Emergency Nursing Resource: The Use of Capnography During Procedural Sedation/Analgesia in the Emergency Department

Do emergency department patients receiving procedural sedation/analgesia who are monitored with capnography, as compared to those monitored per common practice (vital signs, pulse oximetry, and clinical assessment), have better outcomes because hypoventilation and apnea are detected earlier during sedation and recovery?

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Background/Significance

Medication administration and patient monitoring are common roles for emergency nurses during procedural sedation and analgesia. Negative outcomes associated with sedation are usually related to airway or respiratory issues. Unfortunately, the usual parameters monitored during sedation in the ED, vital signs and pulse oximetry (SpO_2), are late to respond to hypoventilation. It is common to use supplemental oxygen to increase the patient's oxygen reserves before and during sedation. However, superoxygenated patients desaturate only after prolonged apnea so this practice inadvertently further negates the use of pulse oximetry as an early warning sign for respiratory depression or upper airway obstruction (Dietch, Chudnofsky, & Dominici, 2008). End tidal CO_2 ($ETCO_2$) monitoring has been shown to detect hypoventilation before changes in vital signs, SpO_2, or clinicians' observations (Anderson, Junkins, Pribble, & Guether, 2007; Burton, Harrah, Germann, & Dillon, 2006; Hart, Berns, Houck, & Boenning, 1997; Miner, Heegard, & Plummer, 2002; Pino, 2007; Yildizdas, Yapicioglu, & Yilmaz, 2004; Lightdale, Goldmann, Feldman, Newburg, & DiNardo, 2006; Krauss & Hess, 2007; Dietch, Chudnofsky, & Dominici, 2008). Also, unlike SpO_2, measurement of $ETCO_2$ is less likely to be affected by patient movement or low peripheral perfusion states (Krauss & Hess, 2007). Many authors support the use of capnography as the preferred method to detect hypoventilation during procedural sedation (American Academy of Pediatrics; American Academy of Pediatric Dentistry, 2006; Gilboy & Hawkins, 2006; Green, 2007; Hertzog & Havidich, 2007; Jakubaszko & Sololowski, 2008). A recent study demonstrated a 17% reduction in the incidence of hypoxia (42% v. 25%) when capnography was used in addition to standard monitoring during PSA in adult patients receiving propofol (Dietch, Miner, Chudnofsky, Dominici, & Latta, In press.). However, it is unclear whether a sub-clinical episode of respiratory depression, upper airway obstruction, or a brief period of desaturation is clinically significant or if earlier detection with capnography makes any difference in patient outcomes. As a result there is no clear consensus in the literature regarding the use of $ETCO_2$ monitoring during PSA in the ED (American College of Emergency Physicians, 2005; Scottish Intercollegiate Guidelines Network, 2004; Smalley & Nowicki, 2007; Levine & Platt, 2005). Emergency Nursing Resource is intended to provide information on capnography during sedation using an evidence-based approach.

Methodology

This ENR was created based on a thorough review and critical analysis of the literature following ENA's Guidelines for the Development of the Emergency Nursing Resources. Via a comprehensive literature search, all articles relevant to the topic were identified. The following databases were searched: PubMed, eTBLAST, Cochrane - British Medical Journal, Agency for Healthcare Research and Quality (AHRQ; www.ahrq.gov), and the National Guideline Clearinghouse (www.guidelines.gov). Searches were conducted using the key words "capnography" or "end tidal CO_2" and "sedation" and "emergency." Searches were limited to English language articles on human subjects from 2002- November 8, 2009. In addition, the reference lists of articles found via literature search were scanned for pertinent references.

Articles that met the following criteria were chosen to formulate the ENR: research studies, meta-analyses, systematic reviews, and existing guidelines relevant to the topic. Other types of article were also reviewed and provided as additional information. The ENR authors used standardized worksheets, including Evidence-Appraisal Table Template, Critique Worksheet and AGREE Work Sheet, to prepare tables of evidence ranking each article in terms of the level of evidence, quality of evidence, and relevance and applicability to practice. Clinical findings and levels of recommendations regarding patient

management were then made by the Clinical Guidelines Committee according to the ENA's classification of levels of recommendation for practice, which include: Level A High, Level B. Moderate, Level C. Weak or Not recommended for practice (See Table 1).

Table 1. Levels of Recommendation for Practice

Level A recommendations: High • Reflects a high degree of clinical certainty • Based on availability of high quality level I, II and/or III evidence available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) • Based on consistent and good quality evidence; has relevance and applicability to emergency nursing practice • Is beneficial
Level B recommendations: Moderate • Reflects moderate clinical certainty • Based on availability of Level III and/or Level IV and V evidence using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) • There are some minor or inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice • Is likely to be beneficial
Level C recommendations: Weak • Level V, VI and/or VII evidence available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence and/or opinion • There is limited or low quality patient-oriented evidence; has relevance and applicability to emergency nursing practice • Has limited or unknown effectiveness

Not recommended for practice
• No objective evidence or only anecdotal evidence available; or the supportive evidence is from poorly controlled or uncontrolled studies
• Other indications for not recommending evidence for practice may include:
  ○ Conflicting evidence
  ○ Harmfulness has been demonstrated
  ○ Cost or burden necessary for intervention exceeds anticipated benefit
  ○ Does not have relevance or applicability to emergency nursing practice
• There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. For example:
  ○ Heterogeneity of results
  ○ Uncertainty about effect magnitude and consequences,
  ○ Strength of prior beliefs
  ○ Publication bias

Evidence Table and Other Resources

The articles reviewed to formulate the ENR are described in the Evidence Table. Other articles relevant to capnography were reviewed to serve as additional resources (Other Resources Table).

Summary of Literature Review

Interpretation of Capnography Results

An elevated $ETCO_2$ level indicates retention of CO_2 due to hypoventilation and/or a decreased respiratory rate (Krauss & Hess, 2007). A decrease in $ETCO_2$ may indicate hyperventilation or respiratory depression with low tidal volumes (Krauss & Hess, 2007). One study noted that most abnormal $ETCO_2$ values were lower than the patient's baseline although no hyperventilation or increase in respiratory rate was observed (Burton, Harrah, Germann, & Dillon, 2006). Most authors cite the following criteria as significant $ETCO_2$ findings warranting intervention: absolute change in $ETCO_2$ of 10 mm Hg or greater, $ETCO_2$ 50 mm Hg or greater, or absent waveform (i.e. apnea) (Dietch, Chudnofsky, & Dominici, 2008; McQuillin & Steele, 2000; Miner, Heegard, & Plummer, 2002; Hart, Berns, Houck, & Boenning, 1997; Jakubaszko & Sololowski, 2008). In addition to the previous parameters, Burton et al. considered an $ETCO_2$ of 30 mm Hg or less abnormal (2006). One study found that a change in $ETCO_2$ of greater than 10% of the patient's baseline, instead of an absolute change of 10 mm Hg, identified twice the number of patients who developed hypoxia (Dietch, Chudnofsky, & Dominici, 2008). A subsequent study by the same investigators defined respiratory depression as $ETCO_2$ greater than 50 mm Hg, a change of 10% from baseline, or loss of waveform for 15 seconds or more (Dietch, Miner, Chudnofsky, Dominici, & Latta, In press.) This study found that most patients who developed hypoxia had an $ETCO_2$ change greater than 10% from baseline but loss of waveform was most likely to result in hypoxia (Dietch, Miner, Chudnofsky, Dominici, & Latta, In press.).

Initial interventions for hypoventilation include repositioning the patient's head to restore airway patency and verbal or physical stimulation to encourage the patient to breathe (Hertzog & Havidich, 2007; Krauss & Hess, 2007). If these measures are inadequate to reverse the situation then decreasing medication doses, ceasing medication administration, or the administering reversal agents may be considered (Krauss & Hess, 2007). If apnea occurs and is unresponsive to repositioning or stimulation, bag-mask ventilation is indicated (Krauss & Hess, 2007).

The completion of the procedure does not end the risk of respiratory depression. McQuillin and Steele (2000) found that the highest $ETCO_2$ levels occurred after the end of the procedure but before the patients returned to their baseline level of consciousness.

Use of Supplemental Oxygen

Supplemental oxygen may delay the onset of hypoxia which may delay the recognition of hypoventilation during PSA (Miner, Heegard, & Plummer, 2002; American College of Emergency Physicians, 2005; Green, 2007). In light of this information, monitoring with $ETCO_2$ is more likely to be helpful if supplemental oxygen is used during sedation (Dietch, Chudnofsky, & Dominici, 2008; Green, 2007).

Description of Decision Options/Interventions and the Level of Recommendation

Conclusions and recommendations about the use of capnography for procedural sedation and analgesia (PSA) in adults and children in the emergency department:

- Capnography is a useful technique for detecting respiratory depression during and after PSA.
- $ETCO_2$ is a more sensitive indicator of respiratory depression than SpO_2 or clinician assessment during PSA as well as in the recovery phase.
- There is a lack of evidence to support that using capnography during PSA directly improves patient outcomes.
- Capnography is a useful adjunct for monitoring patients during PSA in the emergency department (Level B).

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