Capnography Monitoring In The PACU: Improving Patient Safety Through Education

Robert Mueller

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Approved by:

Dr. Stacey Schlesinger	Project Faculty Advisor
Dr. Wanda Williams	DNP Program Director

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Abstract

Background: The prompt recognition of respiratory depression is a basic element of postoperative nursing care. Despite the routine use of pulse oximetry and respiratory rate monitoring, detection of respiratory depression is often delayed until oxygen desaturation occurs. Capnography monitoring can detect respiratory depression more quickly and accurately, particularly in the presence of supplemental oxygen delivery. **Methods**: This quality improvement project utilized a pre-post design to measure utilization of capnography monitoring and acquired knowledge by postanesthesia care unit (PACU) nurses following an educational intervention. **Results:** The utilization of capnography monitoring increased from 0.38% pre-intervention to 1.3% post-intervention (p=0.02). Average postanesthesia nurse knowledge scores increased from 5.09 to 5.39 (p=0.26). **Conclusion:** Capnography monitoring education led to a statistically significant increase in utilization of capnography monitoring in postoperative patients. Capnography monitoring education did not, however, lead to a statistically significant increase in nurse's knowledge. Future efforts to increase utilization of capnography monitoring should address barriers to implementation and extend education to all postanesthesia care unit nursing staff.

Keywords: capnography, end tidal carbon dioxide, post anesthesia care unit, respiratory depression, hypoventilation, safety

Background and Significance

Respiratory related injuries in the post anesthesia care unit (PACU) remain the most common source of closed malpractice claims involving anesthesia providers (Kellner et al., 2018). Kellner et al. (2018) reports that over 40% of closed claims involved missed or delayed diagnoses, highlighting the challenges involved in effectively monitoring this patient population. While the use of capnography monitoring has yet to become commonplace in the PACU, one meta-analysis found that the likelihood of identifying postoperative respiratory depression was six times higher in patients monitored with capnography versus pulse oximetry alone (Lam et al., 2017). Multiple studies have shown that episodes of respiratory depression in the PACU have a strong predictive value for additional respiratory depression episodes on general floors (Deljou et al., 2018, Rivas et al., 2023). This suggests that capnography may be a valuable tool not only in identifying respiratory events in the PACU, but also in identifying patients who may be at higher risk of additional respiratory complications once they transfer to a nursing floor.

The American Society of Anesthesiologists (ASA) guidelines for post anesthesia care outline the importance of monitoring both oxygenation and ventilation (American Society of Anesthesiologists, 2019). These guidelines include pulse oximetry specifically as a standard of care for monitoring oxygenation, but they stop short of including capnography for monitoring ventilation (American Society of Anesthesiologists, 2019). Interestingly, ASA guidelines for monitoring during anesthesia do specifically include capnography monitoring as the standard of care for ensuring adequacy of ventilation in all cases that include any level of sedation (American Society of Anesthesiologists, 2020). Perianesthesia nursing monitoring standards do not include the routine use of capnography monitoring in the PACU, however they do recommend capnography be used if available and indicated (ASPAN, 2016).

Opioid related adverse events are associated with a host of problems including increased length of stay, higher costs, and a threefold increase in inpatient mortality (Kessler et al., 2013). In an analysis of anesthesia closed claims involving opioid induced respiratory depression, Lee et al. (2015) noted that most claims involved death or severe brain damage, occurred within 24 hours of surgery, and were deemed to have been preventable. Reviewers determined that 97% of these claims could have been prevented with better monitoring (Lee et al., 2015). The respiratory depressant effects of opioids likely contribute to the frequency of respiratory events in the PACU as one study involving over 37,000 post-surgical patients noted that 99% of patients received opioids post-operatively (Kessler et al., 2013). Lee et al. (2015), suggests that capnography monitoring could be used to detect respiratory depression, but notes a lack of familiarity among nursing staff as a barrier to implementation of this technology.

Purpose

With the established problem of adverse respiratory events in the PACU, this project aimed to increase the utilization of capnography monitoring postoperatively and improve knowledge by providing nurses with an educational presentation reviewing the incidence of postoperative respiratory events, the limitations of pulse oximetry when used alone, and the advantages capnography monitoring provides.

Review of Current Evidence

A focused literature review was conducted using two databases, the Cumulative Index to Nursing and Allied Health Lite (CINAHL) and PubMed. Search terms included: “etco2 or end-tidal carbon dioxide or capnography”, “PACU or post anesthesia care unit or recovery”, “respiratory depression or respiratory events”, “accuracy” and “safety” in various combinations using Boolean operators. After limiting the search results to articles in English that had the full text available, a total of 272 articles were resulted. These results were further filtered to only include systematic reviews, randomized controlled trials, and meta-analyses. Articles were then screened for project relevance. A review of the citation lists of pertinent articles also generated further relevant articles. This yielded a total of 16 articles that were included in this review. Additional sources used include standards of care and practice recommendations from professional organizations.

Limitations of Current Monitors

Routine monitor selection in the PACU is determined by the standards and recommendations for patient care established by professional organizations, and include pulse oximetry, ECG monitoring, and either non-invasive or arterial blood pressure monitoring (ASA, 2019; ASPAN, 2016). These monitors are used to measure heart rate, respiratory rate, blood pressure and oxygen saturation in the blood. However, these monitors alone or in concert, do not reliably detect hypoventilation or impending respiratory compromise. Monitoring related challenges and delayed recognition are commonly cited issues in analyses of closed claim data of respiratory incidents in post-surgical patients (Kellner et al., 2018; Lee et al., 2015). In a single database with 92 respiratory depression claims, 77% resulted in severe brain damage or death, and 97% were determined to have been preventable with improved monitoring (Lee et al., 2015). Continuous respiratory rate monitoring is usually accomplished using thoracic impedance pneumography via the ECG leads, which attempts to quantify respiratory rate based on the principle that electrical resistance to a current passing through the chest changes during inspiration and expiration. The accuracy of this technique is hindered by a host of factors including artifact from patient movement, poor lead placement, and detection of chest wall movement during acts other than respiration (Gaucher A et al., 2012). While a decrease in pulse oximetry can be a result of respiratory depression, this change can be completely masked or significantly delayed in patients receiving supplemental oxygen (Arakawa et al., 2013; Jungquist et al., 2019; Niesters et al., 2013). In one study, 50% of patients in the PACU had sustained signs of respiratory depression despite their SpO2 values not changing (Jungquist et al., 2019). The inherent limitations of thoracic impedance pneumography and the ubiquitous use of supplemental oxygen in this patient population prevent respiratory rate monitoring and pulse oximetry from reliably detecting hypoventilation in the PACU.

Capnography Monitoring Efficacy

Capnography monitoring is used in a variety of clinical indications to monitor the adequacy of ventilation. Capnography monitoring relies on sidestream technology whereby exhaled gases are aspirated into tubing attached to a nasal cannula or facemask and transported to a monitor to display a capnography waveform and end-tidal carbon dioxide (ETCO2) concentration (Krauss et al., 2022). Capnography accurately reflects alveolar ventilation in extubated patients, including newborns and adults (Hagerty et al., 2002; Shunsuke et al., 2015). In addition to ETCO2, capnography provides an accurate measure of respiratory rates (Gaucher A et al., 2012). Crucially, the accuracy of ETCO2 and respiratory rate are maintained during patient conditions commonly seen in the PACU, namely lower tidal volumes and during supplemental oxygen therapy (Gaucher et al., 2012; Jungquist et al., 2019; Shunsuke et al., 2015). The efficacy of capnography monitoring has made it a standard of care during general anesthesia (ASA, 2020). Capnography accurately detects hypoventilation in a variety of clinical situations, including during procedural sedation, bronchoscopy, and in the PACU (Chung et al., 2020; Ishiwata et al., 2018; Jungquist et al., 2019; Waugh et al., 2011). A meta-analysis examining capnography use during procedural sedation found that instances of respiratory depression were 17.6 times more likely to be detected when patients were monitored by capnography (Waugh et al., 2011).

Capnography Versus Current Monitors

Capnography provides more rapid and accurate identification of respiratory depression (Chung et al., 2020; Jungquist et al., 2019; Lam et al., 2017). Respiratory rate detection has been shown to be more accurate using capnography as it is not subject to many of the confounding variables that plague thoracic impedance pneumography (Gaucher et al., 2012). When compared to pulse oximetry, capnography monitoring provides for significantly earlier detection of hypoventilation or respiratory depression across a variety of patient settings (Chung et al., 2020; Millane et al., 2020). One study looking at respiratory adverse events in the PACU reported an average earlier detection time of over eight minutes when capnography was used compared to standard monitors alone (Chung et al., 2020). Capnography monitoring has also been shown to have a higher sensitivity for detection of hypoventilation over standard monitors, greatly increasing the likelihood of prompt recognition (Jungquist et al., 2019; Lam et al., 2017; Waugh et al., 2011). The differences between capnography and pulse oximetry's abilities to detect hypoventilation are greatly amplified in the presence of supplemental oxygen as ETCO2 levels are not impacted, and changes in SPO2 are significantly delayed or may not change at all (Arakawa et al., 2013; Jungquist et al., 2019; Niesters et al., 2013).

Summary of Evidence

Despite the use of various continuous monitors, the literature shows that effective monitoring in the PACU is an ongoing problem. Although not currently considered a standard of care, capnography can quickly and accurately detect respiratory depression that may be delayed or missed by current monitors, especially in the presence of supplemental oxygen. Although relatively few studies have examined capnography monitoring directly in the postoperative setting, results from these studies have shown a dramatic increase in both speed and sensitivity of detection of respiratory depression. Furthermore, many of the articles studying patients in other settings deal with patients in similar states as may be expected in the PACU like various levels of sedation, opioid administration, and supplemental oxygen use. Together this evidence supports this project's aim to increase capnography utilization by educating PACU nurses on its use and utility.

Theoretical Model

Kurt Lewin's change theory was used as the theoretical framework to guide this DNP project. Lewin's (1951) three stage model for enacting change consists of three steps: unfreezing, changing, and refreezing. The theory highlights the importance of driving and restraining forces which act in opposition to facilitate or oppose change (Lewin, 1951). The intervention of this project aims to serve as an unfreezing step by educating PACU nurses on the advantages of capnography monitoring. By increasing their knowledge of the safety benefits of effectively monitoring ventilation, and addressing common perceived barriers to use, this educational presentation should increase the driving forces and reduce the restraining forces leading to a change in practice. Dissemination of the results of this project to department leadership can then be used to examine the effectiveness of the changing step. From that point any ongoing barriers to change can be identified and addressed before moving on to the refreezing step.

Methods

Design

This quality improvement project utilized a pre-post intervention design to quantitatively measure knowledge and utilization of capnography before and after an evidence-based educational intervention. Actual utilization of capnography monitoring in the PACU was evaluated by assessing documentation of ETCO2 in the electronic health record at baseline and following the educational intervention to assess for interval change.

Translational Framework

The Iowa Model is a commonly used guide to the evidence-based practice process, with demonstrated utility for users with any experience level and across a variety of settings (Buckwalter et al., 2017). The Iowa Model consists of a flowchart guiding users through the multi-step process. These include identifying triggering issues, integrating practice change, and disseminating results, with various decision-making points along the way (Buckwalter et al., 2017). This framework was an ideal guide for this project, which aimed to synthesize the evidence surrounding capnography use in the PACU and potentially serve as the first step in a phased approach towards quality improvement and sustainable practice change. The Iowa Model was used in the development of this project, as underutilized capnography monitors were identified as an opportunity for improvement. The potential for improving patient safety through the use of capnography was then discussed with the department director who confirmed that this topic represented a priority for the unit. An initial team was formed including myself as the principal investigator (PI), my faculty advisor, and the PACU department director. A systematic review of the literature was then conducted. The available evidence demonstrates that capnography is an accurate and effective monitor of ventilatory status and assists PACU nurses in the timely identification of respiratory compromise. Results have been reported back to the department director and included in a poster presentation for dissemination.

Setting and Sample

A convenience sample was recruited from the 32 nurses currently employed at the clinical facility site. The patient care unit is a 24 bed PACU within a large teaching hospital in the southeastern United States. This pool of nurses consisted of a diverse group in terms of experience level and demographic characteristics. Patients recovered in this PACU include both pediatric and adult patients who have undergone a wide variety of surgical procedures. Inclusion criteria for participants includes registered nurses providing bedside care in the PACU setting. Exclusion criteria includes any other healthcare professionals, and nurses who do not provide care in the PACU setting.

Project Implementation

Following the university and facility institutional review boards determination that this project did not constitute human research, participants were recruited via emails sent by the department director, and by flyers posted on the unit by the PI. Participation was voluntary and informed consent was assumed for those who completed surveys. The baseline assessment of PACU registered nurse (RN) capnography knowledge was measured using a pretest survey (see appendix A). The pretest survey was designed by the PI for the purpose of this project because no existing tool was identified in the review of the literature. The survey was distributed via email and flyers and used a scannable QR code survey link for participant responses.

The evidence-based educational intervention was conducted at the end of a regularly scheduled staff meeting and lasted approximately 15 minutes. Content included current evidence on the limitations of currently utilized respiratory monitors, the advantages of capnography, and practical information on how to connect and interpret data from the capnography monitor.

Two days following the educational intervention, the postintervention survey (see appendix A) was distributed to the PACU RNs via e-mail. The post-intervention survey contained the same questions as the baseline survey.

To measure actual utilization of capnography monitoring in the PACU, a report from the electronic health record was generated showing the frequency of capnography monitoring for a period of 30 days before and after the educational intervention.

Data Collection

The PI worked with a data specialist at the facility site to generate an electronic report for the purpose of this project. This report included the total number of patients seen in the PACU over a 30-day period prior to and following the educational intervention, including if they had ETCO2 data charted during their recovery.

Qualtrics online software was used to create the pre-intervention and post-intervention surveys and to collect and record responses. A link to the preintervention survey was distributed via emails and posted flyers. The preintervention survey consisted of 17 questions designed to assess baseline knowledge of capnography monitoring. This included capnography benefits, application, data interpretation, perceived barriers, and willingness to incorporate capnography into practice. A postintervention survey consisting of the same questions was distributed via follow up email two days following the educational intervention. Survey responses were anonymous. In order to link the pre and post intervention survey responses, the surveys included a self-generated code consisting of the respondent's father's first initial, mother's first initial, and the two digits corresponding to the month they were born.

Data Analysis

All data was compiled and analyzed with the assistance of a statistician from the University of North Carolina at Greensboro. The preintervention and postintervention responses were transcribed into Excel for analysis. Only three postintervention survey responses had a self-generated code matching a preintervention response, so attempts to link pre and post responses for data analysis were abandoned.

The responses to questions two through five and nine through 13 were coded for correctness by assigning a number of one through seven to the corresponding Likert scale response, with seven representing the most correct response and one the least correct. The coded responses to those survey questions were used to generate average knowledge scores at baseline and postintervention. These knowledge scores were then analyzed using a two-sample F-test in excel to determine equal or unequal variances, followed by a two-sample t-test assuming equal variances. Responses to questions related to barriers, perceived abilities, and intent to incorporate ETCO2 monitoring into practice were grouped into agree to any extent, neutral, or disagree to any extent. This included the responses to questions six through eight, and 14 through 17.

Data on capnography utilization from the electronic health record was transcribed into excel in a 2x2 table and a chi-square test was performed.

Results

Data was analyzed from a total of 2133 medical records (1052 pre-intervention; 1081 post-intervention). Prior to the educational intervention, four of 1052 reviewed records (0.38%)

had documentation that capnography monitoring was used. Following the educational intervention, 14 of 1081 reviewed records (1.3%) had documentation that capnography monitoring was used. A chi-square test was conducted on this data and indicated a statistically significant result ($p=0.02$).

Responses from a total of ten preintervention and nine postintervention surveys were collected and recorded. Only three postintervention survey responses had a self-generated code matching a preintervention response, so planned attempts to link preintervention and postintervention responses for data analysis were abandoned.

At baseline, 90% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I know how to set up and start $ETCO_2$ monitoring on a patient" and 10% reported they "neither agree nor disagree". 60% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I can interpret changes in $ETCO_2$ waveforms", while 10% reported they "disagree" and 30% reported they "neither agree nor disagree". 80% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I can interpret changes in the $ETCO_2$ value", while 10% reported they "disagree" and 10% reported they "neither agree nor disagree". 80% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I feel that I have the skills and knowledge to utilize $ETCO_2$ monitoring effectively", while 10% reported they "disagree" and 10% reported they "neither agree nor disagree". 90% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I have the equipment necessary to initiate ETCO2 monitoring immediately available in the PACU", while 10% reported they "disagree" or "slightly disagree". 20% of preintervention survey respondents reported that they "slightly agree" or "agree" that "It takes too long to set up ETCO2 monitoring when a patient first arrives to the PACU", while 70% reported they "disagree" or "strongly disagree" and 10% reported they "neither agree nor disagree". 50% of preintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I think it is likely given my current knowledge that I will incorporate $ETCO_2$ monitoring in my practice", while 50% reported they "neither agree nor disagree".

Following the educational intervention, 100% of respondents reported that they "slightly agree", "agree" or "strongly agree" that "I know how to set up and start $ETCO_2$ monitoring on a patient". 89% of postintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I can interpret changes in $ETCO_2$ waveforms", and 11% reported they "neither agree nor disagree". 100% of postintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I can interpret changes in the $ETCO_2$ value". 100% of postintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I feel that I have the skills and knowledge to utilize $ETCO_2$ monitoring effectively". 89% of postintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I have the equipment necessary to initiate ETCO2 monitoring immediately available in the PACU", while 11% reported they "disagree" or "slightly disagree". 78% of postintervention survey respondents reported that they "disagree" or "strongly disagree" that "It takes too long to set up ETCO2 monitoring when a patient first arrives to the PACU", and 22% reported they "neither agree nor disagree". 78% of postintervention survey respondents reported that they "slightly agree", "agree" or "strongly agree" that "I think it is likely given my current knowledge that I will incorporate $ETCO_2$ monitoring in my practice", while 22% reported they "neither agree nor disagree".

The coded responses to questions two through five and nine through 13 were used to generate average knowledge scores at baseline and postintervention. The calculated baseline mean average knowledge score for pre-survey responses was 5.09. The calculated mean average knowledge score following the educational intervention was 5.39. A t-test was performed that did not demonstrate statistical significance ($p=0.26$).

Discussion

The goal of this quality improvement project was to improve PACU utilization of capnography monitoring in postoperative patients and improve knowledge on this monitoring technique. The results of this project demonstrate that an educational intervention was associated with a small but statistically significant increase in utilization of capnography in the PACU and a small increase in reported knowledge.

Although the postintervention increase in capnography monitoring was only 0.92%, this result is clinically significant considering the potentially catastrophic consequence of unrecognized respiratory depression. Based on previous evidence, this increase in capnography monitoring use should improve respiratory depression detection and patient safety in the PACU. At this facility alone, with an average of 1067 patients per month a 0.92% increase in utilization means an additional 9.8 patients per month, or 117.8 patients per year will be benefit from the addition of capnography monitoring. In addition to improved patient safety while in the PACU, the addition of capnography monitoring may better inform providers about patient readiness for transfer to general floors where postoperative respiratory depression may not be delayed.

None of the respondents on the postintervention survey indicated that they perceive a barrier related to time it takes to set up capnography monitoring. About 10% of respondents on both the preintervention and postintervention surveys did indicate that they perceive a barrier related to equipment. One potential ongoing equipment barrier at this facility is that the nasal cannulas that are utilized in the operating rooms do not interface with the PACU capnography monitors, so nurses would have to swap nasal cannulas on arrival to the PACU. This potential barrier was observed by the PI at the time of the intervention, but not addressed specifically in the surveys.

While knowledge scores did increase, they failed to reach statistical significance, indicating that knowledge may not be the primary driver of capnography utilization. Responses showed an increase in nurses perceived ability to effectively utilize capnography monitoring and their intention to incorporate capnography monitoring into their practice. Despite these changes, the majority of patients in the post intervention data collection period did not have capnography data documented.

Limitations

There are several limitations to this project. These include the use of a small convenience sample of nurses that attended a single staff meeting, the limited response rate for preintervention and postintervention surveys, the inability to link preintervention and postintervention surveys, and an inability to determine whether postintervention survey respondents even attended the education intervention. Although most nurses that attended the educational intervention did complete the preintervention survey, this represented only a fraction of the total PACU nursing staff as it was predominately attended by nurses scheduled to work that particular day. These factors make it difficult to draw meaningful conclusions about the overall effectiveness of an educational intervention to increase knowledge and increase capnography utilization. The unanticipated barrier of needing to change out nasal cannulas on arrival to PACU was not discovered until the time of the intervention and therefore strategies to mitigate this barrier were not included in the educational intervention.

Recommendations for future study

A recorded educational intervention distributed to all staff may have generated more survey responses and a bigger increase in capnography utilization. A better strategy for linking surveys would be to have Qualtrics software require postintervention respondents to enter a code matching a code from the preintervention surveys.

Another potential strategy to increase utilization could center around a more robust attempt to identify barriers to use via additional surveys. If the lack of standardized equipment between the operating room and the PACU proved to be a barrier, working with both the PACU and anesthesia leadership to unify the equipment used could further improve capnography utilization.

A logical extension of this project could be to incorporate patient outcomes. Capnography utilization could be compared to respiratory adverse events, such as reintubations, to identify actual improvements in patient safety. This data could then be used to create buy in for including capnography in a protocol or standard workflow in the PACU.

Conclusion

Based on the current evidence this project aimed to increase utilization of capnography monitoring equipment in the PACU by increasing nurses' knowledge of the benefits of capnography and the limitations of standard respiratory monitors. The implementation of an evidence-based educational intervention was associated with a statistically significant increase in capnography utilization despite failing to achieve a statistically significant increase in nurses' knowledge. Future efforts to further increase utilization should explore existing barriers to utilization and extend education to a greater number of staff.

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Appendix A

Survey tool

The following self-generated code will only be used to link responses on the pre and post survey.

Please enter your father's first initial, your mother's first initial, and the two digits corresponding to the month you were born: ___________ (example format: TK05)

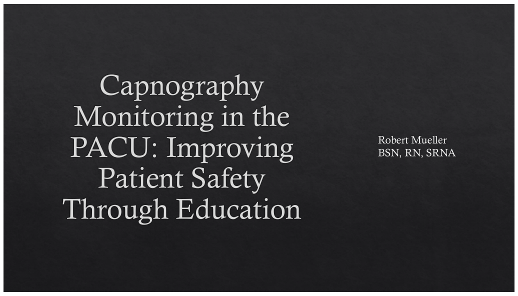
Please select what is most applicable to your experience with the use of End-tidal CO2 (ETCO2) monitoring	**Never**	**Rarely**	**Occasionally**	**Frequently**	**Always**
Q1. I use ETCO2 monitoring on patients in the PACU					

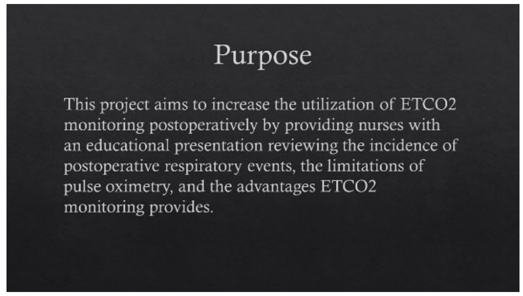
For each of the following questions please circle the response that best reflects your attitude toward each statement.	**Strongly Disagree**	**Disagree**	**Slightly Disagree**	**Neither Agree nor Disagree**	**Slightly Agree**	**Agree**	**Strongly Agree**
Q2. The monitors I currently use are adequate for detecting changes in respiratory status							
Q3. Pulse oximetry alone can effectively detect hypoventilation							
Q4. Supplemental oxygen diminishes the ability of pulse oximetry to detect respiratory depression							
Q5. Current respiratory rate monitoring using ECG leads provides reliable data							
Q6. I know how to set up and start $ETCO_2$ monitoring on a patient							
Q7. I can interpret changes in $ETCO_2$ waveforms							

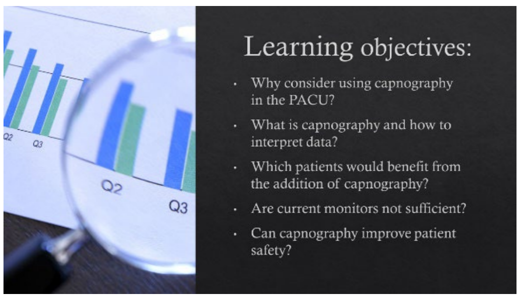
Q8. I can interpret changes in the ETCO2 value							
Q9. ETCO2 monitoring alone can effectively detect hypoventilation							
Q10. Supplemental oxygen diminishes the ability of ETCO2 monitoring to effectively detect hypoventilation							
Q11. ETCO2 monitoring detects respiratory depression sooner than pulse oximetry							
Q12. ETCO2 monitoring would improve patient safety in the PACU							
Q13. It is within my scope of practice to initiate ETCO2 monitoring							
Q14. I have the equipment necessary to initiate ETCO2 monitoring immediately available in the PACU							
Q15. It takes too long to set up ETCO2 monitoring when a patient first arrives to the PACU							
Q16. I feel that I have the skills and knowledge to utilize $ETCO_2$ monitoring effectively							
Q17. I think it is likely given my current knowledge that I will incorporate $ETCO_2$ monitoring in my practice							

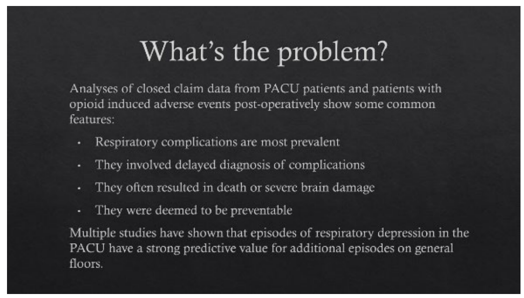
Appendix B

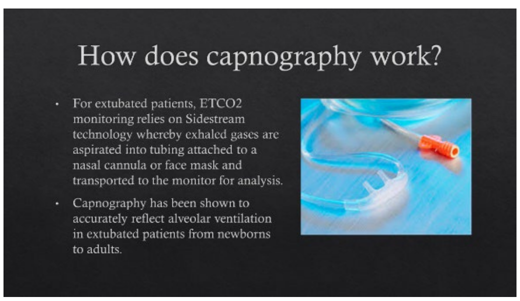
Interventional PowerPoint

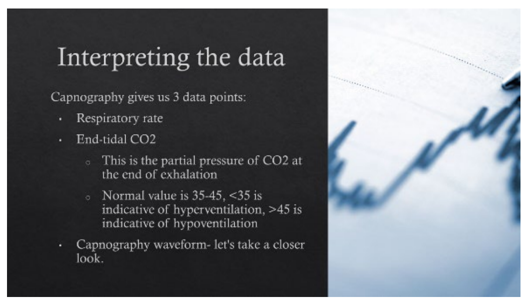


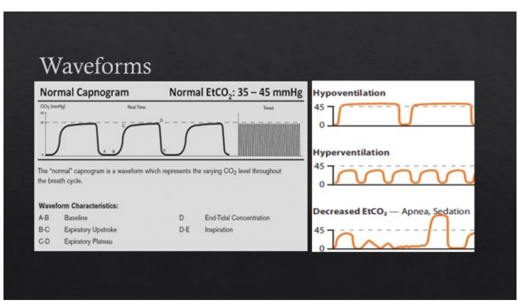


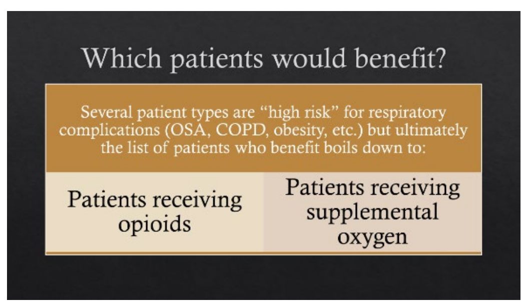


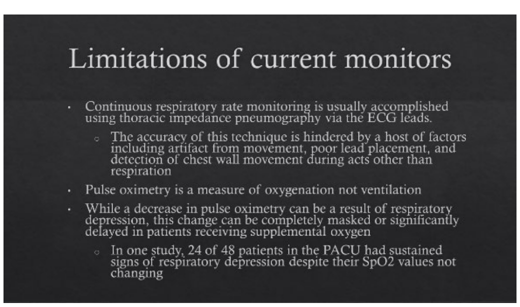


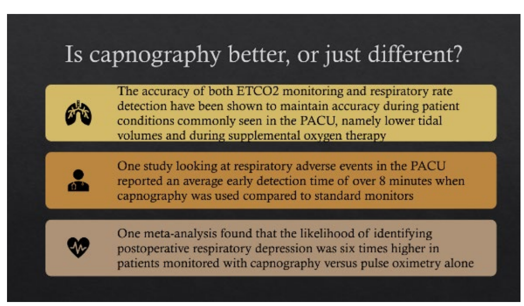


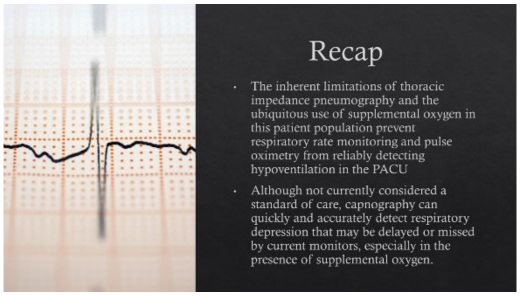


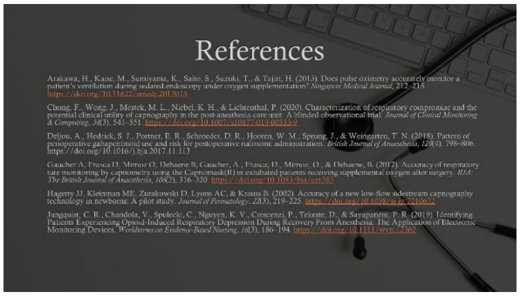









Recap
The inherent limitations of thoracic impedance pneumography and the ubiquitous use of supplemental oxygen in this patient population prevent respiratory rate monitoring and pulse oximetry from reliably detecting hypoventilation in the PACU
Although not currently considered a standard of care, capnography can quickly and accurately detect respiratory depression that may be delayed or missed by current monitors, especially in the presence of supplemental oxygen.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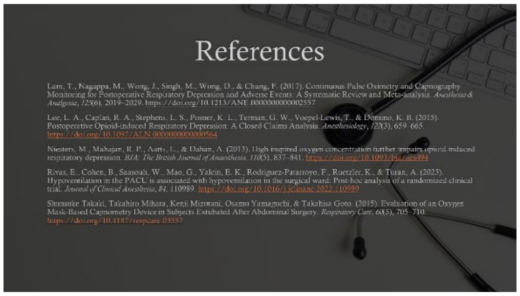
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