

Capnography (ETCO₂), Respiratory Depression, and Nursing Interventions in Moderately Sedated Adults Undergoing Transesophageal Echocardiography (TEE)

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Purpose: Little attention has been paid to the safety of moderate sedation given to adult patients undergoing transesophageal echocardiography (TEE). Although capnography has been found to indicate respiratory depression earlier than pulse oximetry in other sedation scenarios, its usefulness during TEE has not been clearly documented.

Design: A prospective, single-group, observational design was used.

Methods: A total of 200 adult patients undergoing TEE with moderate sedation were studied. Patient demographic and procedural physiologic variables, types and doses of sedating medications administered, incidence of respiratory depression, and types and effectiveness of nursing interventions delivered when subjects experienced respiratory depression were examined.

Finding: Respiratory depression identified by capnography occurred in 45% of the subjects. Capnography provided earlier identification of respiratory depression than pulse oximetry. Hydromorphone was associated with respiratory depression more so than other agents; whereas nursing interventions were effective in preventing more serious cardiorespiratory compromise.

Conclusions: Capnography, as a tool to provide early warning of respiratory depression or airway compromise, has the potential to further decrease the incidence of serious adverse events due to inadvertent oversedation.

Keywords: capnography, sedation, TEE, research.

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Conflict of interest: None to report.

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SAFETY DURING PROCEDURAL MODERATE (“CONSCIOUS”) SEDATION, especially as it relates to cardiorespiratory compromise, has been a topic of increasing discussion over the last decade. Many studies have evaluated the safety of procedural sedation in endoscopic procedures, especially in those performed by gastroenterologists such as esophagogastroduodenoscopy or colonoscopy.^{1,2} Several well-done studies^{3,4} and reviews^{5,6} also support the safety of procedural sedation in emergency departments. Standard care during moderate sedation⁷⁻⁹ includes the presence and monitoring of the patient by a

registered nurse, separate from others who are conducting or assisting with the procedure, who continuously assesses the patient, ensuring a patent IV line, electrocardiogram monitoring, administration of supplemental oxygen by nasal cannula, and pulse oximetry monitoring (SPO₂) are in place. Emergency equipment is kept close by in case of adverse cardiorespiratory events, to include the inadvertent advancement from moderate sedation to deep sedation, where respiratory drive and airway patency is compromised.

One important advent in the last decade has been the increasing use of capnography, the measurement of respiratory end-tidal CO₂ (ETCO₂), during procedural sedation. Sandlin¹⁰ suggested ETCO₂ monitoring was the wave of the future, and this assertion is proving true. With its origins in the operating room to monitor ventilatory adequacy, capnography is a physiologic monitoring technology that enables the plotting of a ventilatory waveform, the capnogram, by measuring exhaled CO₂ levels via an infrared sensor near the mouth or nose.¹¹ Mainstream sensors are placed in the ventilatory circuit of intubated patients, whereas sidestream sensors are most often integrated into a wearable nasal cannula where oxygen can simultaneously be administered. Sidestream sensors are most often used in ETCO₂ monitoring during procedural sedation.

Pulse oximetry, a technology that allows for noninvasive monitoring of the oxygen saturation of hemoglobin, has been in standard use during sedation and anesthesia for decades. The value of capnography over pulse oximetry as a monitoring technology during moderate sedation is that hypoventilation, or airway compromise, occurs before oxygen desaturation; thus, capnography provides earlier warning of respiratory depression than does pulse oximetry, enabling clinicians to intervene before development of hypoxia.

Advancement from moderate sedation to deep sedation occurs more often than is sometimes thought. Patel et al¹² reported that 54/80 (68%) of subjects in their study advanced from moderate to deep sedation when meperidine and midazolam were used during endoscopic procedures. Qadeer et al¹³ found that 83.1% of subjects in the arm of their study where clinicians were blinded to cap-

nography readings experienced abnormal ventilation. A recent meta-analysis of five studies which included 332 patients across different procedure types and settings (emergency department, upper endoscopy, and monitored anesthesia care conditions) found that cases of respiratory depression were 17.6 times more likely to be detected if capnography was used than in cases where it was not used (95% CI, 2.5 to 122.1, $P < .004$).¹⁴ Because of the clear advantages of capnography as a supplement to pulse oximetry during moderate sedation, the American Society of Anesthesiologists (ASA)⁷ approved new basic standards for anesthesia monitoring that went into effect on July 1, 2011. One new element, Standard 3.2.4, requires that capnography be used during moderate sedation. Although these standards apply to ASA members and perhaps more broadly to care provided by all anesthesia providers, the movement toward enhancing sedation safety through the use of capnography is clear. Odom-Forren¹⁵ provides additional commentary on the capnography-safety movement and further discusses on other possible regulatory issues.

Although the overall safety of procedural sedation for selected procedures has been thoroughly evaluated, little research has been conducted on sedation safety during transesophageal echocardiography (TEE). TEE is a widely used diagnostic technique which allows cardiologists to thoroughly evaluate the anatomic structure of the heart (especially along the left border of the heart), cardiac contractility, heart valve function, and evidence of cardiac thrombus, among other features.¹⁶ TEE is performed by intubating the esophagus with an echo probe so that the heart is evaluated from a posterior position, as compared with transthoracic echocardiography which takes an anterior or lateral approach. In the United States, TEE is normally conducted in procedural areas using moderate sedation. Interestingly, in many other countries, sedation is not as commonly used¹⁷ and when it is, the combination of benzodiazepines with opiates—a common practice in the United States for most procedural sedation—is avoided.¹⁸ The safety of TEE as a procedure was evaluated early after it became a popular imaging modality, with studies focusing more on complication rates from bleeding or esophageal damage.¹⁹ One early study of 150 patients undergoing TEE published in 1994²⁰ found that pulse oximetry readings declined in nearly all patients, with 18% of patients experiencing SPO₂

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