UND Nurse Anesthesia Program Student DNP Project Presentations

2026 Spring Educational Meeting
North Dakota Association of Nurse Anesthetists
Fargo, ND

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Implementation of a Local Anesthetic Systemic Toxicity Education Program for Perioperative Nurses

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Local Anesthetic Systemic Toxicity

- A high-stakes, low-frequency event
- Most often occurs by:
  - Inadvertent intravascular injection
  - Exceeding maximum recommended safe doses
  - Increased vascular uptake of LA

(Joudeh et al., 2025)

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Incidence

- As mentioned, exceedingly rare
- Estimated to be about 1.8 out of 1000 peripheral nerve blocks (Macfarlane et al., 2021)
  - May be misdiagnosed and therefore underreported
- In 53% of LAST cases, symptoms occurred within 10 minutes after LA injection (Mahajan et al., 2022)

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Literature Review

- Search Strategy
  - Databases: Medline, CINAHL, PubMed, Joanna Briggs Institute, Google Scholar
  - Keywords: Local anesthetic systemic toxicity, local anesthetic toxicity, education, perioperative nurse, lipid emulsion, treatment, local anesthetic systemic toxicity education program for nurses.
  - Limited to publication dates between 2015 and 2025
  - Resulted in many articles that were narrowed down to 13 articles included in our literature review

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Literature Review Continued

- Knowledge deficit about LAST among nurses was prevalent in the literature
  - Bevil et al., 2019 showed an average score of 52% on pretest
  - Ferry and Cook, 2020 identified only 29% of their sample of perioperative nurses had previous knowledge of LAST
  - White et al., 2024 showed that ~90% of nurses were aware of LAST, only 51.6% were able to accurately identify symptoms of LAST

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Goals

- 60% of perioperative nursing staff will complete the LAST education program including pre and post-test by November 21, 2025
- 70% of perioperative nurses who complete the LAST education program will report increased confidence in the recognition and management of LAST.
- 70% of perioperative nursing staff who complete the LAST education program will demonstrate increased knowledge on the recognition and management of LAST.

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Purpose

- Increase knowledge and confidence of perioperative nurses related to LAST recognition and management
- Increase patient safety and improve timely recognition and rapid management of LAST

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Education Module

- What was covered?
  - Signs and Symptoms of LAST
  - ARSA Checklist
  - Where to find Lipids at their facility
  - Lipid emulsion therapy

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Who is at Risk?

- Anyone who receives local anesthetic
- Increased risk
  - Extremes of age
  - Pregnancy
  - Carnitine deficiency
  - End organ failure
  - Cardiovascular disease
  - Liver disease
  - Decreased plasma protein concentration
  - Metabolic or Respiratory Acidosis
  - Taking medication that inhibit sodium channels

(White et al., 2024)(Mahjan et al., 2022)

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Signs & Symptoms

Early

- Circumoral numbness
- Metallic taste
- Auditory changes – ringing in ears
- Lightheadedness
- Visual changes
- Agitation

Late

- Muscle twitching
- Seizures
- Coma
- Respiratory arrest
- Cardiac excitement - tachycardia, ventricular arrhythmias, and hypertension
- Cardiac depression - bradycardia, hypotension, impaired contractility, asystole

(White et al., 2024) (Macfarlane et al., 2021)

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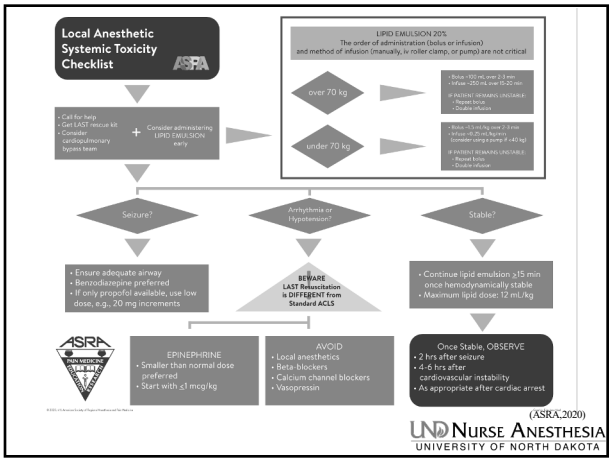

(ASRA 2020)

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Lipid "Shuttle"

- Previous theory "Lipid Sink"
  - Compartment fill with lipids prior to removing LA from the system
- Move to multi system approach of "Lipid Shuttle"
  - LA are lipophilic with positive charge
  - Negative charged lipids draw out LA from highly perfused areas
    - heart and brain
  - Lipids "Shuttle" LA to larger mass organs
    - Muscles – storage
    - Liver – detoxification

(Ernesto & Pak, 2024)

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DNP Scholarly Project

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Design & Methods

- Quasi-experimental, one-group pretest-posttest design
- Population
  - Perioperative Registered Nurses (30)
    - Pre-operative & Post operative (12)
    - Operating Room Circulators (18)
- Setting
  - 133 bed Level II Trauma Center in the upper Midwest

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Procedures

- In person educational module was presented on three separate occasions during monthly staff meetings.
- Participants completed a pre-test and were given an ASRA LAST checklist handout and 30-minute PowerPoint educational module on LAST.
- Next participants completed a Post-test.

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Results

Table 2: OR Circulator - Knowledge Questions

	Pre-Intervention	Post-Intervention	Significant (p ≤ .05)
Question 1	66.7%	88.9%	p = .054
Question 2	61.1%	88.9%	p = .027
Question 3	27.8%	83.3%	p < .001
Question 4	22.2%	88.9%	p < .001
Question 5	22.2%	94.4%	p < .001
Question 6	11.1%	88.9%	p < .001
Question 7	38.9%	94.4%	p < .001
Question 8	22.2%	88.9%	p < .001
Question 9	27.8%	44.4%	p = .149

Table 3. PACU/Pre-op - Knowledge Questions

	Pre-intervention	Post-intervention	Significance (p ≤ .05)
Question 1	83.3%	100.0%	p = .070
Question 2	58.3%	100.0%	p = .006
Question 3	75.0%	91.7%	p = .137
Question 4	41.7%	100.0%	p < .001
Question 5	58.3%	91.7%	p = .030
Question 6	25.0%	100.0%	p < .001
Question 7	25.0%	83.3%	p = .002
Question 8	33.3%	100.0%	p < .001
Question 9	25.0%	58.3%	p = .049

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Results Continued

Table 5. OR Circulator - Confidence Questions

	Pre-Intervention (Mean)	Post-Intervention (Mean)	Significance (p = .05)
Question 1	2.44	3.72	p < .001
Question 2	2.17	3.44	p < .001

Table 6. PACU/Pre-op - Confidence Questions

	Pre-Intervention (Mean)	Post-Intervention (Mean)	Significance (p = .05)
Question 1	2.58	3.75	p < .001
Question 2	2.42	3.58	p < .001

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Interpretation of Results

Table 4. Combined Knowledge Test Score Comparisons

	Pre-Intervention	Post-Intervention	Significance (p=.05)
OR Circulator	33.3%	84.6%	p = <.001
PACU/Pre-op	47.2%	91.7%	p = <.001

- This table represents a pooled average of total test scores both pre- and post-intervention.
- Based on these results we can reasonably ascertain that we accomplished the goals of our project

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Implications

- Practice Implications
  - This project assessed the need for LAST education for perioperative nurses. Further follow up is required to assess the full implication of the LAST educational module for perioperative nurses.
- Clinical Implications
  - Education concerning low-incidence, high-stakes events will potentially better prepare the care team to manage these crises and lead to more favorable patient outcomes.

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Conclusions

- Limitations
  - Pre-test/Post test timing
  - Lack of long-term retention assessment
  - Small sample size
- Sustainability
  - Education modules are easily adapted to fit unit needs.
- Future Directions- what can CRNAs do with this information?
  - Can be expanded on to include other departments that care for patient's receiving local anesthetics i.e. L&D
  - Include high-fidelity patient simulations for team-based learning opportunities

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Thank You
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Improving Teamwork for Emergency C-sections Requiring General Anesthesia

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Why This Matters

Approximately 32% of deliveries in the US are via C-section
Only 3-6% of C-sections are performed under general anesthesia
Limited exposure means OB nurses rarely experience GA inductions
Prolonged decision-to-delivery intervals increase maternal and perinatal morbidity and mortality

(Ring et al., 2021; Ayeni et al., 2021)

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Practice Problem

During emergency induction of general anesthesia for cesarean section, impaired teamwork and task saturation can lead to missed critical tasks and delays in care that place the parturient and fetus at increased risk for complications.

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Purpose of This Project

Develop and present an educational module and simulation to improve OB nurses' understanding and confidence working with anesthesia providers during OB emergencies that require general anesthesia.

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Design & Methods

Quantitative pretest-posttest design

Level II trauma center in the Midwest to labor and delivery nurses

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Education and Simulation Session

- Obstetric pathophysiology changes
- Risk of GA to the parturient
- Emphasize monitoring, vascular access, equipment, positioning, airway
- Simulation of emergency c-section

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Benefits of Simulation

- Opportunity to promote teamwork & reflection
- Improve clinical outcomes, skills, and knowledge retention
- Opportunity to improve efficiency & safety

(MacLennan et al., 2023; Ortner et al., 2014)

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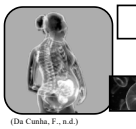
Changes in Cardiovascular Physiology


(Da Cunha, F., n.d.)

Cardiovascular
- ↑ blood volume
- ↑ CO
- ↑ HR

Necessitates Need For:
- ✓ EKG monitors
- ✓ BP Monitors
- ✓ Pulse Oximeters

Hematological
- ↑ plasma > RBCs = anemia
- ↑ platelet consumption and aggregation -> hypercoagulable state.
  - ↑ risk of thrombotic or bleeding events

Necessitates Need For:
- ✓ Patent IV for medications

(AANA, 2023)

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Changes in Vascular Physiology


(Image source: iStock by Getty Images)

↓ SVR → ↑ peripheral venous engorgement → Capillary engorgement of the airway → Oropharyngeal and glottic edema → Potential Difficult Intubation!

(AANA, 2023)

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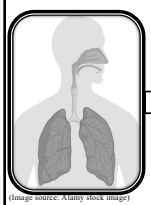
Changes in Respiratory Physiology


(Image source: Alamy stock image)

- ↑ MV and VO2
- ↓ FRC
- ↑ chest circumference and breast volume -> more difficulty manipulating the laryngoscope blade

Necessitates Need For:
- ✓ Good Patent Positioning
- ✓ Preoxygenation

(AANA, 2023)

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Changes in Gastrointestinal Physiology


(Image source: Shutterstock illustration stock)

- ↑ risk of gastric reflux
- ↓ gastric emptying times
- ↓ lower esophageal sphincter tone

Increased Risk of Aspiration!
- ✓ RSI
- ✓ Cricoid Pressure

(AANA, 2023)

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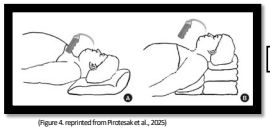
PATIENT POSITIONING FOR GA INDUCTION

Goal: align the external auditory meatus (ear) with the sternal notch
- Sniffing position
- Ramp with device or blankets


(Figure 4, reprinted from Pirotesak et al., 2025)

Optimal position for successful intubation

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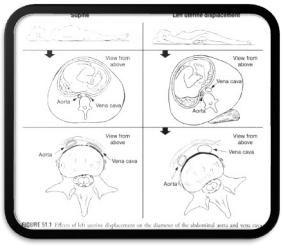
Left Uterine Displacement

- ✓ Uterine bump under the right hip
- ✓ Bed can be tilted to the left



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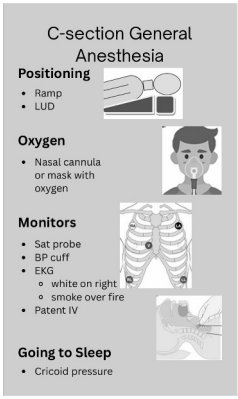
Education Resource



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Essential Points

- Physiologic changes in pregnancy increase GA difficulty and risk
- Teamwork reduces task saturation during stressful scenarios and improves outcomes
- Simulation maintains skills and knowledge for high-risk obstetric emergencies

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Demographics

- 6 RNs without any critical care or OR experience

Table 1

Years	As an RN	In OB
0 to 2	1	1
6 to 8	1	3
> 9	4	2
Totals	**6**	**6**

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Results

- 4 Likert-style confidence questions
  - All showed improvement in confidence
- 6 Multiple-choice knowledge questions
  - 4/6 showed improvement
  - 2/6 showed no change

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Interpretation of Results

Statistically significant improvements in both knowledge and confidence

Positive impact combining didactic education and simulation

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Implications

- Regular education and simulation training helps maintain skills for rare but high-risk obstetric emergencies.
- Improved team preparedness reduces delays and improves outcomes.
- Participants reported positive feedback and perceived the training as valuable for clinical practice.

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Conclusions

Limitations	• Small sample size
Sustainability	• 30-minute training • Reproducible
Future Directions	• Yearly education • Additional sites

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Thank You
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Bispectral Index Monitoring and Postoperative Neurocognitive Disorders in the Geriatric Population

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Introduction

- What happens after anesthesia matters too, especially in older adults
- Geriatric patients are at increased risk for PoNCD, leading to serious downstream effects
- BIS monitoring offers an evidence-based solution to guide anesthetic depth
- Despite this, it remains underutilized in clinical practice

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Purpose

- **Educate:**
  - Incidence and clinical relevance of PoNCD in geriatrics
  - Efficacy of BIS monitoring in decreasing PoNCD.
  - Current evidence supporting the use of BIS monitoring to decrease PoNCD.
- **Our Goals:**
  - Provide an educational module to 70% of anesthesia staff at designated level II trauma center
  - Observe a 10% increase in scores to show an improvement in knowledge base from participation in pre- and post-training assessments
  - Demonstrate at least 75% of provider knowledge retention on post-training assessment one month following initial module presentation

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Background and Significance

The geriatric population is increasing and is at a higher risk of developing PoNCD

- The geriatric population is continually growing:
  - Currently 12% of the general population
  - Expected to be 22% by 2050 (Bettelli, 2023)
- The growing aging population, combined with medical advances, correlates to an increase in geriatric surgical care recipients.

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Postoperative Delirium

- Delirium diagnosed during the period occurring as soon as 10 minutes within the postoperative period up to 7 days or until discharge, whichever happens first
- **Characterized by:**
  - Hypoactive symptoms (More common in elderly patients and associated with poorer prognosis)
  - Hyperactive symptoms
  - Combination
- **Risk factors:**
  - Polypharmacy, long duration of procedure, pre-existing neurological conditions
- **Assessment:**
  - Confusion Assessment Method (CAM)

(European Society of Anaesthesiology, 2017; Janjua et al., 2023)

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Postoperative Cognitive Dysfunction

- Defined as a decline in cognitive function that may last from 1-12 months after surgery or longer without universally accepted diagnostic criteria
  - Symptoms may mimic signs of typical aging with subtle onset
  - Best assessed by comparing pre-surgical neurocognitive function tests to post-operative tests
    - Mini Mental State Examination (MMSE)

Signs and Symptoms
- Loss of memory
- Difficulty concentrating
- Decreased ability to perform executive functions

Effects
- Increased length of hospital stay
- High medical expenses
- Loss of autonomy
- Increased mortality

(Elisha et al., 2023; Wang et al., 2023)

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BIS Monitor

- Well-known tool that uses a proprietary algorithm to analyze raw EEG data
  - Produces a dimensionless BIS value that correlates to level of sedation and awareness
- Target BIS range during general surgery: **40-60**
- Derived from:
  - Degree of high frequency activation
  - Amount of low frequency synchronization
  - Presence of nearly suppressed periods
  - Presence of fully suppressed periods

(Medtronic, 2021; Wang & Huang, 2021; Wright et al., 2023)

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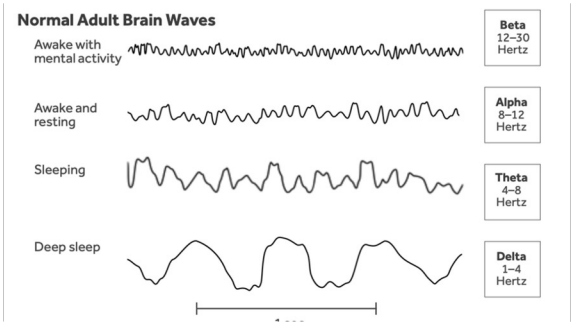

(Medtronic, 2020)

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Bis Monitoring and POD

- Treatment of POD begins with **prevention**
  - 30-40% of POD is preventable
  - Further treatment is targeted towards identified cause(s)
- BIS potentially reduces postoperative delirium in geriatric patients by avoiding burst suppression and excessive anesthesia
- BIS reduces the neurotoxic effects of anesthetics by reducing overuse of anesthetic agents
- BIS ensures sufficient sedation to avoid intraoperative awareness which is associated with POD

(Elisha et al., 2023)

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Literature Review

- **Level of anesthetic depth**
  - There is a correlation of anesthetic depth, dosing of anesthetic agents, and the BIS value
  - Anesthetic depth affects the development of POCD
- BIS monitoring decreased incidence of delirium by 17.5% compared to 27.5% in non-BIS group(Zhou et al., 2018)
- BIS-guided anesthesia decreased POCD by 31% 3 months post non-cardiac surgery (Gu et al.,2024).

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Literature Review

- **Neuroprotection**
  - BIS monitoring proved to be protective against POD 1 day postoperatively (Gu et al., 2024)
  - Use of BIS monitoring was neutral for POCD 1 week postoperatively, BIS was found to be protective against POCD 12 weeks after surgery (Bocskai et al., 2020)
  - Lighter plane of anesthesia provides better neuroprotection (Hou et al., 2017)

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Literature Review

- **Additional benefits**
  - Reduction in time to extubation
  - Quicker time to orientation
  - Decreased OR time and PACU time
  - Reduced incidence of PONV
- **Type of surgical procedure**
  - No statistically significant difference between BIS and non-BIS in cardiac, orthopedic, or colon surgery (Shan et al., 2021)

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Anesthesia Implications

- **Factors that influence the readings of the BIS Monitor:**
  - Choice of anesthetic agent(s)
  - Patient's age
  - Pre-existing neurological conditions
  - Temperature
  - Surgical equipment interference and artifact
- **Increased patient satisfaction**
  - Reduced PONV
  - Decreased time to extubation
  - Decreased OR and PACU time

(Wang & Huang, 2021; Oliviera et al., 2015)

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Best Practices

- Apply BIS monitor prior to induction
- Maintain BIS range 40-60
- Consider MAC requirements of geriatric patients
- Maintain normothermia
- Alternative methods for postoperative pain control
- ERAS Guideline Recommendation:
  - *"Summary and recommendation:* anaesthetic depth should be guided either maintaining an end tidal concentration of 0.7–1.3 MAC or BIS index between 40 and 60 with the aim not only to prevent awareness but also to minimize anaesthetic side effects and facilitate rapid awakening and recovery. Avoid too deep anaesthesia (BIS < 45), especially in elderly patients"
  - *Recommendation grade*: strong

(Feldheiser et al., 2016)

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Design and Methods

- Setting: Level II trauma center in the upper Midwest
- Participants: Anesthesia providers
  - 13 out of 17 CRNA's attended
- Design: single-group, quasi-experimental design
  - Pretest, posttest, and retention test
  - Survey exploring changes in practice

Pretest → Education → Posttest → Retention Test

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Results

- Goal: Present educational module to 70% of anesthesia staff at designated level II trauma center
  - 13 out of 17 CRNA's; 76.4%
- Goal: Observe a 10% increase in scores to show an improvement in knowledge base from participation in pre- and post-training assessments
  - High pretest scores; No decline in posttest scores
- Goal: Demonstrate at least 75% of provider knowledge retention one month following initial module presentation
  - There was no decline in knowledge retention; there was a 15.4% increase regarding one item on the retention test compared to the post test

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Question #	Pretest % Correct	Post % Correct	% Difference	Statistical Significance
1	100%	100%	0%	No
2	92.3%	100%	-7.7%	No
3	69.2%	61.5%	7.7%	No
4	84.6%	100%	-15.4%	No
5	23.1%	69.2%	-46.2%	Yes
6	92.3%	100%	-7.7%	No
7	100%	100%	0%	No
8	15.4%	61.5%	-46.2%	Yes
9	92.3%	100%	-7.7%	No
10	100%	100%	0%	No

- The paired-response results were compared using the Wald statistic at a significance level of $0.05_{1\text{-tail}}$.
- All retention test scores were the same as posttest scores with the exception of question 3 where there was a 15.4% increase

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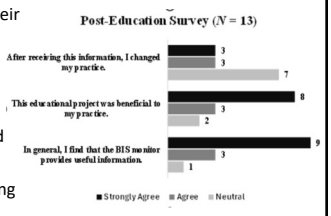
Results

- 11 of 13 CRNAs (84.6%) found the information to be beneficial to their practice
- 6 of 13 CRNAs (46.2%) confirmed changing their practice after receiving the education
- 12 of 13 CRNAs (92.3%) identified that they either agreed or strongly agreed the BIS monitoring education was useful



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Implications

Practice Implications	Clinical Implications
• Improve knowledge and confidence in the use of BIS monitoring to decrease postoperative cognitive disorders • Integration of multimodal brain monitoring as comprehensive brain-protective strategy	• Deliberate anesthetic interventions for the geriatric population for improved outcomes • Optimizing anesthetic depth with individualized dosing strategies • Prevention of burst suppression or avoidance of prolonged burst suppression

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Future Directions

Proposed future DNP practice change projects:

- Integration of standardized cognitive assessment into preoperative workflow for geriatric patients
- Focus on enhancing accuracy in detecting postoperative cognitive outcomes

Intervention Strategies:

- Incorporate Mini Mental State Examination into preoperative examinations
- Standardize timing and administration procedures across providers
- Ensure appropriate training for healthcare staff conducting assessments

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Limitations & Sustainability

- **Limitations:**
  - Limited generalizability
  - Single site-implementation
  - Small sample size
- **Sustainability:**
  - Developed educational module for future use
  - Ongoing training for anesthesia providers
  - Cognitive assessment tools for reinforcement of evidence-based practices

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Conclusion

- Project participants demonstrated competency through performance on assessment tools
  - Retention assessment useful for evaluation of short-term knowledge
- Bispectral index monitor is a valuable indicator of anesthetic depth
- Enhanced understanding of interventions and anesthetic agents supports geriatric neurologic outcomes
- Individualized anesthetic care is essential for optimizing geriatric patient outcomes

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Thank You
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Airway Management in the Rural Setting

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Spring 2026

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Introduction

- Inadequate airway management has devastating consequences.
  - Complication rate is 45% higher for out of department emergent airways.
  - Increased risk of morbidity and mortality.
- Contributing factors
  - Provider inexperience.
  - Failure to adhere to failed airway protocol.

(Tankard et al., 2022)

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Purpose

- To assess the impact of providing an educational session to rural hospital staff on airway management and related technical skills.
- Goals:
  - Enhance staff knowledge and confidence with assisting or providing airway management.
  - Provide hands-on practice with airway equipment to develop competency.

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Background

- Rural healthcare challenges
  - Limited resources
  - Provider shortages
  - Lack of specialty care
  - Increased ED utilization
- Collaborative and experienced team approach to airway management

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Literature review

- Difficult airway
- Sellick's maneuver/ BURP
- Positioning
- BVM/Adjuncts
- Education/Simulation
- Rural Health

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Difficult Airways

- Defined as difficulty or inability to successfully facemask ventilate and/or achieve tracheal intubation.
- Incidence 0.07-0.16%.
- Unpredictable despite thorough assessment.

(Jung, 2023; N.A., 2003)

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Sellick's Maneuver/BURP

- Sellick's maneuver
  - Cricoid pressure that is utilized during rapid sequence intubation to reduce risk of aspiration.
  - ~30-40 newtons
  - Controversial benefit
- BURP
  - Backward, upward, rightward, posterior pressure used to better exposure larynx during intubation.
  - Reduced incidence of difficult laryngoscopy

(Neumar et al., 2020; Yu et al., 2020)

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Positioning

- Optimal Intubating Conditions
  - Ramping
  - Shoulder Rolls
  - HOB elevated
  - Head position higher in bed
- Sniffing position
  - Oral, pharyngeal and laryngeal axes alignment
  - Improved positioning facilitates successful intubation

(Bennet et al., 2020; George et al., 2024; Higgs et al., 2018; Sarma et al., 2020)

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Bag-Valve Mask

- Vital components of BLS
  - Appears easy, but difficult to master.
- EC vs Two-handed technique
- Pressure limits

(Komatsu et al, 2010)

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Education/Simulation

- Hands on components of educational sessions promote long-term knowledge retention.
- Frequent use of knowledge and skills is critical in remaining competent.

(Albooghobeish et al., 2024; Myers et al., 2024; Grabinky et al, 2011)

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Design & Methods

- Quasi-experimental, one-group pretest-posttest design
- Critical access hospital (CAH) in northwest Minnesota
- Population included 13 healthcare professionals who assist during airway manipulation
- Participants completed a pretest, education session, and posttest

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Results

- Participants scored high on knowledge-based questions
  - ACLS, BLS experience
  - Knowledge gaps
- Confidence questions:
  - Demonstrated participants had high confidence using many BLS techniques.
  - Showed improvement in confidence using BVM, NPA/OPA use, and BURP/Selick's maneuver

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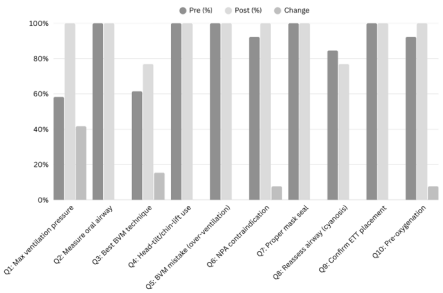
Interpretation of Results



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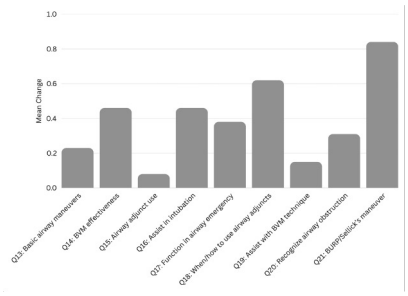
Interpretations of Results



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Interpretation of Results

- Statistically significant improvements
  - Mask ventilation and awareness of insufflating pressures
    - Correct responses increased from pre-test 58.3% to 100% after education, a statistically significant difference
  - The use of airway adjuncts
    - Pre-education results (M = 2.15, SD = 1.144) were significantly lower than post-education results (M = 2.77, SD = .927)
  - Roles in airway emergencies
    - Pre-education results (M = 2.08, SD = .862) were significantly lower than post-education results (M = 2.46, SD = .877)

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Implications

- Practice Implications
  - Demonstrate increase in knowledge and confidence supports the use of an airway education program.
  - Emphasizes the importance of interprofessional collaboration
- Clinical Implications
  - Reinforces staff knowledge, promoting staff competence
  - Improved patient safety in emergent situations

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Conclusions

- Limitations
  - Small sample size
    - Greater clinical application with future studies
  - Single rural site
    - Unique challenges
    - Urban vs Rural
- Sustainability
  - Annual training
    - Simulation based training
    - Address knowledge gaps
  - Time commitment

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End-Tidal Carbon Dioxide ($EtCO_2$) Monitoring in the Post Anesthesia Care Unit (PACU) and Education of Early Respiratory Compromise Detection

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EtCO2 Monitoring Background

- CO_2 in the blood at the end of exhalation and provides a real-time assessment of ventilation via a capnogram.
- ***Standard of care for anesthesia since 1986*** and widely used to improve patient safety.
- Detects hypoventilation, hypercarbia, perfusion complications, and airway obstruction earlier than pulse oximetry alone.
- Early detection can prevent reintubation, ICU admission, prolonged PACU stay, and mortality.

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EtCO2 Monitoring Background

Capnography + pulse oximetry provides a more complete assessment of ventilation and oxygenation, **predicting respiratory compromise 10 minutes** prior to the event **with 80% accuracy** (Jungquist eta l., 2019).

Studies show **capnography can detect respiratory events 8-11 minutes** earlier than standard monitoring (Chung et al., 2020).

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Utilization of EtCO2 Monitoring in PACU

Why is the PACU important

- Respiratory compromise is leading cause of morbidity in PACU
- Incidence of critical respiratory events in the PACU **0.8% to 6.9%** with some studies as high as **34%** (Karcz &Papadakos, 2013).
- Identifying problems early can help prevent reintubation and longer PACU stays

Practice Gap

- ***Inconsistent $EtCO_2$ use in PACU***
  - Use Varies because:
    - Guidelines are not clear
    - Provider preferences
- Limited nurse confidence in waveform interpretation
- Reliance on pulse oximetry alone
- Delayed recognition of hypoventilation and airway obstruction

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Purpose & Goals of the Project

Purpose: To evaluate whether targeted educational intervention improves PACU nurse knowledge and confidence in $EtCO_2$ monitoring and respiratory compromise detection.

Project Goals: Increase the knowledge and confidence levels of $EtCO_2$ monitoring of PACU nurses working at a midwestern Level II Trauma Center

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Literature Review

- **Respiratory compromise is the leading cause of PACU morbidity** (Karcz & Papadakos, 2013).
- Pulse oximetry only measures oxygenation
  - Supplemental O_2 can mask hypoventilation, making **SpO_2 a late indicator** of respiratory decline.
- Capnography detects ventilation changes earlier than pulse oximetry (Chung et al., 2020).
  - Capnography + pulse oximetry improves early intervention (Jungquist eta l., 2019).
- Despite being a standard of care in anesthesia, $EtCO_2$ is not consistently used in PACU.
- Practice gap: limited nurse training and inconsistent protocols.
- Education increases nurse competence & confidence in waveform interpretation (Atherton et al., 2022).
- Literature identifies PACU knowledge gap in waveform interpretation.

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Literature Review

Reduces respiratory events in high-risk populations:

- OSA
- Obesity
- Age > 75
- High opioid use

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$EtCO_2$ Monitoring & Early Respiratory Compromise Detection Education

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$EtCO_2$ Monitoring Overview

What is EtCO2?
- CO_2 is a byproduct of aerobic metabolism. It travels through the venous system to the lungs, where it crosses into the alveoli and is removed from the body through ventilation (Godden, 2011).
- Cardiac output affects how quickly CO_2 reaches the lungs (Jungquist et al., 2019).
- $EtCO_2$ levels and the capnogram give real-time picture of ventilation status and potential clinical decline (Khanna et al., 2024).

Benefits
- Early detection of respiratory issues
- Provides real-time picture of ventilation status

Limitations
- Limited access to equipment
- Variability in protocols
- Lack of staff training
- (Wilks & Foran, 2021)

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Putting It All Together – What Information Matters for PACU Nurses?

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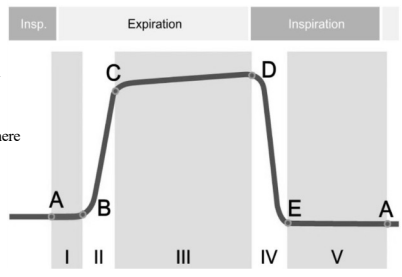
What Does $EtCO_2$ Tell Us?

Phase I, II & III Expiration

Phase IV & V Inspiration

Point D EtCO2 measured here



(Apex Anesthesia Review, 2025)

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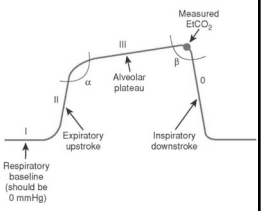
Analyzing the Waveform

1. Is there a waveform present?
2. Does the waveform go back to baseline?
3. How does the expiratory upstroke look?
4. How does the expiratory plateau look?
5. How does the inspiratory downstroke look?



(Long, 2016)

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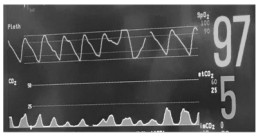
Open v. Closed Circuit Capnogram

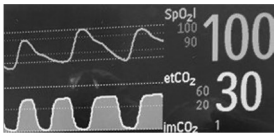
Open
Examples: Nasal canula and simple mask

EtCO2 value is unreliable
Reference waveform vs. no waveform
- Waveform is not reliable – just ensure there is some sort of waveform present indicating inspiration and expiration



Closed
Examples: Endotracheal tube

EtCO2 value is reliable
Waveform changes indicate respiratory compromise
- Waveform shape should be analyzed



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Respiratory Compromise in the PACU

Primary Risks
- Surgery >2hours
- Neuromuscular blockade
- High risk surgeries
- High peri-operative opioid use

Secondary Risks
- Obstructive sleep apnea
- Chronic heart disease
- Obesity (BMI>28)
- Advanced age (<75 years)
- Smoking
- Pulmonary Diseases (Severe COPD)

Common Causes
- Residual Neuromuscular Blockade
- Hypoventilation
- Upper Airway Obstruction
- Laryngospasm
- Bronchospasm

Categories	Risk Factors
Patient	Age > 60 years ASA > 2 CHF COPD Cigarette smoking (Miller says > 40 pack years)
Procedure	Aortic > thoracic > upper abdominal – neuro – peripheral vascular > emergency General anesthesia Duration of anesthesia > 2 hrs
Diagnostic Testing	Albumin < 3.5 g/dL (indicates poor nutritional status)

(Apex Anesthesia Review, 2025)

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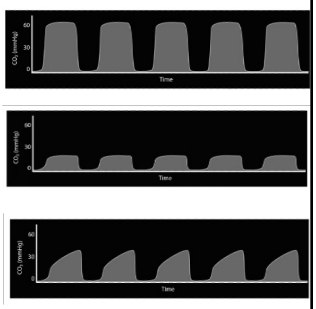
Identifying Capnograms

Elevated $EtCO_2$
- Sepsis
- Fever
- Hyperthyroidism
- Hypoventilation
- Narcotics
- MH

Low EtCO2
- Hyperventilation
- Hypothermia
- Hypotension
- Pulmonary embolism

Airflow Obstruction
- COPD
- Asthma
- Bronchospasm
- Kinked ETT
- "Shark-fin"
- Prolonged upstroke with increased alpha angle



(Apex Anesthesia Review, 2025)

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Design & Methods of Project

Study Design: Quasi-experimental, one-group pretest–posttest design

Purpose: Evaluate changes in PACU nurse knowledge and confidence after education

Setting: Midwestern Level II Trauma Center PACU

Population: PACU registered nurses with prior critical care/ER experience

Exclusions: Nursing students, LPNs, CNAs, and RTs

Sample size: 17 nurses (pre-test), 16 nurses (post-test)

Implementation
- Pre-educational survey assessing $EtCO_2$ knowledge and confidence
- In-person educational intervention:
  - PowerPoint presentation
  - Supplemental educational pamphlet
  - Post-educational survey

Analysis
- Pre- and post-survey results compared using paired-sample t-test analysis

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Results

Knowledge Outcomes
- Correct identification of inspiration and expiration phases increased from **25.0%** to **81.3%** ($p < .001$)
- Recognition of airway obstruction improved from **76.5%** to **100%** ($p = .019$)

Confidence Outcomes
- Increased confidence interpreting $EtCO_2$ waveforms
- Increased confidence using $EtCO_2$ monitoring in intubated and non-intubated PACU patients
- Higher likelihood of incorporating capnography into routine PACU assessment

Overall Findings
- Educational intervention resulted in statistically significant improvements in knowledge and confidence
- Supports effectiveness of targeted capnography education for PACU nurses

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Interpretation of Results

- Education significantly improved $EtCO_2$ knowledge and waveform interpretation.
- Improved waveform interpretation supports earlier recognition of respiratory compromise.
- Increased confidence promotes greater capnography use in PACU practice.
- Findings support education as a strategy to improve respiratory monitoring and patient safety.
- Results support $EtCO_2$ monitoring as an effective adjunct to pulse oximetry for postoperative assessment.

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Practice & Clinical Implications

Practice Implications
- ***Supports incorporating $EtCO_2$ education into PACU*** orientation and annual competency programs
- Reinforces the need for standardized, nurse-driven capnography protocols in the PACU
- Promotes consistent use of $EtCO_2$ monitoring for high-risk postoperative patients
- Provides a scalable, low-cost educational model for other PACU settings

Clinical Implications
- Enhances early detection of respiratory compromise before oxygen desaturation occurs
- Supports timely clinical intervention, reducing risk of reintubation and ICU admission
- Improves postoperative respiratory assessment when used alongside pulse oximetry
- Strengthens patient safety and quality of care in the immediate postoperative period

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Conclusions

Limitations
- Small sample size and single-site design
- No long-term knowledge retention testing
- High baseline clinical experience

Sustainability
- Low-cost, easily reproducible, and adaptable
- Easily integrated into PACU competencies

Future Implications
- Expand implementation at additional hospitals to evaluate generalizability.
- Assess long-term knowledge retention following capnography education.
- Evaluate patient-centered outcomes, including ICU admissions, respiratory complications, and hospital length of stay.

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Tranexamic Acid in Postpartum Hemorrhage

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When Minutes Matter: Postpartum Hemorrhage in Rural Practice

- Every few minutes, a woman dies from postpartum hemorrhage
- Rural and low-resource settings are especially vulnerable
- Early recognition and timely intervention save lives

(Al-Dardery et al., 2023; Rowher et al., 2025; Tran et al., 2022).

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The Global Burden of Postpartum Hemorrhage

- PPH accounts for 25% of maternal deaths worldwide
- PPH affects 14 million women annually

Rural and Low-Resource Impact

- 99% of maternal deaths occur in low-resource settings
- Challenges related to these settings include delayed recognition, and limited access to blood products and emergency services requiring speciality providers (IR, OB etc)

(Al-Dardery et al., 2023; Bellos & Pergialiotis, 2021; Rowher et al., 2025; Tran et al., 2022).

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Who is at Risk?

- Previous history of PPH
- Gestational hypertension
- Placenta previa
- Multiparty
- Prolonged labor
- Use of forceps/vacuum for delivery
- Retained placenta

Patients with cardiac, respiratory, or hepatic disease are at higher risk, even with minimal blood loss

(Al-Dardery et al., 2023; Rowher et al., 2025).

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Physiologic Changes in Pregnancy

Pregnancy Induced Changes:

- Increased levels of clotting factors I, II, VII, VIII, IX, and XII
- Decreased Protein S and Activated Protein C (anticoagulant)
- Reduced fibrinolysis, resulting in hypercoagulable state

Clinical Significance:

- Hypercoagulability gradually increases throughout pregnancy, peaking at term and persisting into the postpartum period.

(Mielke & Obermeyer, 2020).

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Pathophysiology of PPH

Following placental separation from the decidua several mechanisms occur:

- Myometrial contractions
- Platelet aggregation at the site of placental detachment (site of injury)
- Release of tissue factor, which activates the clotting cascade

(Mielke & Obermeyer, 2020).

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Pathophysiology of PPH

Balance between the Coagulation System & Fibrinolysis

- Tissue factor activates the clotting cascade, leading to high levels of thrombin
- Thrombin converts fibrinogen into fibrin, which forms the basis of a blood clot
- While fibrin stabilizes the clot it also activates the fibrinolytic system to convert plasminogen into plasmin (breaks down fibrin to prevent excess clotting)

-Severe blood loss in PPH, dysregulates the counterbalance between the coagulation and fibrinolytic systems. Making TXA's antifibrinolytic properties valuable in the management of PPH.

(Mielke & Obermeyer, 2020).

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Historical Background

- **1986**: TXA receives approval from the U.S. Food and Drug Administration for patients with hemophilia to prevent hemorrhage with tooth extractions.
- **2017**: The WOMAN trial demonstrates that early TXA administration significantly reduces mortality in women with postpartum hemorrhage.
- **2017–2018**: After the WOMAN trial, the World Health Organization (WHO) and American College Of Gynecologists (ACOG) update guidelines recommending TXA as part of the treatment for postpartum hemorrhage.

(Shakur et al., 2017; U.S. Food and Drug Administration, 2013; WHO, 2017)

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Practice Problem

Postpartum hemorrhage remains the leading obstetric emergency worldwide and continues to contribute significantly to preventable maternal morbidity and mortality, particularly in rural and low-resource settings

(World Health Organization [WHO]., 2017; Tran et al., 2022).

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Purpose

The purpose of our DNP project was to develop and implement an evidence-based educational program for CRNAs in rural healthcare settings to enhance their knowledge, confidence, and competency in the use of TXA for the prevention and treatment of PPH

Project Goal:
Improve rural CRNAs knowledge and confidence levels on the use of TXA for postpartum hemorrhage

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Literature Review

Background

- Postpartum hemorrhage remains a leading cause of morbidity and mortality specifically in rural and low-resource settings where access to additional specialty surgical care and blood products are limited

Evidence Supporting TXA Use

- Large randomized trials and meta-analyses have shown that TXA significantly reduces blood loss, maternal morbidity and mortality from PPH when administered as an early intervention

Gaps Identified in Literature

- Despite strong evidence, TXA remains underutilized due to knowledge gaps, inconsistent availability, and lack of standardized protocols particularly in rural healthcare

(Al-Dardery et al., 2023; Mielke & Obermeyer, 2020; Shakur et al., 2017; Tran et al., 2022; WHO, 2017)

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DNP Scholarly Project

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Design & Methods

Setting: Level III 36-bed rural healthcare facility in the Midwest

Population: Voluntary participation from 4 CRNAs with >10 years of experience

- Inclusion Criteria: Licensed CRNA currently practicing anesthesia
- Exclusion Criteria: Student Registered Nurse Anesthetists, Obstetric/Gynecologic Providers, and Nurses

Study Design: A quasi-experimental one-group pretest-posttest was used to evaluate CRNAs knowledge and confidence levels on the use of TXA for the management of PPH.

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Design & Methods

- Pretest and posttest surveys were administered before and after the educational module, consisting of 10 knowledge questions on TXA administration and PPH management
- Two 5-point Likert scale questions were asked to evaluate the effectiveness of the educational module
- Data collected was then uploaded to Microsoft Excel, stored on a password-protected computer, and de-identified.
- Data analysis was completed by Mr. West, our statistician, using descriptive statistics and paired sample t-tests to evaluate changes in knowledge and confidence.

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Results & Interpretation

- Knowledge scores improved following the educational intervention
  - Not statistically significant
- CRNA confidence of TXA administration for PPH increased
  - Statistically significant
- All participants reported increased likelihood to use TXA in the future for their practice

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Implications

- CRNAs provide over 80% of anesthesia care in rural communities, making them critical providers during obstetric emergencies
- Despite strong evidence supporting TXA, it remains underutilized due to knowledge gaps, inconsistent drug availability, and lack of standardized protocols
- Early administration of TXA has been shown to significantly reduce maternal morbidity and mortality related to PPH
- In rural settings with limited blood products and specialty surgical services, TXA serves as a critical time-sensitive intervention
- TXA is especially practical in rural healthcare due to its low cost, long shelf life, and ease of administration

(AANA, 2020; Mielke & Obermeyer, 2020; Shakur et al., 2017; Tran et al., 2022)

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Conclusions

- Limitations
  - Sample size
  - Small facility site
  - Education module presented once
- Sustainability
  - Educational module can be reused for other hospital sites
  - TXA cost-effective & long shelf-life
- Future Directions

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Development of an Evidence-Based Driven Airway Assessment Tool for Clinical Practice

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Project Purpose

Develop a quantitative airway assessment tool **grounded in evidence-based research** and obtain initial feedback from anesthesia providers regarding its perceived usefulness and feasibility for future implementation.

The overarching goal of this tool is to reduce the **subjectivity of preoperative airway evaluations** and decrease the incidence of unanticipated difficult airways, with the hope for potential integration into the electronic health record (EHR) system.

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Prevalence of Unanticipated Difficult Airway

The unanticipated difficult airway following induction of anesthesia is **one of the most dangerous situations** encountered perioperatively

Current incidence rates: **1.5%-6.8%** (Paxton & Parotto,2024).
Majority unanticipated

Incidence of **severe** complications: 1 in 22,000

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Difficult Airway Complications

- Failed intubation may lead to:
  - Gastric insufflation
  - Trauma to the pharynx
    - Bleeding and secretions in airway
  - Edema
  - Aspiration
- Severe cases:
  - Cardiovascular instability
  - Emergent surgical airway
  - Hypoxic brain injury
  - Death

(Traylor & McCutchan, 2023)

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Practice Gap

Individual, bedside airway assessments currently exist as part of the required preanesthetic assessment, but again, they are not **standardized.**

A standardized, quantitative airway assessment tool could better standardize practice and reduce the incidence of difficult airway.

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Literature Review

- Purpose: Identify published research from peer reviewed databases on airway assessments and how they predict difficult airway in the preoperative setting
- Databases: Clinical Key, CINAHL, & PubMed
- Search Terms: **related to difficult airway and all criteria used for the tool**
- A total of twenty-four articles were utilized

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Risk Factors Used for Tool Development

Mallampati
Thyromental distance
Limited Mouth Opening
Obesity
High Score on Upper Lip Bite Test
Surgery/Radiation to Head/Neck
Previous Difficult Airway
Obstructive Sleep Apnea
Limited Cervical Spine Mobility
High ASA score
Congenital Facial Abnormalities (Treacher-Collins, Pierre Robin Syndrome)
Airway Obstruction (Goiter, Trauma)
Facial/Neck Trauma

(Roth et al., 2019).

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0 – 40 = low
41 – 100 = moderate
101 – 160 = high

Mallampati (moderate)
Class I – 0
Class II – 5
Class III – 10
Class IV – 10

Thyromental Distance (moderate)
> 6 cm (3 fingers) - 0
< 6 cm (3 fingers – 10

Mouth opening (moderate)
> or equal to 3 fingers – 0
< 3 fingers – 5

Obesity (BMI) (high)
< 29.9 - 0
Class I (30 – 34.9) - 10
Class II (35 – 39.9) - 10
Class III (> or equal to 40) - 15

Upper Lip Bite Test (high)
Class I – 0
Class II – 10
Class III – 20

Surgery/Radiation to Head/Neck (high)
Yes – 10
No – 0

Previous difficult airway (high)
Yes – 20
No – 0

Obstructive Sleep Apnea (moderate)
Yes (or suspected) - 5
No – 0

Cervical Spine Mobility (high)
Full – 0
Moderately limited - 10
Severely Limited - 15

ASA (high)
1 – 0
2 – 5
3 – 10
4 – 10

Congenital Facial Abnormalities (i.e., Treacher Collins, Down syndrome, Pierre Robin)
Yes – 20
No – 0

Airway Obstruction (i.e., tumor, trauma)
Yes – 10
No – 0

Facial/Neck Trauma
Yes – 10
No – 0

Pilot Tool

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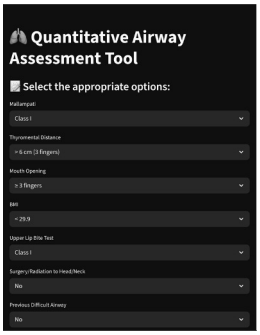
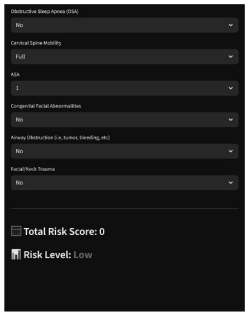
Interactive Assessment Tool





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DNP Scholarly Project

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DNP Scholarly Project Objectives

1) To identify and select key predictive variables from existing assessment tools and existing evidence that correlate with difficult airway management.

2) To design and pilot a novel composite airway scoring system that quantitatively integrates selected variables to predict potentially difficult intubations in adult surgical patients.

3) To assess the feasibility and perceived usefulness of the developed scoring system through a survey measuring acceptability, ease of use, and potential for future application.

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Design & Methods

Descriptive cross-sectional design

Setting: Three hospitals in the upper Midwest
- One CRNA-only and two Level II hospitals with ACT models

Population: Anesthesia providers who perform preoperative assessments

Tool & Survey sent via work email
- Survey via Qualtrics
- Demographic information included position held and number of practice years
- Also included poster via QR code with access to materials

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Results- Participant Characteristics

13 anesthesia providers participated in the evaluation

Participants represented **diverse anesthesia practice environments**, including:
- Rural CRNA-only settings
- Critical access hospitals
- Anesthesia care team (ACT) environments
- Level II trauma centers

100% of respondents reported no prior use of a quantitative airway assessment tool

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Results- Provider Evaluation

A **mixed-methods analytic approach** was used to evaluate survey responses

Both **quantitative survey data** and **qualitative provider feedback** were analyzed

The majority of respondents (12 of 13) indicated the airway assessment tool was **clinically appropriate and relevant for practice**

Several participants described the tool as **comprehensive and reflective of routine airway assessment practices**

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Results- Provider Feedback

Several respondents identified **concerns related to the weighting of specific predictors** within the scoring system

Mallampati classification was perceived as **overrepresented**

Participants suggested **greater emphasis on clinically significant predictors**, including:
- History of difficult airway
- Limited mouth opening
- Airway obstruction
- Obstructive sleep apnea (OSA)

Respondents emphasized that **predictive accuracy requires real-world clinical testing**

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Interpretation of Results

Participants **supported the clinical relevance** of the included airway predictors and provided feedback on the **relative weighting of specific criteria**

The tool was perceived as **clinically useful and broadly applicable** across anesthesia practice environments

Provider feedback identified **opportunities for refinement of predictor weighting** within the scoring system

Findings emphasize the **need for prospective research evaluating the tool in real-world clinical practice**

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Implications for CRNA Practice

An **objective airway assessment tool** may improve **consistency and standardization** in preoperative airway evaluation

Quantitative scoring may support **earlier identification of high-risk airways** prior to the induction of anesthesia

The tool may be particularly valuable for **CRNAs practicing independently or in rural and resource-limited environments**

Structured assessment may reduce reliance on **subjective clinical judgment alone**, improving decision-making and airway planning

Findings highlight the **importance of continued research in clinical practice** to refine predictive airway assessment strategies

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Future Directions

Additional research is needed to **refine the weighting of high-impact airway predictors**, including:

- Previous difficult airway history
- Mouth opening limitations
- Airway obstruction
- Obstructive sleep apnea

Prospective pilot testing using a randomized control trial should be conducted in diverse anesthesia practice environments

Further research should evaluate **the predictive accuracy and clinical usability** of the scoring system

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Future Directions

Long-term development may allow **integration of the tool into electronic health records (EHRs)**

EHR integration could allow **automated prompts or alerts** when high-risk airway features are identified during the preoperative evaluation

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Conclusion

Unanticipated difficult airway remains a **significant patient safety risk**

Current airway assessment practices are **inconsistent and subjective**

A quantitative airway assessment tool may improve **standardization and early risk identification**

Provider feedback supported feasibility, while highlighting areas for refinement

Future research and EHR integration may support broader clinical implementation

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Thank You
Are There Any Questions?

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