


UND Nurse Anesthesia Program
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Continuous ST Segment Monitoring
in the OR

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Introduction

- Coronary artery disease remains the leading cause of death for both men and women
 - The overall death rate has decreased 31% in the last 10 years, but the burden of the disease, esp. the cost of care, is the highest of all diagnostic groups at 315.4 billion dollars
- 1.4-3.9% of surgeries are complicated by a major perioperative cardiac event
- **Cardiac complications are the most common cause of post-operative morbidity and mortality**



Myocardial Ischemia & Infarction


- Atherosclerosis of the coronary arteries is the most common cause of ischemia
- It is now being recognized as an *inflammatory disease*
- Imbalance between supply and demand can be caused by:
 - An underlying cardiac abnormality such as CHF or moderate to severe valvular disease
 - Catecholamine release during surgery can lead to tachycardia and hypertension which increases demand, along with increasing the propensity for plaque rupture
 - Tachycardia in the patient with stable coronary disease can decrease coronary blood flow because of shortened diastolic time



General Risk Factors


- Male gender
- Age >65
- Hyperlipidemia
- Hypertension
- Cigarette smoking
- Obesity
- Diabetes
- Family history
- Sedentary lifestyle

(2014 ACC/AHA)



Specific Risk Factors

- **Revised Cardiac Risk Index (RCRI)**
 - Surgical procedure
 - History of ischemic heart disease
 - History of CHF
 - History of CVA
 - DM requiring insulin
 - Creatinine >2mg/dl
- **National Surgical Quality Improvement Program (NSQIP)**
 - 20 patient predictors combined with surgical procedure to give odds of 15 different adverse outcomes specific to that procedure



Identifying Perioperative Myocardial Ischemia

- Difficult because patients are unable to express symptoms (which is usually the first sign)
- How else can we detect it? Are their warning signs while under anesthesia?
- Monitoring devices used for detection
 - Transesophageal echocardiography
 - Pulmonary capillary wedge pressures
 - Electrocardiography



Transesophageal Echocardiography

- Detects and localizes regional wall motion abnormalities (RWMA)
- RWMA happen within one minute of perfusion deficit, thus most sensitive monitor for detection
- Limitations are: not cost effective for routine use, requires specialized training for proficiency, can only visualize a small area of myocardium at a time and use limited to time while intubated (possibly missing critical risk times for ischemia)
- Thus 2014 ACC/AHA guidelines do not recommend its routine use for non-cardiac surgery for ischemia monitoring



Pulmonary capillary wedge pressures

- Monitors for ischemia by measuring trends of the pulmonary artery wedge pressures that correlate with left ventricular function
- It is an indirect measurement thus can be falsely influenced by multiple factors: mitral stenosis, COPD, location of catheter etc
- Cons: Invasive procedure with potentially serious complications
- Poor sensitivity and specificity



Electrocardiography

- Changes in the ST segment can indicate ischemia or infarction
 - **ST depression** can indicate myocardial ischemia from either increased oxygen demand or limited coronary blood flow
 - **ST elevation** can indicate myocardial infarction from total occlusion of a coronary artery
- Advantages:
 - ECG is already a standard of care for the monitoring of patients under anesthesia
 - Cost effective
 - Noninvasive
 - Simple to operate
 - Monitors multiple “views” of the heart simultaneously and continuously,
 - Can be highly sensitive and specific for detection of ischemia or infarction



Case Information

- Surgical Procedure
 - Right open, radical nephrectomy for a urinary fistula after partial nephrectomy for renal cell carcinoma
- Age- 69 y/o
- Weight- 76kg
- Gender- female
- ASA- 3
- Allergies- Keflex, Morphine, Bactrim & Sulfa



Pre-operative Evaluation

- Medical History
 - Asthma, hypertension, dyslipidemia, diabetes type 2, atrial fibrillation with prior partial nephrectomy, chronic pain
- Surgical History
 - Cholecystectomy, lithotripsy, cystoscopy, shoulder/knee and hip arthroplasty
- Pre-op VS
 - BP 134/73, HR 90, RR 16, oxygen sat 95%
- Pre-op labs
 - Unremarkable (Hct 35.4 g/dl and Cr 0.9mg/dl)
- Airway assessment
 - Mallampati I, normal TMD, normal inter-incisor distance and full ROM in her neck



Cardiac Pre-operative Evaluation

- ECG
 - NSR, no ST abnormalities
- Echo
 - EF 65%, mild diastolic dysfunction, mild LV hypertrophy, no RWMA or valvular issues
- METs level
 - **< 4 with fatigue being her predominant symptom**
- Cardiology consultation classified her as an intermediate cardiovascular risk d/t the procedure itself and she was cleared for surgery.
- No beta blocker was ordered d/t history of bradycardia

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Intra-operative Monitoring

- Connected to standard monitors
 - Including 5-lead ECG with V lead (brown) placed in the V5 position
 - ST segment monitoring was initiated, baseline established
 - Alarms set for 1mm deviation and ECG strip printed
- Arterial line placed in L) radial artery with a good waveform
- Additional 18G IV started in the forearm

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Anesthetic Course

<ul style="list-style-type: none"> • Induction <ul style="list-style-type: none"> – Fentanyl 100mcg – Propofol 150 mg – Rocuronium 50mg • Technique <ul style="list-style-type: none"> – Intubated with 7.0 ETT – +BBS, +ETCO2 • Vent Settings <ul style="list-style-type: none"> – VCV w/ TV 550, rate 12, PEEP 5 	<ul style="list-style-type: none"> • Maintenance <ul style="list-style-type: none"> – Sevoflurane 2% – Ofirmev 1gm pre-incision – Fentanyl 50-100mcg prn – Rocuronium 10mg prn • Anti-emetics <ul style="list-style-type: none"> – Decadron 4mg – Zofran 4mg • Reversal <ul style="list-style-type: none"> – Glycopyrolate 0.6mg – Neostigmine 3mg
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Intraoperative Issues

- Total Anesthesia Time
 - 3 hours
- Estimated Blood loss
 - 1100ml
- Volume replacement
 - Crystalloid 2500ml
 - Albumin 500ml
 - 2 units RBCs (mid-case Hgb 8.8g/dl)
- Surgical course
 - Required Phenylephrine 300mcg to maintain BP within 20% of baseline
 - UOP >1ml/kg/hr throughout case
 - **ST segments remained 0.1-0.3 mm from baseline**

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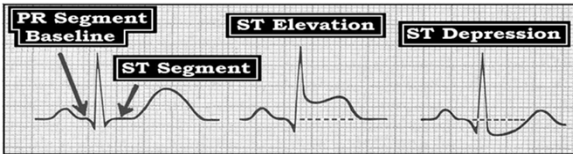
Post-operative Course

- Extubated awake in the OR, placed on 3L NC
- Pain level in PACU 1/10
- No PONV reported
- Admitted to general floor
 - Next day Hgb 10.5g/dl
 - Discharged on day 4 with no complications

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Continuous ST segment Monitoring

- ST segment is measured from J Point (end of QRS segment at isoelectric line) to the beginning of T wave
- When calculating for deviation, ST segment is compared to preceding PR segment as isoelectric reference



Source: ecginterpretation.com
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Continuous ST segment monitoring

- When 5-lead ECG is connected, the monitor's algorithm establishes a baseline
- At predetermined intervals, all subsequent ST segments are compared to this baseline and deviations are displayed as a positive or negative numerical value
- Alarm parameters are set to notify if ST segment changes > 1-2mm from that baseline
- **Visual detection of changes has been shown to NOT be reliable**
- Implications: Discharging previous patient from monitor, changing electrode placement after baseline has been established, change in body position can alter ST segments
- **Limitations: Previously documented left bundle branch block or ventricular paced rhythm are not candidates.**



ECG Lead Placement

- Limb leads= I,II,III, AVR, AVF, and AVL**
- I and AVL monitor the lateral wall generally corresponding with circumflex distribution
 - II, III and AVF monitor the inferior wall and correspond with right coronary artery perfusion
 - AVR is generally not a diagnostic lead
 - Limb leads are derived from the white, green, black and red electrodes placed on the perimeter of the chest
 - Even though the monitor only displays one of these leads continuously, it is monitoring the ST segments of all 6 of these leads



ECG Lead Placement

- **Precordial leads= V1-V6**
 - V1 and V2 monitor the septal wall and the distribution of the left anterior descending artery (LAD). Can also show reciprocal changes of the posterior wall
 - V3 and V4 monitor the anterior wall and the distribution of the LAD as well
 - V5 and V6 monitor the lateral wall and circumflex distribution
 - With a 5-lead ECG, only one precordial lead is continuously displayed and monitored for ST segment changes
 - Which precordial lead is monitored, is determined by where the anesthetist places the brown lead



Chest Lead Placement

Chest Lead Electrode Position.

V1 – fourth intercostal space at the right sternal edge
 V2 – Fourth intercostal space at the left sternal edge
 V3 – Midway between V2 and V4.
 V4 – Fifth intercostal space in the mid-clavicular line
 V5 – Left anterior axillary line at the same horizontal level as V4
 V6 – Left mid-axillary line at the same horizontal level as V4 and V5

Source: www.jan.ucc.nau.edu (2016)



Lead Selection

- Historically we have monitored in II and V5
 - Prior research was based on holter monitoring, not in the OR
 - ST segments were measured from the isoelectric line, not the patient's baseline
- New research used continuous 12-lead ECG monitoring prior to induction through the 3rd post-operative day and measured deviation (2mm in one lead or 1mm in two contiguous leads) from the patient's baseline




Novel ECG Lead Selection

- Ideally, if the patient had a 12-lead which demonstrated changes in a specific lead or known CAD in a certain vessel, then that specific V lead known as a "fingerprint" should be monitored as it will be the most sensitive
- **V3 was found to be the most sensitive chest lead**, showing ST segment changes the earliest. Along with lead III
- **V4 was found to be the most specific.** V4 was the second most sensitive lead but it was better at detecting ST segment changes that would progress to myocardial infarction (defined by elevation in troponin)




Recommendations

- ACC/AHA recommended intraoperative ST segment monitoring in lead V4 rather than lead V5 for patient's undergoing non-cardiac surgery
- AACN published practice-alert around the same time based on a systematic review of literature recommending:
 - Leads III and V3 be used for patients with a cardiac history as it will show changes the earliest
 - Stressed importance of monitoring in "fingerprint" lead if previously documented change in ST segments
- Some monitors have the technology to do derived 12-lead (or EASI) monitoring. This will monitor ST segments in all 12 leads removing need to make a selection




Characteristics of Perioperative Myocardial Infarction (PMI)

- Almost always preceded by ST segment depression
 - Rarely preceded by ST elevation (leading to hypothesis of majority of PMI caused by imbalance of supply and demand, not plaque rupture)
- Strong association between duration of ST depression (>20 min or 60 min cumulative) and progression to myocardial infarction
 - The longer the duration of depression correlated with a higher trend in peak troponin levels
- **Each episode of depression was preceded by tachycardia**




Characteristics of Perioperative Myocardial Infarction (PMI)

- Highest risk of significant ischemia (>10 min) is from emergence through post-op day 2
 - Majority of prolonged ischemia events started during emergence (d/t increased heart rate and blood pressure, sympathetic discharge and pro-coagulant activity)
 - May see brief episodes during high demand periods (intubation, tachycardia)
- > 50% of PMI are silent (no symptoms)




Review of Case Study

- Continuous ST segment monitoring was a simple, cost effective and valuable tool for a patient with increased risk factors undergoing a high risk surgery
- Assuring **correct** ECG electrode placement for the most accurate data
- Establishing a ST segment baseline
- Setting the alarms at 1mm of deviation
- Printing a ECG strip prior to induction for reference were all good strategies for effective ST segment monitoring
- Areas of improvement include: monitoring in lead V4 (because the patient did not have **documented** CAD) instead of V5 for more sensitive detection of ST segment changes
- Patient did not experience any episodes of tachycardia but this literature review highlighted again the connection between this and myocardial ischemia




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Thank You
Any Questions????



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Anesthesia Considerations for
Intraoperative Blood Transfusion

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Introduction

- The majority of RBC transfusion occurs in surgical patients (U.S. Department of Health and Human Services, as cited by Qian et al., 2013).
- Blood transfusion has been identified as one of the most overused interventions in the U.S. (Joint Commission, 2012).
- While life-saving at times, blood transfusion has been associated with increased morbidity and mortality rates.
- RBCs are expensive: acquisition to transfusion of a single unit costs between \$1,600-2,400 (Wu et al., 2010).
- Appropriate surgical blood management may not only affect patient safety, but healthcare costs as well (Ferraris et al., 2011).

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Case Information

- Right radical robotic (possibly open) nephrectomy for primary kidney cancer with metastasis to the lung
- 65 year-old
- 110kg, 175cm
- Male
- ASA 3
- No known allergies

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Preoperative Evaluation

<ul style="list-style-type: none"> • Past Medical History <ul style="list-style-type: none"> – HTN – DM 2 – CVA (2013) • Surgical History <ul style="list-style-type: none"> – Tonsillectomy – Bronchoscopy – Endobronchial ultrasound • Anesthesia History <ul style="list-style-type: none"> – No history of anesthetic complications 	<ul style="list-style-type: none"> • Home medications <ul style="list-style-type: none"> – Aspirin – Fish oil – Tamsulosin – Insulin glargine – Lisinopril – Amlodipine – Clonidine
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Preoperative Evaluation Continued

<ul style="list-style-type: none"> • Pertinent Labs/EKG <ul style="list-style-type: none"> – Hemoglobin 14.2 g/dL – Hematocrit 42.5% – Platelets 187 per mL – PT 10.4 seconds – PTT 23.8 seconds – Blood type: AB positive without antibodies <ul style="list-style-type: none"> • 2 units of RBCs typed and cross matched – EKG: Normal sinus rhythm 	<ul style="list-style-type: none"> • Preoperative VS <ul style="list-style-type: none"> – BP 166/72 – HR 72 – RR 20 – SaO2 90% on RA – T 36.9° C • Airway Evaluation <ul style="list-style-type: none"> – Mallampati II – Full neck ROM – No notable dental history or viable issues
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Anesthetic Course


- Technique: GETA
- Induction
 - Standard non-invasive monitors
 - Preoxygenated with 100% O2 via face mask for approximately three minutes
 - Fentanyl 50mcg, lidocaine 50mg, propofol 200mg, cisatracurium 20mg
 - Macintosh 3 blade, 7.5mm cuffed ETT
- Maintenance
 - Desflurane 1.0 MAC
 - Initial FGF 1LPM air and 1LPM O2
 - Arterial line and additional 16-gauge IV
 - NS and LR infusions, cefazolin 2g, famotidine 20mg, metoclopramide 5mg, dexamethasone 10mg, ondansetron 4mg, dextrose 25g for mild hypoglycemia, and PRN fentanyl, hydromorphone, phenylephrine, and ephedrine



Intraoperative Issues

Difficult Tumor Dissection


- Approximately 3 hours into the operation, a general surgeon was consulted due to the tumors proximity to the hepatic flexure of the bowel
- Approximately 4 hours into the surgery, it was converted to an open procedure due to tumor size and involvement with surrounding tissues
 - At this time, the patient remained hemodynamically stable with negligible blood loss
- Approximately 30 minutes after converting to an open procedure, significant surgical bleeding was encountered
 - The IVC had been inadvertently incised by the surgeon



Intraoperative Issues Continued


Massive Blood Loss

- Previously consulted general surgeon assisted, while waiting for the vascular surgeon
- TEE was performed by the MDA, which showed a nearly empty LV
- Several units of RBCs and other products were transfused
 - 12 units RBCs, 3 units PLTs, 1 unit FFP, and 1L 5% albumin
 - Estimated total blood loss was 8,000ml; patients estimated TBV was 8,260ml
 - Massive transfusion protocol initiated **after** repair of the IVC
- Medications
 - Boluses of epinephrine, phenylephrine, ephedrine, and vasopressin
 - Infusions of phenylephrine and epinephrine
 - Calcium gluconate 4g and 300mEq of sodium bicarbonate
 - Desflurane discontinued due to severe hemodynamic instability
 - Two subsequent doses of cisatracurium were given, 10mg each



Postoperative Care


- The patient bypassed PACU; transferred directly to the CCU
 - Transfusion of blood products and infusions of phenylephrine and epinephrine continued
- Upon arrival to the CCU, the patient cardiac arrested
 - One round of CPR was performed
 - A single lumen right femoral central line was inserted
 - Care was turned over to the critical care physician
- Two days after surgery the patient was extubated and on the third postoperative day was transferred to a general floor A&O x3.



Discussion

Intervention Starts with Prevention: Preventing Blood Loss


- Preparation may need to begin several days/weeks before elective surgery
- Careful review of medical records and a thorough interview
- Discontinue anticoagulation medications as appropriate. The ASA Task Force on Perioperative Blood Management (2015) recommends:
 - Consult an appropriate specialist and discontinue anticoagulation therapy
 - Transition to shorter acting drugs, such as heparin or LMWH, may be appropriate
 - Discontinue non-aspirin antiplatelet agents (i.e. clopidogrel, ticagrelor). Exception, history of PCI
 - Aspirin may be continued on an individual patient basis
- Erythropoietin and/or iron may be administered or autologous blood may be donated prior to surgery



Discussion Continued

Transfusion Thresholds: Blood Loss & Anemia


- Wu et al. (2010) Retrospective Study
 - 239,286 older patients (>65 years), undergoing noncardiac surgery
- Chen et al. (2015) Retrospective Study
 - 424,015 older patients (>65 years), undergoing noncardiac surgery
 - Both studies looked at intraoperative blood transfusion in relation to 30-day postoperative mortality rates
 - Benefit from intraoperative transfusion if “substantial” operative blood loss (>500ml) or low preoperative hematocrit (<24%)
- Wu et al. (2012) Retrospective Study
 - 46,608 older patients (>65 years), undergoing noncardiac surgery
 - Relationship between hospital rates of transfusion in patients with substantial blood loss (>500ml) and 30-day postoperative mortality rates
 - Hospital which transfused patients with substantial blood loss had lower risk-adjusted 30-day postoperative mortality rates



Discussion Continued

Low Volume Transfusion


- Bernard, Davenport, Chang, Vaughan, and Zwischenberger (2009) Prospective Study
 - 127,177 adult patients (average age 52.9 years), undergoing noncardiac general surgery
- Ferraris et al. (2011) Exploratory Observational Study
 - 8,728 propensity-matched adult patients, undergoing noncardiac nonvascular thoracic surgery
 - Both studies looked at the effect of low volume intraoperative transfusion (1-2 units) on morbidity and mortality
 - Increased morbidity and mortality was associated with low volume intraoperative transfusion



Discussion Continued

Transfusion within 72 Hours


- Abdelsattar, Hendren, Wong, Campbell, and Henke (2015) Prospective Observational Study
 - 2,243 propensity-matched adult patients (>18 years), undergoing vascular or general abdominal surgery
 - Blood transfusion within 72 hours of surgery and 30-day postoperative mortality
 - Increased postoperative mortality; paradoxical exception, decreased risk of MI
- Ferraris, Hochstetler, Martin, Mahan, and Saha (2015) Observational Study
 - 470,407 adult patients, undergoing noncardiac surgery
 - Predictive operative mortality and associated risk of blood transfusion
 - “High-risk” patients did not have significant risk with blood transfusion; however, “low-risk” patients had substantially increased risk



Discussion Continued

Cancer and Immunomodulation


- Al-Refaie, Parson, Markin, Abrams, and Habermann (2012) Prospective Study
 - 38,926 adult patients (>18 years), undergoing surgical resection of thoracic, abdominal, or pelvic neoplasms
 - Intraoperative blood transfusion and association with outcomes
 - Adverse effects of intraoperative blood transfusion, including increased 30-day postoperative mortality rates
 - Unlike other studies, adverse effects were found despite a low preoperative hematocrit level
- Ferraris, Ballert, and Mahan (2013) Retrospective Study
 - 553,288 propensity-matched adult surgical patients,
 - Blood transfusion and the development of systemic inflammatory response syndrome (SIRS)
 - Transfused patients had increased morbidity, including SIRS, and mortality



Discussion Continued


Massive Transfusion

- Turan et al. (2013) Prospective Study
 - 5,143 adult patients, undergoing noncardiac surgery
 - Association between massive transfusion (5 RBC units) and patient outcomes
- Johnson et al. (2016) Retrospective Study
 - Approximately 3,500 medical and surgical patients
 - Association between high-dose transfusion (>10 units throughout hospitalization) and morbidity and mortality
 - Mortality increased with increase in RBC units transfused



Discussion Continued


- Brown et al. (2012) Prospective Cohort Study
 - 604 blunt injury/hemorrhagic shock patients, age 18-90 years, which received massive transfusion
- Holcomb et al. (2011) Retrospective Study
 - 643 massively transfused trauma patients
 - Both studies defined massive transfusion as 10 or > units of RBCs in 24 hours)
 - High early ratios (FFP/RBC 1:1.5 and PLT/RBC 1:9 or 1:1 respectively) were associated with better patient outcomes
- Sharpe et al., (2012) Prospective Study
 - 165 surgical trauma patients
 - More units of RBCs transfused = lower component ratios
 - Lower component ratios increased mortality rates



Discussion Continued

Case Report Discussion

- The patient was “optimized” prior to surgery
- Additional IV access and invasive hemodynamic monitoring (arterial line) had been initiated prior to the start of surgery. A type and crossmatch was completed preoperatively.
- Despite, best efforts, significant blood loss was encountered
- The blood loss was quickly communicated to anesthesia
- Although not following a high component ratio initially, as supported by current literature, the patient had a positive outcome



Discussion Continued

Intraoperative Transfusion Management

"Blood transfusion can be both good and bad, depending on the clinical situation." (Ferraris et al., 2015, p. 608)

- Blood transfusion has been shown to be beneficial if there is an indication for transfusion; however, in the absence of massive bleeding or symptomatic anemia, it has not proven to be advantageous (Smilowitz et al., 2016)
- There has been debate over the ideal transfusion trigger and subsequently, transfusion practices have varied widely (Abdelsattar et al., 2015; Ferraris et al., 2012; Qian et al., 2013)



Discussion Continued

- Current literature supports restrictive versus liberal transfusion.
 - As discussed previously, transfusion of even small amounts of blood (1-2 units) has been associated with adverse surgical outcomes (Bernard et al., 2009; Ferraris et al., 2011; Ferraris et al., 2012; Gance et al., 2011)
 - In a recent Cochrane review (Carson et al., 2015), which included a wide variety of patients (surgical, critical care, trauma, cancer, etc.), transfusion at a restrictive threshold (7-8 g/dL) was not associated with adverse effects when compared to initiation at a liberal threshold (9-10 g/dL).

"The determination of whether hemoglobin concentrations between 6 and 10g/dl justify or require red blood cell transfusion should be based on potential or actual ongoing bleeding (rate and magnitude), intravascular volume status, signs of organ ischemia, and adequacy of cardiopulmonary reserve." (ASA Take Force on Perioperative Blood Management, 2015, p. 251)



Recommendations

- While current transfusion guidelines leave much room for practitioner discretion, based on current literature restrictive transfusion trigger is favorable
- If massive transfusion is required, it is recommended to transfuse a "high" ratio of FFP/RBC and PLT/RBC
 - There is no clear-cut definition of high component ratios. In research the definition varies (Brown et al., 2012; Holcomb et al., 2011; Sharpe et al., 2012):
 - FFP/RBC 1:1 -1:1.5
 - PLT/RBC 1:1 – 1:9



Recommendations Continued

- Massive transfusion protocols are not all the same. It is advisable that anesthesia providers be familiar with the protocol at the facility in which they practice.
- Despite the known potential involvement of vasculature with renal cell carcinoma, there is extremely scarce data regarding the risk of bleeding and associated blood loss in patients undergoing a radical nephrectomy. It is recommended that research be performed on this topic



Conclusion

- While blood transfusion may be life-saving at times, it has also been associated with increased morbidity and mortality.
- It is important that anesthesia professionals be knowledgeable about current literature regarding transfusion in the surgical patient.
- Intervention starts with prevention
 - Optimize patients prior to elective surgery
- The risks versus the benefits of transfusion must be carefully weighed for each patient to achieve best outcomes.



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Thank You Are There Any Questions?

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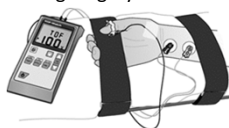
Anesthetic Considerations for the use of Acceleromyography for Neuromuscular Blockade

Kathryn L. Gacek, SRNA

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Introduction

- Acceleromyography neuromuscular monitoring was introduced in the late 1980s.
- Acceleromyography is a quantitative neuromuscular monitor utilized to assess the level of neuromuscular blockade in patients who received neuromuscular blocking drugs during surgery.



Source: <http://anesthesiology.pubs.asahq.org/article.aspx?articleid=1922364>

(Claudius & Viby-Mogensen, 2008)
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Introduction Continued

- Clinical tests used to evaluate depth of neuromuscular blockade:
 - Head lift
 - Grip strength
 - These tests have been found to be subjective, unreliable and require patient cooperation
- Prevalence:
 - Using qualitative, subjective nerve stimulators is < 40%
 - Using quantitative, objective nerve monitoring is < 17%

(Brull & Kopman, 2017; Clausius & Viby-Mogensen, 2008)



Case Information

- Left parietal craniotomy
- 32-year-old female
- 150cm
- 55kg
- No known drug allergies
- ASA physical status: level 3



Pre-operative Evaluation

- Past Medical History:
 - Meningioma
 - Chronic left sided headaches
 - Latent lung tuberculosis
- Surgical History:
 - Cerebral angiogram performed the day prior to the proposed surgery
- Anesthetic History:
 - Uncomplicated



Pre-operative Evaluation Continued

- Pre-op VS:
 - Blood pressure: 120/92 mmHg
 - Heart rate: 103/min
 - Respiratory rate: 20/min
 - Room air oxygen saturation (SpO2): 96%
 - Temperature: 97.6° Fahrenheit
- Mallampati score: 2
- Thyromental distance: 3 fingerbreadths
- Basic metabolic panel and complete blood count laboratory results: WNL



Anesthetic Course

- Pre-induction:
 - Midazolam 1mg IV
- Inhalational and intravenous induction:
 - Oxygen at 10L per minute and sevoflurane end-tidal concentrations of 1.25%, fentanyl 100 mcg IV, lidocaine 40 mg IV, propofol 110 mg IV, rocuronium 30 mg IV
- Airway & Ventilation:
 - 7.0 mm cuffed ETT, volume control, respiratory rate of 12 breaths/min, tidal volume 460mL
- Sevoflurane turned off and desflurane initiated with end-tidal concentrations of 5% throughout the procedure
- Other medications administered:
 - Dexmedetomidine IV gtt: 0.4mcg/kg/min, remifentanyl IV gtt: 0.15mcg/kg/min, cefazolin 2 g IV, ondansetron 4mg, levetiracetam 1000 mg IV, mannitol 30 mg IV, Ofirmev 1 g IV
- 20-gauge arterial line placed in the left radial artery
- Acceleromyography neuromuscular monitor applied without calibration to the right thumb and electrodes on the right ulnar nerve



Intraoperative Issues

- Hypotension:
 - Treated with:
 - Phenylephrine bolus x 1: 200mcg bolus IV
 - Phenylephrine infusion: 5mL/hr
 - Dexmedetomidine infusion: decreased to 0.3mcg/kg/min
- Moderate neuromuscular blockade (train of four < 2/4):
 - Rocuronium 10mg boluses were administered x 4 (after initial intubating dose)
- Hypocalcemia (ionized calcium 1.03 mmol/L):
 - Treated with:
 - Calcium gluconate 1 g IV
 - Repeat lab: ionized calcium 1.33 mmol/L



Post-operative Course

- Emergence:
 - Remifentanyl IV gtt decreased: 0.05mcg/kg/min, glycopyrrolate 0.2 mg IV, neostigmine 2.5 mg IV, lidocaine 50 mg
- No signs of residual paralysis
- Total procedure time: five hours and thirty minutes
 - Estimated blood loss: 850mL
 - Urine output: 2,635mL
 - Volume replacement:
 - Normal saline: 3,000mL
 - Lactated ringers: 475mL
 - 5% albumin: 500mL
- Discharged home on postoperative day thirteen with home care

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Pathophysiology

- The neuromuscular junction is the site where the motor neuron and muscle cell communication occurs.
- When the nerve’s action potential becomes depolarized, an influx of calcium ions travels through the voltage-gated calcium channels into the nerve cytoplasm.
- The ACh molecules move across the synaptic cleft and bind to nicotinic cholinergic receptors and the muscle membrane’s motor end-plate.

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Pathophysiology Continued

- Only two identical α subunits can bind to a ACh molecule.
- When enough ACh receptor sites are occupied, the end-plate potential will depolarize the perijunctional muscle membrane.
 - Sodium channels open which allows for the release of calcium from the sarcoplasmic reticulum.
- ACh is hydrolyzed into acetate and choline by the enzyme acetylcholinesterase located on the motor end-plate adjacent to the ACh receptors.
- After unbinding ACh, the receptors’ ion channels close, allowing the end-plate to repolarize and move calcium back into the sarcoplasmic reticulum.

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Pharmacology

- There are two different classes of neuromuscular blocking drugs that can be used in the perioperative setting:
 - Depolarizing or non-depolarizing (NDMA)
 - Both agents act on the post-synaptic junction at the neuromuscular junction.
- Depolarizing neuromuscular blockers are composed of two ACh molecules.
- NDMA’s are composed of one ACh molecule.

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Pharmacology Continued

- Anticholinesterase medications:
 - Used to antagonize the effects of NDMA’s
 - Work by competitively binding to the post-synaptic receptor at the neuromuscular junction
 - Slow the breakdown of ACh
 - Increasing the concentration of ACh at the post-synaptic nicotinic receptor on the muscle, thereby re-establishing normal function
- Depolarizing neuromuscular blockers are not able to be antagonized with an anticholinesterase medication.
- Depolarizing neuromuscular blockers are reversed by the body’s plasma cholinesterase.

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Train of Four Monitoring

- The AANA (2013) states, “when neuromuscular blocking agents are administered, monitor neuromuscular response to assess depth of blockade and degree of recovery” (p.1).
- Gold standard of neuromuscular monitors:
 - Mechanomyography, a quantitative, objective monitor
- Of the quantitative, objective neuromuscular monitors available, the acceleromyography monitor is most widely used.
- A cohort study by Bhananker et al. (2015) found anesthesia providers overestimate the TOF count, especially during counts 1, 2, and 3 utilizing a qualitative, peripheral nerve stimulator in comparison to the quantitative, acceleromyography monitor, TOF-WATCH SX™.

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Train of Four Monitoring Continued

- **Acceleromyography**
 - Can be used to measure the patient's amount of blockade through quantifying the number of twitches via the acceleration of muscle tissue in response to nerve stimulation.
 - Based on Newton's second law of motion: force = mass x acceleration
 - "A piezoelectric transducer is attached to a muscle, and when the innervating nerve is stimulated, the muscle movement is sensed by the transducer; a voltage is generated in the piezoelectric crystal, and this electrical signal is analyzed by the acceleromyography monitor" (Brull & Kopman, 2017, p. 186).

(Brull & Kopman, 2017; Claudius & Viby-Mogensen, 2008; Welliver et al., 2015)



Acceleromyography Monitor Calibration

- The purpose of calibration is to adjust a supramaximal intensity current that is specific to each patient prior to receiving a NDMA.
- Calibration is recommended in scientific research however, it is still undecided if it is warranted in the clinical setting:
 - Schreiber (2014) recommends calibration prior to administering neuromuscular blocking agents.
 - Does not provide 100% reliability and may overestimate recovery of neuromuscular blockade by up to 15%.
 - Capron et al. (2006) states "even in the uncalibrated mode, (acceleromyography) remains the most accurate test to reliably detect residual paralysis" (p. 1582).
 - Colegrave et al. (2016) concluded at a TOF \geq to 1.0, the non-calibrated TOF-WATCH SX™ is as reliable as a calibrated TOF-WATCH SX™.
 - Schreiber et al. (2011) concluded that the TOF-Scan™ bypasses the need for calibration compared to its counterpart TOF-WATCH SX™.
- Eliminating calibrating prior to the administration of NDMA's decreases a step during the busy phase of induction.

(Colegrave, Billard, Motamed, & Bourgain, 2016; Schreiber, 2014; Schreiber, Mucha, & Fuchs-Buder, 2011).



Acceleromyography Monitoring Sites

- **Adductor Pollices**
 - The most common mode of intraoperative monitoring in the United States.
 - Capron et al. (2006) found the best correlation between acceleromyography and mechanomyography is to have the electrodes placed on the hand rather than the wrist.
- **Oribularis Oculi**
 - Requires increased stimulation to elicit the orbicularis oculi response therefore increasing likelihood of eliciting responses from other facial muscles.
 - Increased risk for residual paralysis monitoring at the eye muscles than at the adductor pollices.
- **Flexor Hallucis Brevis**
 - May be considered as alternative site with the use of acceleromyography.

(Gatke et al., 2002; Heer & Hetland, 1999; Larsen et al., 2002; Thilen et al., 2012)



Residual Paralysis

- Several studies have attributed residual paralysis with adverse events:
 - Inspiratory obstruction, hypoxemia-related increase in ventilation, postoperative critical respiratory events, intraoperative awareness, and unpleasant symptoms of muscle weakness
- A TOF ratio < 0.9 using the ulnar nerve to assess the adductor pollices muscle utilizing a quantitative neuromuscular monitor allows for increased incidence of residual neuromuscular blockade.
- A TOF ratio > 0.4 does not allow providers to accurately assess for the presence of fade.
- Residual paralysis has occurred in up to 64% of cases when utilizing qualitative monitoring methods.

(Brull & Kopman, 2017; Fuchs-Buder, Nemes, & Schmitt, 2016; Kopman & Eikermann, 2009; Murphy et al., 2013; Sauer, Stahn, Seitz, Noeldge-Schomburg, Mencke, 2011; Thilen et al., 2012; Welliver et al., 2015)



Residual Paralysis Continued

- Specific anticholinesterase medication dosing recommendations are based on quantitative or qualitative neuromuscular monitors.
 - Kopman & Eikermann (2009) outline guidelines for neostigmine administration with a quantitative neuromuscular monitor such as an accelermyograph:
 - TOF count with no response the provider should delay administering anticholinesterase until a TOF count of 2 has been obtained
 - TOF ratio < 0.4 or TOF count of 2-3 the provider can give neostigmine dose 0.02 – 0.05 mg/kg
 - TOF ratio 0.4 – 0.9 a neostigmine dose of 0.015 – 0.025mg/kg
 - TOF ratio > 0.9 the provider does not need to use anticholinesterase to antagonize the NDMA previously given

(Bhananker et al., 2015)



Recommendations

- Further research is needed regarding the necessity of calibrating the acceleromyography in clinical practice.
- Further research is needed regarding how frequently to monitor neuromuscular blockade to provide a moderate block with the use of acceleromyography monitoring.
- Further research is needed regarding monitoring sites other than the adductor pollices muscle in the event the adductor pollices muscle monitoring can not be performed.
- A TOF count and ratio should be obtained prior to antagonizing the effects of NDMA's.
 - Tracheal extubation should not occur until a TOF ratio of 0.9 has been achieved.



Conclusion

- This patient underwent a parietal craniotomy and remained paralyzed intraoperatively at a TOF of 2/4 or less with the aid of an acceleromyography monitor.
- The piezoelectric transducer was taped to the patient's thumb and the thumb was allowed to move freely.
 - This is congruent with the evidence that if the patient has a thumb that is allowed to move freely, this is the best place to monitor neuromuscular blockade.
- With the use of acceleromyography, it was predictable the patient would require additional boluses of paralytic around 36 minutes from the prior dose.
- The patient had a TOF count of 4/4 over an hour prior to receiving an anticholinesterase medication, therefore a TOF ratio was not performed.
 - The acceleromyography monitor is superior over the peripheral nerve stimulator as it provides the practitioner with a TOF ratio. The TOF ratio can help guide the practitioner as to appropriate anticholinesterase dosages.
- The acceleromyography monitor is one tool that can be used to aid the anesthesia provider in making appropriate judgement for tracheal extubation to reduce the incidence of residual paralysis.
 - A TOF ratio of 0.9 or greater has been shown to decrease residual neuromuscular blockade.



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Thank You
Are There Any Questions?



The Effect of Intravenous Tranexamic Acid on Postoperative Blood Loss in Patients Undergoing a Total Knee Arthroplasty

Kaylene Hill, SRNA



Introduction

- Total knee arthroplasty is a commonly performed orthopedic surgery
 - The most common complication associated with this type of surgery is blood loss and the need for a blood transfusion
- Blood transfusions have been found to be an independent risk factor for myocardial infarction, stroke, infection, renal failure, and even death



Case Information

- Surgical Procedure
 - Right total knee arthroplasty
- Age- 54 y/o
- Weight- 139kg
- Gender- male
- ASA- 3
- No known allergies



Pre-operative Evaluation

- Medical History
 - Hyperlipidemia, gastroesophageal reflux disease, type 2 diabetes, nephrolithiasis, eczema, attention deficit hyperactivity disorder, arthritis of the knee, depression, gout, obesity, anxiety, narcissistic personality disorder, and mood disorder. The patient also experienced a deep vein thrombosis after a previous knee surgery.
- Surgical History
 - Knee arthroscopy, strabismus surgery, left knee arthroplasty, and colonoscopy
- Pre-op VS
 - BP 136/84, HR 96, RR 16, oxygen sat 95%
- Pre-op labs
 - unremarkable (Hgb 15.9 g/dl, Hct 45.6%)
- Airway assessment
 - Mallampati II, normal TMD, full ROM in his neck and normal dental exam
- ECG
 - NSR with right bundle branch block



Anesthetic Course

- | | |
|---|--|
| <ul style="list-style-type: none"> • Induction <ul style="list-style-type: none"> – Fentanyl 100mcg – Versed 2mg • Technique <ul style="list-style-type: none"> – Spinal anesthesia with 22g Pencan needle – Bupivacaine, 0.5%, 4 mL • EtCO2 NC at 4 L/min | <ul style="list-style-type: none"> • Maintenance <ul style="list-style-type: none"> – Propofol 25-75mcg/kg/min – Tranexamic acid, 1,000mg both before and after tourniquet use • Anti-emetics <ul style="list-style-type: none"> – Zofran 4mg |
|---|--|



Intraoperative Issues

- Total Anesthesia Time
 - 3 hours
- Estimated Blood loss
 - 600ml
- Volume replacement
 - Crystalloid 2600ml
- Additional medications
 - 200 mL Tranexamic acid



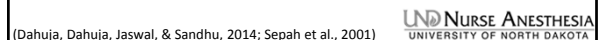
Post-operative course

- Auto transfuse drain placed
- Admitted to general floor
 - Same day 620 mL output from drain
 - Postoperative day one, hgb 12.7 g/dL and 50mL output from drain
 - Drain removed on postoperative day one for total output of 670 mL



Pathophysiology of blood loss

- Blood loss occurs both intraoperatively and postoperatively
- Blood loss from surgical trauma causes an increase in platelet activity, an increase in coagulant factors and a decrease in coagulation inhibitors



Pathophysiology and clotting cascade

- Three layers make up the blood vessel wall (intima, subendothelial, and adventitia)
- Inner most layer keeps the blood flowing and excretes procoagulants, anticoagulants, and fibrinolytics
- The second layer is rich in collagen, which helps platelets adhere to the wall to repair the injury
- The third layer produces factors in platelet function and factors that produce vasodilation and vasoconstriction

(Nagelhout & Plaus, 2014)



Pathophysiology and clotting cascade

- When there is damage to the vessel wall, it is detected by the intima layer and the body responds to repair the injury.
- Vasoconstriction at the injury site occurs
- Different stages then occur to stop the bleeding and repair the damage

(Nagelhout & Plaus, 2014)



Pathophysiology and clotting cascade

- Adhesion stage
 - Von Willebrand factor appears and attaches to glycoprotein Ib to make platelets “sticky”
 - Platelets are linked together to form platelet plug
- Activation stage
 - Occurs when the platelet plug is not adequate to seal the injury and thus, the clotting cascade is activated
 - Fibrin is created to seal the injury and allow it to heal

(Nagelhout & Plaus, 2014)



Fibrinolysis

- Four factors make up a clot
 - Plasminogen, plasmin, fibrin and fibrin degradation products
- Once the injury is healed, fibrinolysis occurs to prevent excess buildup of fibrin

(Nagelhout & Plaus, 2014)



Fibrinolysis

- Alpha-Antiplasmin and tissue plasminogen activator inhibitor are responsible for stopping fibrinolysis
- Antithrombin III is activated to remove factors from the clotting cascade
 - Stops the formation of clots

(Nagelhout & Plaus, 2014)



Factors to help decrease blood loss

- Spinal anesthesia
- Use of tourniquet
 - Does not affect blood lost postoperatively
- Hypotensive anesthesia
- Acute normovolemic hemodilution
- Minimally invasive surgery
- Use of pre-donated autologous blood

(Gao et al., 2016)



Tourniquet use

- Tissue damage experienced by the Esmarch bandage causes an activation in platelet aggregation
- Tourniquet inflation produces hypercoagulable state
- At deflation, tissue damage and inflammation causes the release of tissue plasmin activator

(Burlelson et al., 2016; Kam, Kavanaugh, & Yoong, 2001)



Tourniquet use

- After tourniquet use, there is an increase in peripheral blood thrombotic activity
- Fibrinolysis peaks 6 hours after surgery but lasts up to two days
- Anoxia and tissue acidosis also promote the release of tissue plasminogen activator

(Blanié et al., 2013; Pachauri, Acharya, & Tiwari, 2014)



Tranexamic Acid

- Derived from amino acid lysine
- Reversibly binds with high affinity to one of the lysine binding sites on plasminogen
- Once TXA is bound, plasminogen is unable to bind with fibrin to complete fibrinolysis
- Plasminogen can no longer interact with fibrin to create fibrin degradation products
- Clot remains intact

(McCormack, 2012; Sadigursky et al., 2016; Sepah et al., 2001)



Tranexamic Acid Effectiveness

- Reduces amount of postoperative blood loss
- Reduces the need for blood transfusions
- Decreased hemoglobin drop in patients postoperatively

(Alvarez et al., 2008; Benoni, Lethagen & Fredin, 1997; Blanié et al., 2012; Burlelson et al., 2016; Dahuja et al., 2014; Danninger & Memtsoudis, 2015; Formby, Pickett, Van Blaricum, Mack, & Newman, 2015; Gao et al., 2016; Pachauri et al., 2014; Poeran et al., 2014; Sadigursky et al., 2016; Sepah et al., 2011)



Risks and Contraindications

- Several studies have found that TXA does not increase the risk for adverse events
- McCormack, 2012 found that the administration of TXA in cardiac surgery does not increase the risk of myocardial infarction

(Danninger & Memtsoudis, 2015; Gao et al., 2016; Hiippala et al., 1995; Pachauri et al., 2014; Poeran et al., 2014; Sadigursky et al., 2016)



Current FDA Contraindications

- Colorblind patients
- Patients with:
 - Subarachnoid hemorrhage
 - Active intravascular clotting
 - Allergy or hypersensitivity to TXA

(FDA, 2017)



Current FDA Precautions

- Renal insufficiency
- Patients with a history of thrombotic disease
- Concurrent administration with Factor IX or anti-inhibitor coagulant concentrates
- Patients in DIC

(FDA, 2017)



Laboratory studies

- Tranexamic acid administration has no effect on fibrinolytic activity on vessel walls
- Creates local fibrinolysis specific to the wound, that lasts through the postoperative period

(Hiippala et al., 1995; Benoni et al., 1997)



Cost Effectiveness

- Compared to aminocaproic acid
- Decreased hospital costs
 - Earlier rehabilitation
 - Decreased hospital stay
 - Improved patient satisfaction

(Danninger & Memtsoudis, 2015; Gao et al., 2016; Pachauri et al., 2014; Poeran et al., 2014; Sadigursky et al., 2016; Sepah et al., 2011)



Recommendations

- Unless contraindications are identified, all patients undergoing a total knee arthroplasty should be given TXA.
- Further research is needed to determine safety in at risk patients



Conclusion

- Patient given TXA despite previous history of DVT
 - No adverse events and patient did not require need for blood transfusion
- TXA should be considered in any patient undergoing total knee arthroplasty to improve patient outcomes




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Thank You Are There Any Questions?



Utilizing Dexmedetomidine During an Anterior Cervical Discectomy and Fusion

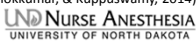
Danielle Kiedrowski, SRNA



Introduction


- Spine surgery is invasive and challenging
- Goals to maintain:
 - Safety with untainted neurophysiologic monitoring
 - Patient comfort
 - Stable hemodynamics
- Challenging due to:
 - Larger doses of opioids often needed thus increasing risk of negative opioid side effects
 - Higher concentrations of volatile and intravenous anesthetics to suppress hyperdynamic response
 - Increasing risk of interference of neurophysiologic monitoring

(Mariappan, Ashokkumar, & Kuppuswamy, 2014)




Case Information

- Anterior cervical discectomy and fusion of 4th and 5th cervical vertebrae
- 47-year-old
- Male
- 79 kg
- ASA physical status level III



Pre-operative Evaluation

- Past Medical History:
 - Seizures, anxiety, hypertension, developmentally delayed (neonatal meningitis), impaired mobility and activities of daily living, gait instability, and dysphagia
- Surgical History:
 - Ventriculoperitoneal shunt placement with two revisions, recent laminectomies of 2nd to 6th cervical vertebrae
- Patient presentation:
 - Following recent surgery, developed increased gait instability, left sided weakness, and dysphagia



Pre-operative Evaluation

- Pre-op VS
 - BP: 148/80
 - HR: 82
 - Rhythm: Normal sinus rhythm
 - Temperature: 98.7 degrees Celsius
 - Oxygen saturations: 98% on room air
- Pre-operative MRI:
 - Worsening disc herniation at the C4 and C5
 - Myelomalacia of the spinal cord at the C5
 - Warranting anterior cervical discectomy and fusion of the C4 and C5
- Airway evaluation:
 - Mallampati: III
 - Thyromental distance: less than 6 cm
 - Inter-incisor distance: less than 4 cm
 - Limited neck mobility

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Anesthetic Course

- Medications:
 - Induction: fentanyl 100 mcg, lidocaine 40 mg, rocuronium 5 mg, propofol 150 mg, and succinylcholine 140 mg
 - Maintenance: 1% sevoflurane inspired concentration in an oxygen and air mixture of 1 L/min each, a propofol infusion at 50 mcg/kg/min, and a dexmedetomidine (DEX) infusion at 0.5 mcg/kg/hr. No DEX loading dose was given
- Technique:
 - Modified rapid sequence induction and GlideScope (Verathon Inc., Bothell, WA)
- Rationale:
 - GlideScope (Verathon Inc., Bothell, WA): for intubation to minimize cervical vertebrae movement as well as the potential for difficult airway and placement of the endotracheal tube

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Intraoperative Issues

- Examples: Uneventful except slight hypotension was encountered mid-way during the case so the propofol infusion was decreased to 25 mcg/kg/min

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PACU

- Hemodynamics remained stable and was transferred to the post-anesthetic recovery unit without complications
- The post-operative evaluation was stable without anesthetic complications
- Patient was admitted as pre-operatively planned for close monitoring

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Post-operative Hospital Stay

- Length of stay: 8 days
 - Developed worsening dysphagia and required a GT tube
 - Required chest physiotherapy (failed incentive spirometry)
 - Intermittent fevers and bowel distension, resolved spontaneously
 - Successfully discharged to a group home with improved left sided-weakness and ambulation however still with a GT
 - Follow up with speech therapy two weeks for dysphagia

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Dexmedetomidine

- MOA:
 - α_2 -agonist, binds to the α_2 receptors in a 1620:1 ratio (Mariappan et al., 2014)
 - Produces sedative, amnesic, analgesic, anxiolytic, and sympatholytic properties without causing respiratory depression (Sen, Chakraborty, Santra, Mukherjee, & Das, 2013)
- Indications:
 - FDA approved for sedative infusions for 24 hours or less in the ICU setting when the patient is intubated and mechanically ventilated (Hospira, 2016)
 - Also approved for “sedation of non-intubated patients prior to and/or during surgical and other procedures” (Hospira, 2016, p. 3)

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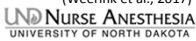
Dexmedetomidine

- **S/E:**
 - Hypotension, bradycardia, sinus arrest, transient hypertension, and dry mouth
 - When the infusion exceeds 24 hours: tachyphylaxis, agitation, acute respiratory distress syndrome, and respiratory failure
- **Dose:**
 - Loading dose of 1 mcg/kg given over 10 minutes
 - Maintenance infusion rate of 0.2 to 0.7 mcg/kg/hour for ICU sedation or 0.2 to 1 mcg/kg/hour for adult procedural sedation and titrated for desired clinical effect (Hospira, 2016)



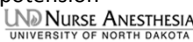
Dexmedetomidine: Pharmacodynamics

- **Sedative effects.** Stimulation of α_2 -receptors in the locus coeruleus among central presynaptic and postsynaptic receptors promoting an endogenous physiologic sleeping pattern
- **Analgesic effects.** DEX binding to the central and spinal cord α_2 -receptors resulting in decreased release of substance P and glutamate thus potentially resulting in opioid-sparing effects
- **Respiratory effects.** DEX minimally suppresses respiratory drive in which the response to carbon dioxide is still present mimicking a natural sleeping pattern (Weerink et al., 2017)




Dexmedetomidine: Pharmacodynamics

- **Cardiovascular effects.** Hemodynamic effects are dose dependent.
- Hypertension and bradycardia are commonly seen when high dosages (loading dose)
- Hyperdynamic vasoconstrictive response caused by the stimulation among α_2 -receptors within the vascular smooth muscle = \uparrow blood pressure and a \downarrow of heart rate from the baroreceptor reflex
- As DEX concentration diminishes, α_2 -receptors within the vascular endothelial cells respond by causing a vasodilation response resulting in hypotension (Weerink et al., 2017)




Anesthetic Considerations: Evoked Potentials

- Anesthetics diminish EPs by interrupting quality & accuracy
- Common IV anesthetic \rightarrow propofol (Sen et al., 2013)
 - \downarrow amplitude of SSEPs and \downarrow MEPs when given in high dosages (bolus doses) resulting in complete interruption of neurophysiologic monitoring (Bithal, 2014)
- All volatile anesthetics have dose dependent amplitude depression, prolonged latency, and motor suppression
- SSEPs are still possible with specific MAC value goals (Bithal, 2014):
 - Isoflurane: MAC value of 0.5-1.0
 - Sevoflurane and desflurane: MAC value less than 1.5
- MEPs are deterred at lower MAC values with all halogenated volatile anesthetics, however, still possible with a MAC value $<$ 0.5 (Bithal, 2014)
- As a rule of thumb, **goal MAC value of 0.5 would be safe for SSEPs or MEPs**




Anesthetic Considerations: Evoked Potentials

- DEX \downarrow anesthetic dosages without hindering neurophysiologic monitoring
- DEX does NOT prolong latency or \downarrow amplitude of SSEPs and MEPs when used at clinical doses (Rozet et al., 2015)
- IV anesthetics:
 - DEX also enhances hypnotic effect of propofol = reduced doses (Rozet et. al., 2015)
 - 48% \downarrow of propofol during induction and a 61% \downarrow during maintenance phase when DEX was used (Sen et al., 2013).
- Volatile anesthetics:
 - 28% decrease of sevoflurane concentration (Harsoor et. al., 2014)
 - 39% reduction in sevoflurane when DEX was used (Harsoor et. al., 2015)



Anesthetic Considerations: Pain Management

- Often, patient population that presents for spine surgery suffers from chronic pain and are treated with long-term opioid medications making pain management perioperatively difficult due to opioid tolerance (Dunn, Durieux, & Nemergut, 2016)
- Large dosages of opioids: cause hyperanalgesia and tolerance thus \uparrow opioid requirement for pain resulting in \uparrow negative opioid side effects (Mariappan et al., 2014)
- Interestingly, the patient described in the case report did not take chronic opioids in which did not fit the typical spine surgical patient and contrasts with this patient profile
- DEX contains analgesic properties therefore \downarrow opioid requirements intraoperatively and post-operatively
- With the \downarrow of opioids, hyperanalgesia, tolerance, and side effects that are associated with opioids and can be \downarrow with the use of DEX



Anesthetic Considerations: Pain Management

- 67 ACDF patients investigating pain, range of motion, motor function, and sensory function pre-operatively and post-operatively relating to patient satisfaction (Hessler et al., 2012)
 - Range of motion, motor function, and sensory function did **not** significantly impact patient satisfaction.
 - Improvement of pain displayed a significant role in patient satisfaction as well as the patient's perception of success of the surgery (Hessler et al., 2012)
- Reduction of opioid use:
 - 66% decrease of opioid requirement post-op with DEX (Arain et al., 2004)
 - 54% decrease in opioid requirement (Garg et al, 2016)
 - A lower pain score, less rescue pain medications, and a 28% decrease of opioid use among individuals that received DEX (Kim et al., 2013)



Evidence Based Recommendations: Practice

- **Method of Anesthetic.** Total intravenous anesthesia technique is superior over the use of volatile anesthetics as there is less potential of interruption of SSEPs and MEPs (Bithal, 2014; Mahmoud et al., 2010; Rozet et al., 2015)
- However, combination of volatile with IV anesthesia is still possible
- Maintaining a MAC of 0.5 or less would allow either SSEPs or MEPs to be safely monitored
- If MEPs are used, consider duration of action of paralytic for intubation



Evidence Based Recommendations: Additional Research

- Bradycardia is more common following the loading dose
 - Suggests the omission of the dexmedetomidine bolus may be advantageous in preventing bradycardia
 - However, additional evidence is needed for this finding to be generalizable



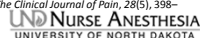
Conclusion

- Anesthetic and opioid requirements during spine surgery are ↓ due to the analgesic and synergistic sedative properties that are present within DEX
- DEX is a great adjunct to use for spine surgery to enhance safety intraoperatively and increase patient satisfaction post-operatively
- Administration of DEX should be evaluated by the anesthesia professional in an individualized manner and carefully monitored
- Further research would be beneficial in the practice of DEX in other procedures or surgeries



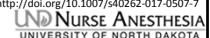
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Thank You
Are There Any Questions?




Management for Spinal-Induced Hypotension in Elective Cesarean Section

Louise Sin, SRNA




Introduction

- In US, spinal anesthesia is used for the majority of elective cesarean deliveries
- Maternal hypotension is a well-known complication with numerous studies reporting the incidence as high as 80% if without adequate prophylaxis
- Associated with other adverse effects such as bradycardia, nausea and vomiting
- Currently, several methods have been described to reduce the incidence including:
 - left uterine displacement (LUD), vascular filling with crystalloid or colloid, use of lower-leg compression and vasopressors, but no single technique has been confirmed to be completely effective




Case Information

- 38 year-old
- 58kg
- Gravida 3, Para 2
- 39 week gestation
- ASA 2
- Presented for an elective c- section with tubal ligation




Pre-operative Evaluation

- Pre-op VS: BP 138/70, P 76/min
RR 20/min, Temp 36.5
- Labs: Hgb 11.6 gm/dL, platelet 228
- Past Medical History unremarkable
- NKDA
- Surgical History: two previous c - sections and a tonsillectomy in childhood
- Current medication: prenatal vitamins
- Airway evaluation: Mallampati II, neck FROM




Anesthetic Course – Spinal Anesthesia

- Pre-load: LR 800ml (10ml/kg) before brought to the OR given within 20 minutes
- Ondansetron 4 mg IV – given before placement of spinal
- Drugs: bupivacaine 0.75% - dextrose 8.25% 1.4ml (10.5mg), fentanyl 20 mcg and morphine 0.2mg
- Placed in supine with left uterine displacement
- T4 dermatome level was obtained
- 3L Oxygen
- Cefazolin 2g IV was given
- Co-load: 800ml (10ml/kg) after spinal block
- Decrease to maintenance rate afterward




Intraoperative Issues

- The first vital sign after spinal – BP 137/68mmHg, HR 105/min
- NBP was monitored every 2.5 minutes
- The SBP were between 120 -135 mmHg before skin incision and then 105– 134 mmHg for the whole procedure
- Patient had no nauseous feeling and no vasopressors (ephedrine/ phenylephrine) was given
- Baby was born 15 minutes after incision with Apgar score 8 and 9
- EBL was 700 ml with 1.5 liters of LR given intraoperatively




PACU

- Transported to the post anesthesia care unit (PACU) on room air
- Did not experience PONV nor require additional pain medication in the PACU
- Discharged home on post op day 3

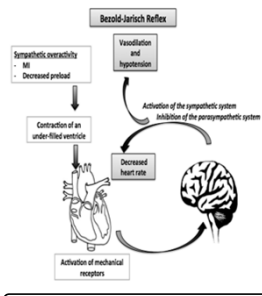


Discussion

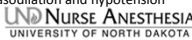
- Traditionally, management of hypotension following regional anesthesia in obstetric has been based on the results of animal experiments in pregnant sheep in the 1960s
- In particular, those studies showed that large doses of vasopressors could result in fetal hypoxia (Khaw et al., 2006)
- This led to an emphasis on non-pharmacological methods and established ephedrine as the vasopressor of choice in obstetric
- However, the results of recent clinical research has declined the superiority of ephedrine and phenylephrine has replaced the choice in current practice (Gao et al., 2015)



Mechanisms of Hypotension During Spinal Anesthesia




- Initially caused by a decrease in systemic vascular resistance (SVR) following pre-ganglionic sympathetic blockade, then leads to peripheral vasodilation and venous pooling
- An additional explanation for hypotension is the **Bezold-Jarisch reflex (BJR)**
- BJR originates from inhibitory mechanoreceptors located in the left ventricle
- The contraction of the poorly filled ventricle stimulate those receptors
- These receptors in turn stimulate parasympathetic pathways and inhibits the sympathetic pathways
- The result of this reflex is a constellation of bradycardia, vasodilation and hypotension




Use of 5-HT3 Antagonist in Bezold-Jarisch Reflex Induced Hypotension

- Routinely, ondansetron is used for treatment of postop nausea, vomiting, and chills
- Research found 5-HT3 can induce the BJR (Sahoo et al., 2012; Owczuk et al., 2008)
- **Sahoo and colleagues (2012)** – conducted a double-blind randomized study on 56 ASA I obstetric patients undergoing elective C- section
- Patients were randomly assigned into two groups receive either IV ondansetron 4mg or normal saline 5 minutes before spinal
- Heart rate (HR), systolic (SBP), diastolic (DBP), mean pressure (MAP) and oxygen saturation (SpO2) were recorded
- Their result indicated that ondansetron prevented BJR, suppressed venodilatation, augmented venous return to the heart and result in lesser reduction in SBP and MAP



Optimal Dosage for Ondansetron Injection

- **Wang and colleagues (2014)** – designed a double-blinded randomized study to compare the efficacy of different doses of ondansetron on reducing maternal hypotension
- A total of 150 participants were assigned to one of five groups
- 5 minutes prior to spinal, they were injected with 5ml of saline (S) or 2mg (O2), 4mg (O4), 6mg (O6) or 8mg (O8) of ondansetron
- The results revealed that the incidence of maternal hypotension was significantly reduced in groups O4 and O6 (p< 0.05) and no bradycardia or vomiting in groups O4, O6 and O8
- Regarding neonatal outcome, there was no significant difference in pH, Pco2, PO2, Hco3 or base excess (P> 0.05)
- Therefore, considering its effects on hypotension, nausea, phenylephrine consumption and neonatal outcomes, **ondansetron 4mg was the optimal dose**



Vasopressor Use in Obstetric

Ephedrine

- Mixed α and β receptor agonist
- Mechanism – both direct (binds and stimulates receptors) and indirect (causes release of norepinephrine from presynaptic vesicles)
- Causes an increase in cardiac contractility, HR, CO, systolic and diastolic BP
- An important concern about ephedrine is the association between its use and fetal acidosis

- Ephedrine has metabolic stimulatory effects that has use for weight loss and athletic performance enhancement in adults
- Maternally administered ephedrine increases fetal HR when large doses of Ephedrine are given before delivery (Ngan Kee and Khaw, 2006)

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Vasopressor Use in Obstetric

Phenylephrine

- Chemically related to adrenaline but pharmacodynamically similar to norepinephrine
- It is a potent, fast-acting with a short duration of action that selectively stimulates α -1 adrenoreceptors with very little activity on the β -1 receptors

- Ngan Kee and Lee (2008) – investigating different factors that predict uterine arterial pH and base excess, and concluded that in order to minimize the risk of fetal acidosis, **ephedrine should NOT be used before delivery** and α -agonist should be the choice for treating spinal hypotension
- Phenylephrine has become firmly established as the vasopressor of choice, for both prophylaxis and treatment of spinal hypotension in obstetrics

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Vasopressor Infusion

- Currently, research continues to focus on optimizing the administration of phenylephrine
- Areas that have been studied include:
 - how phenylephrine could best be administered?
 - whether it should be used proactively (prophylactically) or reactively (only when spinal hypotension has occurred)?
 - whether continuous infusions are superior to bolus?
 - the appropriate dose to avoid side effects such as reactive hypertension and bradycardia (Hessen, 2015)
- Hessen (2014) – a meta-analysis looking at the use of phenylephrine for elective c - section
- Concluded that a continuous infusion (proactive treatment) **started immediately after initiation of spinal** can effectively reduce hypotension and nausea without inducing fetal acidosis compared with bolus doses given only in response to a fall in SBP (reactive treatment)

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Vasopressor Infusion Cont'd

- Although some anesthesia providers regard prophylactic phenylephrine infusion as too aggressive, the review by Heesen (2014) reassured that the risk of reactive hypertension has no difference between prophylactic and reactive regimens and the risk of bradycardia was also similar between groups.
- Study by Stewart et al. (2010) suggested that compared with higher doses, **25 – 50 $\mu\text{g}/\text{min}$** give the lowest rate of both hypotension and hypertension.

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Norepinephrine – The Future Practice?

- Recently, norepinephrine has appeared as a potential alternative agent for treating spinal-induced hypotension in obstetric (O'Sullivan & Cockerham, 2016)
- The reason is the mixed α and β agonist activity of norepinephrine makes it a preferable drug for maintaining BP with less bradycardia, less negative effective on CO and no difference in fetal outcome compared with phenylephrine
- There is limited information available in the literature and few reports of its use in obstetrics.

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Norepinephrine – The Future Practice?

- Ngan Kee (2015) – double-blinded, 104 healthy patients having elective c - section were randomized to have SBP maintained with a **computer-controlled infusion of norepinephrine 5 $\mu\text{g}/\text{ml}$ or phenylephrine 100 $\mu\text{g}/\text{ml}$**
- The primary outcome compared was CO, BP, HR and neonatal outcome
- The authors found that an infusion of norepinephrine maintained BP as effectively as phenylephrine, but with **less bradycardia and less decrease in CO**
- Also, no significant differences in neonatal outcomes

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Recommendations

- 5- HT3 Antagonist
 - Prophylactic 5-HT3 antagonist has an excellent effect on prevention of hypotension in healthy parturient
 - Most of the studies result support to give ondansetron 4mg **5 minutes before spinal**




Recommendations

- Use of Vasopressor
 - Several studies have shown good results with a phenylephrine infusion for treatment of hypotension. But additional studies are needed (Cooper, 2012; Heesen et al., 2015; Ngan Kee et al., 2008; Khaw, 2006)
 - A good starting point is to start at 50 mcg/min straight after spinal injection and then titrate to response, with bolus if needed
- Future Research
 - More RCT should be conducted to determine the safety, optimal infusion rate and dosing strategy of norepinephrine in obstetric




Conclusion

- Based on the clinical presentation of this case study and review of the latest evidence, a combination of pharmacological and non-pharmacological methods is beneficial in minimizing spinal - induced hypotension in elective cesarean delivery
- No single technique has been confirmed to be completely effective




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Thank You
Are There Any Questions?



Anesthetic Considerations of
Patients with MELAS


Maxine Lemaster, SRNA



MELAS

- Mitochondrial myopathies are a group of neuromuscular diseases resulting from a defect of mitochondrial deoxyribonucleic acid
- **Mitochondrial Myopathy, Encephalopathy, Lactic acidosis, and Stroke-like episodes (MELAS)** is a type of mitochondrial myopathy.
- MELAS was first discovered in 1984 by Pavlakis, who differentiated the syndrome from other mitochondrial disorders through clinical features and muscle biopsy
- The approximate incidence is 1 in 4,000 , affecting all ethnic groups and both males and females equally


(Hilton, 1995; Rivera-Cruz, 2013)



Pathophysiology

- Mitochondria are double membrane organelles that are found in nucleated cells
- The inner membrane contains the electron transport chain, serving as the site for oxidative phosphorylation via the Krebs cycle to produce adenosine triphosphate (ATP)
- ATP is necessary for cellular energy and aerobic metabolism
- Mitochondria also serve in apoptosis, cell division, steroid synthesis, heat production, and calcium homeostasis
- **MELAS primarily affects respiratory enzymes I and IV, resulting in an imbalance of energy requirements and availability**
- **Organ deterioration occurs with high energy demand**


(Park, et al., 2010; Rivera-Cruz 2013).



Pathophysiology


- Mutations in mitochondrial DNA are inherited maternally
- When the cell divides, random distribution to daughter cells allows both mutant and normal mitochondria to occur
- Symptoms of MELAS may not occur unless the mutation affects a threshold level
- **There is a diverse presentation of symptoms among those diagnosed with the disorder**
- Most common mutation is A-to-G transition in the gene MT-TL1 at nucleotide 3243

(Hsu et al., 2016 ; Maurtua, et al., 2008)




Case Information

- Surgical Procedure
 - Dental restoration secondary to dental carries
- Pertinent patient information
 - 5 year old male
 - **13.8 kg, 36cm**
 - ASA 2
 - No known allergies




Pre-operative Evaluation

- Past Medical History
 - Born cesarean section at 38 weeks and 2 days
 - Small for gestational age at 2.4kg
 - MELAS
 - **Hearing difficulty**
- Surgical History
 - Neonate circumcision
- Pre-op VS
 - BP 94/60, HR 66, RR 20, O2 saturation 100%
- EKG/Echo
 - **EKG showed sinus bradycardia with left ventricular hypertrophy**
 - Echocardiogram revealed normal cardiac structure and function without cardiomyopathy
- Airway evaluation
 - Mallampati I, FROM, thyromental distance of 3 fingerbreadths




Anesthetic Course

- Induction
 - Inhalational via facemask with 30% Oxygen/70% nitrous and titration of sevoflurane
 - 24 gauge IV inserted
 - 12.5 mcg fentanyl
- Technique
 - Neosynepherine spray to nares
 - 4.0 cuffed nasal RAE ETT inserted nasally
 - Mac 2 blade used to establish grade 1 view
 - McGills forceps used to guide ETT through glottis
- Maintenance
 - Sevoflurane to maintain anesthetic depth
 - 2mg ondansetron
 - 3mg dexamethasone
 - 22.5 mcg fentanyl (35mcg total)
- Ventilator settings
 - Spontaneous respirations with PSV pro assistance
- +BBS,+EtCo2, leak of <20mmhg




Intraoperative Issues

- Surgical course uneventful
- Total anesthesia time
 - 1 hour 20 minutes
- Fluid administration
 - 130 ml lactated ringers
- Blood loss negligible



PACU


- An oral airway was inserted and a deep extubation was performed when spontaneous respirations were maintained with sufficient tidal volumes and no response to suctioning noted
- 6 liters of oxygen applied via simple mask
- Transferred to the PACU without incidence
- Postoperative assessment revealed no apparent anesthetic complications
- Discharged home day of procedure



Presentation of MELAS

- Phenotypic variability secondary to:
 - heteroplasmly
 - tissue distribution
 - threshold effect
- Typically between ages 2-10
- Initial symptoms
 - Muscle weakness/ pain
 - Headaches
 - Anorexia
- Difficulty breathing
 - Short stature
 - Seizures
- Other common manifestations
 - Cardiomyopathy
 - Conduction abnormalities
 - Dementia
 - Peripheral neuropathy
 - Diabetes
 - Impaired vision or hearing


(DiMauro & Hirano, 2013)



Diagnosis

- Diagnosis of MELAS is based on clinical presentation along with biochemical, histochemical, and genetic analysis
- Blood Biochemistry
 - Increased lactate and pyruvate
 - May have increase creatinine kinase
- Imaging
 - Computed Tomography
 - Magnetic resonance imaging
 - Magnetic resonance spectroscopy
 - Positron emission tomography
- Muscle Biopsy
- Genetic Testing


(El-Hattab et al.; Wang & Le, 2015)



Treatment Options


- No cure for MELAS
- Dependent on symptoms
- Multidisciplinary approach
- Supplements
 - CoQ10
 - L-Arginine
 - Creatine
 - Vitamins
- Avoid medications known to cause mitochondrial toxicity
- Genetic counseling

(El Hattab, et al., 2015)



Preoperative Considerations


- Comprehensive assessment
 - Organ involvement is variable
- Laboratory Analysis
 - Endocrine, renal, hepatic function, metabolic panel, CBC, thyroid function
 - Lactic acid /ABGs
- Pulmonary function
 - Chest X-ray
 - Exercise tolerance
- Full neurologic exam
 - Seizures
 - Neuropathy
 - Stroke-like episodes
- Cardiac
 - 12 lead electrocardiogram for evaluation of conduction abnormalities
 - Echocardiogram to evaluate structure and function



Intraoperative Considerations

- Goals
 - Glycemic control
 - Prevent lactic acidosis
 - Sufficient oxygenation
 - Maintain cardiovascular function
 - Normothermia
 - Euvolemia
- Monitoring
 - Standard monitoring
 - Arterial line
 - Electrolytes, blood gas, lactate levels


(Sasano et al., 2007)



Neuromuscular blockers

- Myopathy may require rapid sequence induction with cricoid pressure
 - Nondepolarizer such as rocuronium or cisatracurium
- Response to NDMRs is controversial
 - Increased sensitivity of vecuronium, mivacurium, rocuronium, and atracurium reported
 - Decreased sensitivity related to antiepileptic therapy
 - Hepatic metabolism
 - Increased protein binding
 - Upregulation of acetylcholine receptors


(Aouad et al., 2005; Ellinas & Frost, 2011; Gurrieri, et al., 2011)



Anesthesia

- Volatile agents
 - Depress oxidative phosphorylation in dose dependent manner
 - May have higher sensitivity
 - Considered safe in MELAS
- Propofol
 - Inhibits mitochondrial function through respiratory enzymes in Krebs cycle
 - Induction doses safe
 - Questionable higher risk for PRIS in long term infusions
- Narcotics
 - Considered safe
 - May be at higher risk for respiratory depression in patients with severe myopathy
- Fluid selection
 - Normal saline


(Ellinas & Frost, 2011; Niezgoda & Morgan, 2013; Rivera-Cruz, 2013; Sasano, 2007)



Malignant Hyperthermia

- Malignant Hyperthermia Association of the United States conducted literature review, **revealing little to no association between MH and Mitochondrial myopathies**
- No controlled trials
- Recommendations from MHAUS
 - No need to avoid volatile agents
 - Use caution with succinylcholine due to possibility of hyperkalemia in myopathic patients
 - Anesthetic plan should be based on patient's symptoms, treatment, and type of surgery

(MHAUS, 2017)



Local Anesthesia

- Regional beneficial in reducing stress response
- Specific local anesthetics found to have negative effects on mitochondria
- Consider possible symptoms that may affect neuraxial anesthesia: peripheral neuropathy, sensory loss, learning difficulties, short stature, and myopathy
- Case reports have demonstrated successful use of neuraxial anesthesia

(Bolton, 2003)



Conclusion

- MELAS has a variable presentation that requires a thorough investigation by the CRNA to devise an anesthetic plan
- Careful administration of neuromuscular blockers, volatile agents, propofol, and regional anesthesia is necessary
- Avoid increases in energy requirements
- Postoperative observation of glucose, temperature, pain, and respiratory efforts
 - May require observation in the ICU

(Flanagan & Cheek, 2016)



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Thank You
Are There Any Questions?

