Critical Review Form
Therapy

Does End-tidal Carbon Dioxide Monitoring Detect Respiratory Events Prior to Current Sedation Monitoring Practices, *Acad Emerg Med* 2006; 13:500-504

Objective: **"To determine the ability of $ETCO_2$ monitoring during PSA to detect acute respiratory events before detection by current monitoring methods". (p. 501)**

Methods: **Prospective convenience sampling observational case series of ED patients undergoing procedural sedation and analgesia (PSA) at Maine Medical Center from May to October 2004. Patients were only excluded if they were unable to give consent or if there were no study investigators available. Procedural sedation routine monitoring included continuous oxygen saturation, cardiac rhythm, respiratory rate and blood pressure. These parameters were recorded by a study investigator every 30-seconds during the procedure. The study investigator was one of four physician-investigators (3 residents, 1 attending) who was not simultaneously involved in patient care. The four investigators agreed on monitoring practices and met "intermittently" to ensure consistent enrollment practices.**

End-tidal CO_2 ($ETCO_2$) was measured along with oxygenation, heart and respiratory rate using the LIFEPACK 12 defibrillator/monitor series (MEDTRONIC Emergency Response Systems) which was provided to the investigators by the manufacturer. All patients had supplemental oxygen (2 L/min) during PSA as part of the institutional protocol. The clinical team was blinded to study monitoring data including $ETCO_2$, but an interim safety analysis for each 30-patient enrollment block was planned *a priori*. This interim safety analysis was conducted with two physician investigators and a research nurse not involved in the study.

$ETCO_2$ data included a continuous exhaled CO_2 waveform and numerical display of measured CO_2. Acute respiratory events were defined as oxygen saturation ≤ 92%, an increase in the amount of supplemental oxygen used in response to hypoventilation or desaturation, use of bag-value mask or oral/nasal airway, airway repositioning or verbal/physical stimulation in response to hypoventilation or desaturation.

Investigational acute respiratory events were defined by a change in $ETCO_2$ ≥ 10 mm Hg from the pre-sedation baseline or an intra-sedation $ETCO_2$ ≤30 mm Hg or ≥ 50 mm Hg.

Guide		Comments
I.	**Are the results valid?**	
A.	**Did experimental and control groups begin the study with a similar prognosis (answer the questions posed below)?**	
1.	Were patients randomized?	No, this is an observational (non-interventional) study.
2.	Was randomization concealed (blinded)?	No randomization. However, clinicians were blinded to the $ETCO_2$ levels.
3.	Were patients analyzed in the groups to which they were randomized?	Not randomized so intention-to-treat is not relevant.
4.	Were patients in the treatment and control groups similar with respect to known prognostic factors?	No treatment/control group so no prognostic variables to describe.
B.	**Did experimental and control groups retain a similar prognosis after the study started (answer the questions posed below)?**	
1.	Were patients aware of group allocation?	Yes. No allocation – one group and patients had to consent so they knew which group they were in.
2.	Were clinicians aware of group allocation?	No allocation so clinicians knew their patients were part of this study although clinicians were blinded to the $ETCO_2$ results.
3.	Were outcome assessors aware of group allocation?	Yes.
4.	Was follow-up complete?	No loss to follow-up is reported.
II.	**What are the results (answer the questions posed below)?**	

1.	How large was the treatment effect?	• The median age of patients was 38-years (range 1 – 89) and 58% were male. • The majority of patients had orthopedic procedures (58%), cardioversion (18%), or wound closure (16%) with propofol being used in 68%. • The data monitoring safety board stopped the trial after the second 30-patient enrollment block. • 60% (36/60) of patient had abnormal $ETCO_2$ findings including 32/36 with low levels (without corresponding hyperventilation) and 5/36 with high levels. • In 44% (16/36) episodes of abnormal $ETCO_2$ there were no respiratory events and no clinical team intervention. • There were 20/60 (33%) of PSA encounters with acute respiratory events with $ETCO_2$ providing forewarning of 0 to 271 seconds in 17/20 (85%) including 14/17 with > 0 seconds forewarning.
2.	How precise was the estimate of the treatment effect?	Uncertain since no point estimates or 95% CI are provided in this small sample size.
III.	**How can I apply the results to patient care?**	
1.	Were the study patients similar to my patient?	Uncertain since the methodological description is somewhat sparse. How many procedural sedations had the clinicians performed? At a large academic institution 250 sedations/year seems like a small number. How sick were the patients (co-morbidity scales, ESI) and what was their disposition? Were there any trends noted with different PSA agents? Were sedating physicians also performing the procedure? And had the sedating physicians previously been using $ETCO_2$ monitoring before the study?

2.	Were all clinically important outcomes considered?	No patient-important outcomes were assessed (procedure-related prolonged ED length of stay, avoidable hospitalization, mortality, brain injury). "The impact of earlier detection of hypoventilation and/or apnea with $ETCO_2$ data does not necessarily translate into the potential to effect a clinical intervention that would have altered the recorded respiratory event". (p. 504) "Future studies are needed to investigate the impact of routine $ETCO_2$ monitoring on reduction of patients acute respiratory events". (p. 504)
3.	Are the likely treatment benefits worth the potential harm and costs?	Uncertain. Since 44% of $ETCO_2$ abnormal readings were "noise" (no respiratory events or clinical response required) and since the LIFEPACK-12 retails at $12,495 one would have to conduct a cost-benefit analysis. • What is the value of detecting a respiratory event up to 4-minutes earlier? • What is the harm of a 20-second episode of hypoxia? • How much would a lawsuit cost if a preventable PSA-related brain injury or mortality occurred? Nonetheless, lacking the benefits of a cost-analysis, $ETCO_2$ monitoring is standard practice in the operating room. Why should EM settle for a lesser standard pending definitive evidence?

Limitations

1) **Incomplete description of PSA methods (sedating agents employed, experience of clinicians with PSA and capnometry, solo sedating physician-proceduralist or two-physician terms, etc.).**

2) **Incomplete description of patient population including co-morbid illness burden, BMI, % with OSA, illness severity, admission rate, ED LOS, hospital LOS, level of sedation and patient satisfaction with sedation.**

Bottom Line

The majority (60%) of patients undergoing (mostly propofol) PSA experience an abnormal $ETCO_2$ which is low in 80% of such cases. Still, 40% of abnormal $ETCO_2$ readings result in no respiratory events or clinical response as significant noise clouds the signal. Furthermore, brief episodes of hypoxia may not impact most patients during PSA. Further research should strive to enhance the signal-to-noise ratio while evaluating patient important outcomes like preventable PSA relate morbidity with the use of $ETCO_2$. If a patient-oriented benefit is ultimately demonstrated cost-benefit analyses should be conducted.