropharynx.

Head & Neck Cancer Survival

- The prognostic and survival of squamous cell carcinoma of the head and neck depends on, among many other variables, the stage at presentation, the site of involvement, and the human papillomavirus status.
- The 5-year overall survival in patients with stage I-II disease is typically 70-90%.
- Patients with stage III IV disease typically have a poorer prognosis; for example, patients with locoregionally advanced laryngeal carcinoma have an approximate survival of 40% at 5 years.
Preoperative Evaluation

- It is imperative that you discuss the specific pathology and surgical plan with the surgeon before starting these procedures.
- You will be sharing the airway at times which requires constant communication.
- Ensure CT scan and preop nasal endoscopy have been reviewed to anticipate degree and extent of tumor burden or airway involvement.

Image from WebMD Reference

Preoperative Endoscopic Airway Evaluation (PEAE)

- PEAE extends the airway exam beyond the naked eye and available lines of sight.
- Can change the clinical approach to airway management in high-risk patients.
- In particular, large lesions occupying the hypopharynx may herald difficult or impossible SGA placement.

Image from Medscape Reference

Preoperative Airway Ultrasound

- Gaining interest in recent years.
- Useful for:
  - Airway size and prediction of endotracheal tube.
  - Prediction of difficult laryngoscopy.
  - Airway device placement and depth.
  - Prediction of post-extubation stridor.
  - Emergent surgical airway placement.
  - Evaluation of airway anatomy.


Anesthetic Management Goals in Free Flap Surgery

Vaspressors

- Though opinion is often against vaspressors, there is little to no evidence that their use worsens flap outcomes and growing evidence demonstrates that they may indeed improve outcomes.
- From the SHANA expert consensus statement in 2021: “Vaspressors can be used to optimize the hemodynamic management of this patient population after identifying and correcting other hypotension contributing factors, such as hypovolemia, deep anesthesia, anemia, and electrolyte abnormalities.”


Fluid Management

- Judicious use of intravenous fluids (crystalloids or colloids) and avoidance of hypovolemia and hypotension are important to maintain homeostasis and to avoid flap ischemia.
- Fluid overload may increase the risk of free flap failure in this patient population.
- There is a paucity of data regarding whether the specific type of fluid is beneficial/harmful in free flap surgery.
Blood Transfusion Thresholds

- Goal is to maintain adequate perfusion to end organs as well as perfusion of grafts.
- A reasonable target is a hematocrit of 25-30 secondary to both commonly associated comorbidities and graft considerations.
- Avoidance of hyperviscosity to prevent graft thrombosis also renders transfusions for a hematocrit >30 unnecessary.


Anesthetic Type

- A balanced anesthetic method is preferred, though there is little evidence regarding whether total intravenous or inhalational maintenance is superior.
- Multimodal pain management strategies may enhance pain control during the perioperative period.
- Currently little role for regional anesthetics.


Lines/Monitors

- Optimal monitoring of this patient population includes the use of standard ASA monitors; core temperature monitor, insertion of a Foley catheter to monitor urine output; the placement of an arterial line to monitor hemodynamic parameters, and the monitoring of fluid status metrics such as systolic pressure variation.
- Central Access is rarely necessary in the presence of multiple well functioning peripheral IVs. If one is necessary, the internal jugular should be avoided.


Tracheostomy Management

“What do I do with this thing when it fails at 3 in the morning?”

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

Mark Twain


305
Where to go for Help

National Tracheostomy Safety Project

www.tracheostomy.org.uk

Tracheostomy

- Surgically created hole into trachea
- Temporary or permanent
- Can make airway safer during future treatment
- For medically complex patients, may be permanent

Laryngectomy

- Laryngectomy is the removal of the larynx and separation of the airway from the mouth, nose and esophagus.
- In a total laryngectomy, the entire larynx is removed (including the vocal folds, hyoid bone, epiglottis, thyroid and cricoid cartilage and a few tracheal cartilage rings).

Tracheostomy Basics

- Different types of tubes available can be confusing.
- In general defined by:
  - presence / absence of cuff
  - presence / absence of inner cannula
  - presence / absence of a hole (fenestration)
- Most modern tubes made from synthetic material
- Cuffed tubes used to seal airway to provide positive pressure ventilation or prevent aspiration.
- Uncuffed tubes tend to be used in chronic tracheostomy patients with effective cough reflexes.

Tracheostomy Tube Components

Image Courtesy of Memorial Sloan-Kettering Hospital

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Elective Tracheostomy Management

- Why was the tracheostomy placed?
- When was it placed?
- What is the trach type and size? (availability of emergency equipment)

Indications for Tracheostomy

- Acute or chronic upper airway obstruction (Ludwig's angina, obstructive sleep apnea)
- Risk of chronic aspiration (stroke patients)
- Chronic respiratory failure (ICU patients)
- Retention of bronchial secretions (weak cough, CF)
- Elective during surgical procedures of head and neck

Relative Contraindications:
- Uncorrected coagulopathy (plt <50,000, INR >1.5)
- Presence of laryngeal cancer
- Hemodynamic instability

Aren't Tracheostomies Safe?

- Klemm found 352 tracheostomy related deaths in a review of 25,056 tracheostomies performed in 21 countries, a rate of fatal events in 1.4%.
- Cramer et al. found 623 tracheostomy related deaths over a ten-year period in the United States.

- Cramer et al. also found that these deaths were significantly more common in children (10x more common!) African-American children or adults, and Hispanic adults.
- Additionally, more likely to occur on the weekend.
- Patient advanced education (bachelor’s, master’s, etc.) found to be protective.
High-Risk Patients

- Children, especially newborns and infants
- Smokers
- Alcohol abusers
- Diabetics
- Immunocompromised patients
- Persons with chronic diseases or respiratory infections
- Persons taking steroids or cortisone


Available from the National Tracheostomy Safety Project
https://www.tracheostomy.org.uk/

Emergency Tracheostomy Management

For Podcast Listeners

Anesthesia and Critical Care Reviews and Commentary (ACCRac)

Episode 111: Tracheostomies, Cricothyrotomies and ENT surgery with Dr. Zandy Hillel

“In the event of an emergency, your closest exit may be behind you.”

Awake Intubation

Laura Duggan MD, Associate Professor of Anesthesiology, the University of Ottawa
Awake Intubation

An awake intubation should be performed when there is possibility by history or exam that the airway may be difficult to intubate and/or ventilate.

Associated conditions include:
- Head and neck cancers
- Laryngeal and tracheal pathologies
- Head & neck radiation therapy
- Trauma
- Congenital syndromes
- Limited mouth opening.

Review of clinical nasal endoscopies, head/neck CT scans, and discussion with surgeons are invaluable.

Awake Intubation

Patient Pre-Procedure Preparation

1. Decision for Awake Flexible Endoscopic Intubation
2. IV Glycopyrrolate 0.4 to 0.6 mg early. At least 30 minutes before topicalization
3. Prepare Intubation Cart
4. Lidocaine 4% nebulizer
5. Sedation choice upon entering room (I usually prefer small doses of Midazolam)

“Give me six hours to chop down a tree and I will spend the first four sharpening my axe.”
- Abraham Lincoln

Awake Intubation

Intraoperative Procedure

1. Remifentanil 0.05 mcg/kg/min titrated to mild sedation
2. Madjic 4% lidocaine until no gag (atomizer)
3. Use small Parker (6.0-7.0) ETT
4. Advance scope via supraglottic structures
5. Pass epidural cath through cords and spray 4% lidocaine
6. With view of carina pass ETT into trachea
7. Confirm end tidal CO2
8. Induce with propofol (0.5 mg/kg)

Difficult Airway Society Guidelines

Great Sources of Information

Discussion/Questions?
As to methods, there may be a million and then some, but principles are few. The man who grasps principles can successfully select his own methods.
Neuroanesthesia Panel:
Adverse Events in Spine and Intracranial Surgery
Julio C. Montejano, MD
Assistant Professor of Anesthesiology
Department of Anesthesiology
University of Colorado

Claudia F. Clavijo, MD
Associate Professor
Department of Anesthesiology
University of Colorado

Anthony M. Oliva, MD, PhD
Associate Professor
Department of Anesthesiology
University of Colorado

No conflict of interest to disclose

Intraoperative Emergencies: Spine Surgery
Julio Montejano, MD
Neuroanesthesiology Assistant Professor
University of Colorado School of Medicine

Learning Objectives

- Become familiar with common spine surgery procedures and basic terminology
- Become familiar with basic anesthetic management of spine surgery ranging from simple procedures to more complex
- Become familiar with basic preoperative assessment metrics for the spine surgical patient
- Review basic spine anatomy
- Review potential complications ranging from common to rare and catastrophic
- Discuss basic management and the evidence behind those strategies

Outline

- So this is your first spine...?
- Types of Spine Surgery
- Common approaches
- Preop Risk assessment: Can your Patient Handle it?
- Anesthesia agent choice: Tips and Tricks
- Injury to Spinal Cord
- Injury to Peripheral nerves
- Vascular Injury
- Pulmonary Complications: The lungs are closer than you think
- Emboli: Clots, Fat, Cement and Air
- Post-Operative Vision Loss
- Incidental Dural Tear
- Recurrent Laryngeal Nerve Injury
- Summary
- Questions

So this is your first Spine Surgery...?

- Become familiar with the lingo
- Can your Patient Handle it? (see Next Slides)
- What position will you be in? Will you be in multiple positions?
- How many levels?
- What are the planned corrections?
- What is the expected blood loss?
- Is this a primary spine, a redo, a redo-redo?
- Is there infected Hardware?
- Is there a tumor involved?
- Will there be neuromonitoring and what type?
- Discuss exit strategies and possibility of staging

No conflict of interest to disclose
Types of Spine Surgery and Common Procedures

- Spinal decompression and fusion
- Microdiscectomy
- Artificial Disc Replacement
- Laminectomy
- Vertebroplasty
- Foraminotomy
- Smith-Peterson Osteotomies
- Pedicle Subtraction Osteotomies
- PLIF/ALIF/TLIF/QLIF/OLIF (Really?!)
- Corpectomy

Common Approaches

- Posterior
- Anterior
  - Lumbar often requires a transabdominal approach
  - Thoracic often requires cooperation with a thoracic surgeon and intubation with a DLT for lung isolation
- Lateral
- Combination of all or any of the above
- Arms out or tucked
- Head in pins or prone view
- Wilson Frame vs Axis

Preoperative Risk Assessment: Can your Patient Handle it?

- Physical exam, review of medical history, risk assessment, indicated laboratory testing and imaging
- High risk surgeries will need preoperative testing
- Hemoglobin, platelet count, electrolyte panel including glucose, coagulation studies and a type and screen
- Screening for osteoporosis and nutritional testing
- Other testing as indicated per patient history
- Fitness assessment
- Expected Blood loss and volume shifts
- Positioning concerns
- Airway Management
- Vascular Access

Anesthetic Choices: Tips and Tricks

- Before choosing an anesthetic plan identify the types of IONM if any that will be used
- Institutional policies and protocols if any
- Start with a propofol infusion and add agents from there:
  - Narcotics: neutral effect on signals
  - Ketamine: enhance signals
  - Lidocaine: likely detrimental effect on signals
  - Dexmedetomidine: likely detrimental effect on signals
  - Volatile Anesthetics: negative effects but N2O/ISEPs
  - Paralytics: negative effects on AEPs and DENG

What Could Possibly go Wrong?
Intraoperative Spinal Cord Injury

- Most often mechanical (direct injury, stretching or crushing)
- Can also be ischemic due to vascular injury or due to hemodynamic changes
- Utilization of IONM to monitor in real time and detect potential injury
- Combination of SSEPs, MEPs, EMG and tEMG give highest sensitivity and specificity to identify injury during large or complex manipulations of the spinal column
- If changes in signals are detected, care must be taken to identify source
- Isolate global vs local changes

Intraoperative Spinal Nerve and Peripheral Nerve Injury

- Spinal roots are also at risk even during lumbar/sacral procedures
- IONM can be used to detect injury to spinal nerves and peripheral nerves due to positioning (most commonly brachial plexus)
- Patients sensitive to hemodynamic shifts can also experience ischemic injury to spinal and peripheral nerves
- Signal changes can be cortical or sub-cortical

What can you do?

- Alert the surgeon immediately
- Multidisciplinary discussion between surgeons, anesthetists and IONM teams
- Reverse last surgical intervention if possible
- Increase blood flow
- MAP 85-90 little evidence to push past 95
- Decrease inflammation and edema
- High-dose steroids – mixed evidence
- Retractor tape
- Reposition arms

Vascular Complications

- Aortic injury
- Other major vessel injury
- Can result in massive blood loss
- Adequate vascular access should be planned and obtained ahead of time due to limitations in positioning
- Appropriate blood products should be available
- Appropriate consult services should be available for high-risk procedures

Case

- 42yoF w/ h/o metastatic RCC with lung and spine mets p/w progressive LLE weakness in setting of known spinal canal stenosis p/f L3-L5 PSF and L3-L5 RFA w/ L4 lateral corpectomy

Significant Events

- PSF, Corpectomy and RFA performed, patient repositioned from prone to right lateral decubitus
- No significant bleeding noted per surgeon report following each of the above interventions
- Acute hypotension
- While preparing to close, venous bleeding was noted and thought to be a perforator to common iliac vein
- Bleeding became profuse and non-compressible
- MTP started and vascular consult called
- Vascular surgeon joined and placed aortic balloon accessed groins bilaterally and found a left common iliac artery bleed
Outcome

- Intraaortic balloon was placed and inflated while repair to the common iliac artery was performed.
- Patient became acutely hypotensive and became asystolic.
- Massive PE suspected as pulmonary vasculature was not able to be imaged without any further vascular injury identified.
- CPR continued while CT surgery was consulted for VA ECMO.
- Ultimately efforts were deemed futile due to the extent of injury and the patient suffered intraoperative death.
- EBL > 8 L based on transfusion needs.
- PRBCs 23.
- FFP 36.
- PLT 7.

Solutions to Vascular Complications

- Fix the injury!
- High-risk cases should consider vascular/cardiothoracic surgery consults preoperatively to aid in exposure or to expedite consultation should intraop injury occur.
- Employ blood conservation strategies whenever possible.
- Cell saver.
- Hemodilution.
- Transfusion and supportive care.
- Consider high dose TXA if no contraindications exist.

Emboli: Pulmonary, Fat, Cement and Air

- Pulmonary Embolus.
- Fat Embolus.
- Cement Embolus.
- Air Embolus.
- Obstructive complications and delayed inflammatory reactions.
- If these occur intraoperatively the patient should be monitored for subsequent complications in a critical care setting.

Post Operative Vision Loss

- Incidence of POVL after spine surgery 0.03% to 0.2%
- Relatively rare but devastating.
- Venous congestion vs arterial ischemia vs embolism.
- Pneumothorax, epidural, subdural or subarachnoid hemorrhage, postoperative endoscopic, postoperative seizures, or meningitis.
- Midface risk factors.
- Acute hypotension.
- Avoid pressure on the eyes.
- Consider sublaminar terebinthine alcoholic solution.
- Avoid high and rapid ascent.
- Assignment.
- Scaphoid fracture.
- Injury to lumen.
- Antiplatelet agents, steroids, or OP heparin agents have not been shown to be effective.

Incidental Durotomy

- Reported incidence ranging from 1% to 17%
- Complications range from mild to severe.
- Mental micturition, seizures, posterior column, and/or visual, urinary, dysesthesias, magnetic resonance, leukoencephalopathy, meningitis, or spinal cord.
- Posterior fossa, prevertebral space.
- Risk factors.
- Complex spinal surgery and revision procedures.
- Fracture.
- Spinal tumors.
- Use of high-speed drills.
- Management.
- Primary repair.
- Sublaminar (noninfectious).
- Laminectomy / sublaminar but spine tumor.
Recurrent Laryngeal Nerve Injury

- Preoperative risk assessment
  - Pre-existing swallowing issues, hoarse voice, previous neck surgery, previous cervical spine surgery, thyroid disease, other H&N cancer
  - Incidence ranging from 0.2–16.7%

- Risk factors
  - Female gender, right sided approach, more levels = more risk (controversial)
  - Length of surgery, traumatic intubation, endotracheal cuff pressure

- Management
  - Uni vs bilateral

Conclusion

Intraoperative Neurophysiologic Monitoring (IONM) Alerts and Interventions

Claudia F. Clavijo, MD
Associate Professor
Neurosurgery Section Chief
Department of Anesthesiology University of Colorado

Learning Objectives

- Review purpose and general aspects of IONM
- Learn common intraoperative neuromonitoring alerts
- Understand the importance of the anesthesia team and anesthetic choice in the preservation of responses
- Review complications related with the IONM techniques
- Discuss appropriate interventions to manage alerts

Purpose of IONM

- Reduce the risk of postoperative neurological deficits
- Real-time detection of
  - Ischemia
  - Mechanical insult
  - Malposition of patient
  - Malposition of hardware
- Identification of
  - Nerves
  - Nerve roots
  - Eloquent cortex
  - Spinal cord structures

Types of Recordings

Spontaneous
- Electroencephalography (EEG)
- Electromyography (EMG)

Evoked
- Somatosensory (SSEP)
- Motor (MEP)
- Auditory (ABR)
- EMG
Common Surgical Applications

Spine Surgery
- Most fusions
- Spinal cord tumors

Intracranial Surgery
- Posterior fossa tumors
- Intracranial hemorrhage
- Cerebral mass in or near eloquent cortex

Vascular Surgery
- Carotid endarterectomy
- Aortic aneurysm repair

Cardiac Surgery
- Aortic arch repair or replacement

Intracranial Surgery
- Posterior fossa tumors
- Intracranial hemorrhage
- Cerebral mass in or near eloquent cortex

Head and Neck Surgery
- Parotidectomy
- Thyroidectomy
- Parathyroidectomy
- Neck dissection

Reasons For Alerts

- Patient factors
  - Age, preexisting neurologic status

- Surgical factors
  - Compression, retraction, trauma, vibration

- Anesthesia/physiologic factors
  - Anesthetic agents used, depth of anesthesia, hypotension, temperature, anemia, hypoxia

- Patient positioning
- Miscellaneous

IONM Modalities

SSEP Alert Criteria

- >50% decrease in signal amplitude
- >10% increase in signal latency
- International Society of Intraoperative Neurophysiology released new recommendations

Examples of SSEP Alerts
MEPs

AMEP Alert Criteria

Controversial

- All-or-nothing
- Amplitude reduction (%)
- Threshold increase (100 V)
- Morphology change, latency

Examples of MEP Alerts
Effect of Anesthetics on IONM Responses

<table>
<thead>
<tr>
<th>AGENT</th>
<th>EFFECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalational agent/N2O</td>
<td>Affects SSEP, MEP</td>
</tr>
<tr>
<td>Propofol</td>
<td>Helps preserve responses</td>
</tr>
<tr>
<td>Sufentanil/remifentanil</td>
<td>No effect</td>
</tr>
<tr>
<td>Neuromuscular blockers</td>
<td>Affect MEP, EMG</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Enhances responses</td>
</tr>
<tr>
<td>Dexmedetomidine</td>
<td>Conflicting</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Inconclusive</td>
</tr>
</tbody>
</table>

Conclusion:
In patients with initially small amplitudes, desflurane may limit tcMEP recording because it produces a remarkable amplitude reduction, even in patients without PMDs.

Transcranial motor evoked potentials during anesthesia with desflurane versus propofol – A prospective randomized trial

Conclusion: In patients with initially small amplitudes, desflurane may limit tcMEP recording because it produces a remarkable amplitude reduction, even in patients without PMDs.
Dexmedetomidine?

Susceptibility of Transcranial Electric Motor-evoked Potentials to Varying Targeted Blood Levels of Dexmedetomidine during Spine Surgery

In 40 subjects undergoing spine surgery, dexmedetomidine infusion significantly reduced the amplitude of transcranial electric motor-evoked potentials when combined with a propofol-based anesthetic.

Dexmedetomidine does not affect evoked potentials during spine surgery

Irene Rozet et al. Anesthesia & Analgesia 2015, 121 (2), 492-501
CONCLUSIONS: This study showed that DEX had significant effects on tcMEPs during IOM in brain tumor surgery. Because the high false-positive rate could decrease the accuracy of IOM, outcomes after using DEX should be cautiously interpreted.

- Higher false-positive rate in the DEX group than in the control group
- Bilateral alterations were observed only in the DEX group
- The DEX group required significantly higher intensity and repetition rate to evoke adequate tcMEPs.
- The SSEP results were comparable between both groups.

Complications Related to IONM

- Bruising
- Myalgias
- Mouth and tongue laceration (most common)
- Mandibular fractures
- Dental luxation
- Endotracheal tube damage
- Seizures (clinical and subclinical)
- Arrhythmias, bradycardia, asystole

IONM IS SAFE
**Strategies to Manage Alerts**

Communication between surgical, anesthesia, and neuromonitoring teams is crucial.

- All team members need to search their respective areas for possible contributing factors
- Rule out technical problems
- Recent surgical event? (reversible or not reversible)
- Pharmacology (change in regimen, bolus or NMB)
- Increase perfusion MAP >10-20%
- Physiology (temperature, oxygenation, anemia)
- Position, compression, vascular obstruction, external devices

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**Intraoperative Adverse Events**

- Seizures
- Stroke - occlusive and hemorrhagic
- Venous air embolism
- Hyper/hypotension
- Tachy/bradycardia
- Brain swelling

---

**Postoperative Adverse Events**

- Seizures
- Stroke - occlusive and hemorrhagic
- POIV
- Altered mental status
- Neurologic deficit
- Pain
- Cerebral spinal fluid leak
- Venous thromboembolism
- Cerebral hyperperfusion syndrome

---

**Learning Objectives**

- Review intraoperative and postoperative adverse events relevant to intracranial surgery
- Discuss details of perioperative seizures
- Evaluate interplay of intracranial surgery and stroke
- Review the role of venous air embolism during intracranial surgery
Perioperative Seizures

- Associated with:
  - Increased mortality and morbidity
  - Reduced quality of life
  - Longer hospitalization
  - Literature largely focuses on postoperative seizures
  - With increasing frequency of awake craniotomy, intraoperative seizures happen and must be planned for

Intraoperative Seizures

- Typically from direct cortical stimulation
- Can be seen in awake and anesthetized patient
- Stimulation of cortex can induce seizure activity
- Frontal, supplementary motor area, and pre-motor cortex are higher risk
- Prophylactic anti-epileptic drugs do not impact these seizures
- More risk with higher current and longer stimulation time

Postoperative Seizures

- Biggest risk factor is seizure activity preoperatively
- 5-10% postoperative incidence of new seizures in the seizure-naive brain
- Must be considered during delayed emergence

Stroke

- Majority of perioperative stroke is hemorrhagic
- Varying definitions
  - Postoperative intracranial hemorrhage is a hematoma that requires surgical evacuation
  - Approximately 1% incidence

Factors Associated with Stroke

- Preoperative
  - Hypertension
  - Bleeding disorder
  - Emergency case
- Intraoperative
  - ASA score IV and V
  - Hypertension
  - Type of surgery: Tumor resection is highest risk
Hypertension and Stroke

- Abrupt intraoperative hypertension may perturb cerebral autoregulation
- If the blood-brain barrier is surgically disrupted, there is increased risk of bleeding
- Intraoperative and postoperative blood pressures matter
  - Systolic blood pressure >160 mm Hg increases risk
  - Mean arterial pressure >110 mm Hg increases risk

Venous Air Embolism

- One of the oldest known complications to surgery, documented in early 1800’s
- Precordial Doppler for air-bubble detection first published in 1969
- Neurosurgery in the sitting position increasingly common into 1970’s

Venous Air Embolism Signs/Symptoms

- In patient under general anesthesia:
  - Most common: Decreased ETCO2 and/or SpO2, wheezing
  - More severe: Hypotension, ECG changes
- In awake patient:
  - Most common: Coughing, altered mental status
  - More severe: Acute dyspnea, chest pain, lightheadedness

Venous Air Embolism Detection Methods

- TEE - Most sensitive
  - Detects air at 0.02 cc/kg
- Precordial Doppler Ultrasound - Most common
  - Detects air at 0.05 cc/kg
- ETCO2 - Most practical
  - Change of 2 mm Hg may indicate VAE

Subarachnoid hemorrhage is associated with ECG changes.

Which of the following new ECG findings would MOST warrant monitoring of serial cardiac enzymes?

- A. QT prolongation
- B. Q waves
- C. ST depression
- D. T wave inversion

Venous Air Embolism

- VAE can occur in prone, supine and lateral positions
- Severity related to volume of air entrainment and rate of accumulation
- Human lethal volume estimated to be 3-5 cc/kg
Venous Air Embolism Treatment

- Request surgeon to:
  - Flood surgical field with saline
  - Pack surgical site with soaked dressings
  - Reposition patient if possible
  - Supportive therapy
    - 100% FiO2
    - Inotropes PRN
    - Vasopressors PRN

Summary

- Adverse events related to intracranial surgery significantly impact morbidity and mortality
- Knowledge and recognition of adverse events improves patient care

During a craniotomy in the sitting position, which of the following is associated with an INCREASED risk of a paradoxical venous air embolism?

A - PEEP
B - Nitrous oxide administration
C - Liberal IV fluids
D - Right heart catheter placement

Questions?
Ultrasound-Guided Regional Anesthesia Workshops

Kyle Marshall, MD
CRASH 2023

DISCLOSURE
There are NO disclosures for any faculty participating.

Kyle Marshall, MD
Olivia Romano, MD
Inge Tamm-Daniels, MD
Jillian Vitter, MD
Matthew Lyman, MD
Keleigh McLaughlin, MD

Lower Extremity/Abdominal Workshop
- Quadratus Lumborum
- TAP & Rectus Sheath
- SFI & Fasica Iliaca
- Infragluteal Sciatic
- Popliteal Sciatic & IPRCK
- Femoral: Inguinal & Adductor
- LESS lecture, MORE demonstration
- 6 stations with models

Thank you to our Vendors!!
- Mindray: Rob Kimbrough
- Sonosite: Kristi Howe

Thank you to our Models!!

BEER & WINE - END @ 1630!