# Characteristics of and Predictors for Apnea and Clinical Interventions During Procedural Sedation

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**Study objective:** We describe the characteristics of and predictors for apnea and clinical interventions during emergency department (ED) procedural sedation.

**Methods:** High-resolution data were collected prospectively, using a convenience sample of ED patients undergoing propofol or ketofol sedation. End tidal $CO_2$ ($ETCO_2$), respiratory rate, pulse rate, and $SpO_2$ were electronically recorded in 1-second intervals. Procedure times, drug delivery, and interventions were electronically annotated. Kaplan-Meier curves were used to describe the onset of clinical interventions as a function of sedation time. The onset of apnea (15 consecutive seconds with carbon dioxide $\leq$10 mm Hg) and clinical interventions were estimated with a series of Cox proportional hazards survival models, with time to first apnea or clinical intervention as the dependent variable. Finally, we tested the association between apnea and clinical intervention.

**Results:** Three hundred twelve patients were analyzed (53% male patients). Apnea was preceded by $ETCO_2$ less than 30 mm Hg or greater than 50 mm Hg at 30, 60, and 90 seconds before its onset. Clinical interventions were predicted by apnea, $SpO_2$, and propofol use. Increasing age predicted both apnea and interventions. Apnea was not predicted by respiratory rate or $SpO_2$. Apnea occurred in half of the patients and clinical interventions in a quarter of them. Clinical intervention was not predicted by abnormal respiratory rate or abnormal $ETCO_2$ level. The majority of clinical interventions (85%) were minor, with no cases of assisted ventilation, intubation, or complications.

**Conclusion:** Alterations in $ETCO_2$ predicted apnea along a specific time course. Alterations in $SpO_2$, apnea, and propofol use predicted clinical interventions. Increasing age predicted both apnea and clinical intervention. [Ann Emerg Med. 2016;68:564-573.]

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## INTRODUCTION

### Background

Although considerable progress has been made in the safety and efficacy of procedural sedation,[1,2] we have yet to understand the root causes of the most common adverse events, specifically, respiratory depression and apnea, which can occur in up to 60% of patients.[3-10] Vital sign monitoring allows clinicians to identify adverse respiratory events when they occur, but current monitoring modalities do not have the capability to predict which patients are at risk for respiratory events or anticipate when adverse respiratory events are at risk of occurring.

Current understanding of sedation-related adverse events has been limited by the data-recording capability of vital sign monitors. Until recently, vital sign monitors were unable to stream continuous data, perform continuous data capture, or record data with high resolution. Therefore, sedation research databases were small and discontinuous (because the recordings were at 30- to 60-second intervals maximally). This resulted in missing discrete adverse events and the abnormal cardiorespiratory patterns that preceded these events.

### Importance

The recent advent of cardiorespiratory monitors that can record continuous high-resolution data allows study of the patterns of abnormal breathing and the cardiorespiratory changes that occur before adverse respiratory events on a highly granular level and potential recognition of patterns that were not previously apparent when standard monitoring equipment was used.

### Goals of This Investigation

We used high-resolution data recording during emergency department (ED) procedural sedation to

**Editor's Capsule Summary**

*What is already known on this topic*

The frequency of emergency department (ED) procedural sedation and analgesia-associated respiratory depression is poorly described.

*What question this study addressed*

During procedural sedation and analgesia, does high-fidelity, automated, and multimodal physiologic monitoring detect apnea (defined as >15 seconds with expired carbon dioxide <10 mm Hg) often, and what interventions occur?

*What this study adds to our knowledge*

Of the 312 patients, all aged 8 years or older, who received propofol alone or with ketamine, apnea occurred in nearly half and an intervention in a quarter. The events and interventions were mostly minor (85%), without any intubation or assisted ventilation.

*How this is relevant to clinical practice*

ED procedural sedation and analgesia apnea with these agents is frequent and detected by rigorous monitoring, but the effect on care is limited.

determine the characteristics of and predictors for apnea and for clinical interventions.

## MATERIALS AND METHODS

### Study Design

Data were collected in a prospective, nonrandomized fashion, using a convenience sample of ED patients undergoing procedural sedation at Lions Gate Hospital, North Vancouver, British Columbia, Canada, from May 2013 through July 2014. The study protocol was approved by the University of British Columbia Clinical Research Ethics Board.

### Setting

Lions Gate Hospital is a 250-bed community teaching hospital and Level III trauma center with an annual ED census of 63,000 visits, of which 80% are by adults. All emergency physicians were board certified and participated in the sedations and procedures during which data were collected. The physicians, registered nurses, and respiratory therapists who collected the data were trained in sedation monitoring and data collection.

### Selection of Participants

All spontaneously breathing subjects aged 8 years or older, who had an American Society of Anesthesiologists Physical Status Classification 1 to 3, and who would be receiving sedation for ED procedures were screened for enrollment. Subjects with underlying conditions that could affect ventilation, perfusion, or metabolism were excluded, including intubated subjects; those with clinical signs of cardiopulmonary instability, major trauma, shock, or sepsis; those with an American Society of Anesthesiologists class 4 or 5; those with an inability to provide informed consent (or assent); and those excluded by physician discretion.

### Methods of Measurement

Initial medical assessments were conducted in accordance with established clinical procedures, including the subjects' history, physical examination, and vital signs. If by clinical assessment the patient met eligibility criteria, then he or she was approached by the respiratory therapist for enrollment in the study. Before the start of sedation, the patient received standard vital sign monitoring (ECG, noninvasive blood pressure monitoring, pulse oximetry, and capnography), which was continuously recorded throughout the sedation and recovery periods. Patient demographics (age and sex), body weight, procedure type, premedication administered, drug dosages and times, procedure start and end times, and clinical interventions (verbal stimulation, tactile stimulation, airway repositioning, supplemental oxygen delivery, assisted ventilation, and intubation) were recorded on the data sheet, and all sedation events were electronically annotated on the monitor and time stamped with an event marker on the monitor. The data recorder (ie, the respiratory therapist) pressed the event button on the monitor, typically within 2 to 3 seconds of when an event was detected. There was also a free-text area on the data sheet where any other events or comments could be listed. This produced a time-stamped electronic record that allowed precise matching of the sedation events (drug administration, procedure start and finish, clinical interventions, etc) with corresponding vital sign data. At the completion of the sedation, all device data were electronically transmitted to a designated computer. The subject's clinical data and sedation information were entered into the study data form, and a patient identifier was recorded to link the clinical and electronic monitoring data without compromising patient confidentiality.

### Interventions

Drug regimens were selected according to the treating physician's clinical judgment, with the only absolute contraindication being known allergy to relevant