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Capnography is superior to pulse oximetry for the detection of respiratory depression during colonoscopy

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ABSTRACT

Background: pulse oximetry is a widely accepted procedure for ventilatory monitoring during gastrointestinal endoscopy, but this method provides an indirect measurement of the respiratory function. In addition, detection of abnormal ventilatory activity can be delayed, especially if supplemental oxygen is provided. Capnography offers continuous real-time measurement of expiratory carbon dioxide.

Objective: we aimed at prospectively examining the advantages of capnography over the standard pulse oximetry monitoring during sedated colonoscopies.

Patients and methods: fifty patients undergoing colonoscopy were simultaneously monitored with pulse oximetry and capnography by using two different devices in each patient. Several sedation regimens were administered. Episodes of apnea or hypoventilation detected by capnography were compared with the occurrence of hypoxemia.

Results: twenty-nine episodes of disordered respiration occurred in 16 patients (mean duration 54.4 seconds). Only 38% of apnea or hypoventilation episodes were detected by pulse oximetry. A mean delay of 38.6 seconds was observed in the events detected by pulse oximetry (two episodes of disturbed ventilation were simultaneously detected by capnography and pulse oximetry).

Conclusions: apnea or hypoventilation commonly occurs during colonoscopy with sedation. Capnography is more reliable than pulse oximetry in early detection of respiratory depression in this setting.

Key words: Capnography. Sedation. Colonoscopy.

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INTRODUCTION

Analgesia and moderate sedation are required to perform a wide variety of endoscopic procedures. However, during the performance of moderate sedation inadvertent oversedation may occur, leading to deep sedation and respiratory compromise. Airway management skills and adequate training in reversing deep to moderate sedation status can avoid further complications. To detect episodes of disordered respiration early, minimally acceptable monitoring during moderate sedation involves the use of continuous pulse oximetry in addition to visual assessment of respiratory activity (1-3). However, this method provides an indirect measurement of respiratory function and the detection of abnormal ventilatory activity may be delayed. This delay is especially relevant if supplemental oxygen is provided, because ventilation may be seriously affected while oxygenation remains apparently adequate (4). Capnography refers to continuous, real-time, non-invasive measurement of expiratory carbon dioxide (CO_2). Initially, it was a useful non-invasive tool used during general anaesthetic procedures to monitor ventilation in intubated patients, and later its use spread to non-intubated patients (4). Capnography may provide earlier evidence of respiratory compromise in patients undergoing gastrointestinal endoscopy under sedation.

Here we present the results of a prospective study comparing standard pulse oximetry with capnograhy for the monitoring of ventilatory status during colonoscopies under sedation.

PATIENTS AND METHODS

Patient selection

Fifty patients undergoing colonoscopy were included. Exclusion criteria were age less than 18 years, mechanical ventilation, and a history of allergy to the drugs used for sedation and/or analgesia. A detailed medical history was taken by the endoscopist before the procedure.

Sedation and analgesia protocol

The colonoscopies were performed by one experienced staff gastroenterologist. Several sedation and analgesia regimens were used: petidine plus midazolam, propofol or a combination of propofol, midazolam and fentanyl. These drugs were administered through an intravenous catheter as a bolus or by a patient-controlled sedation pump (PCA) based on the endoscopist's and/or anaesthesist's assessment of patient tolerance and level of sedation. For all procedures, one nurse stationed beside the patient was responsible for monitoring signs of discomfort, restlessness, or agitation, physiologic parameters (pulse oximetry and capnography), and visual assessment of respiratory activity. A second nurse was responsible for the administration of sedative and analgesic drugs, and to give assistance to the endoscopic procedure as directed by the endoscopist.

Monitoring

All patients were monitored simultaneously with conventional pulse oximetry (Nonin 8600, Medical Inc. Minnesota, EE. UU.) and capnography by using a side stream CO_2 detector attached to an oral/nasal cannula sampling device (Microcap, Isso SA. Madrid, Spain). The last device provided a graphic assessment of respiratory activity by using an expired CO_2 detector attached to an adult nasal cannula sampling device with a large oral prong that collects breath samples from both the nose and mouth while also supplying oxygen to the patient. Capnography provides a real-time assessment of respiratory activity that is accomplished through continuous sampling and measurement of CO_2 exhaled. Not infrequently, capnography shows false positive results related to measuring failures, often due to losses of sampling air by mouth. This can be partially mitigated by using nasal cannulas with oral prongs. A continuous waveform of CO_2, called a capnogram, is displayed throughout the ventilatory cycle (Fig. 1). Peaks in the capnogram correspond to expiration and troughs represent inspiration. We also continuously measured numeric values for heart rate, end tidal CO_2 (Et CO_2 maximal CO_2 breath concentration at the end of expiration), pulse oximetry and respiratory rate. Supplemental oxygen (2 l/min through nasal cannula) was administered in every case.

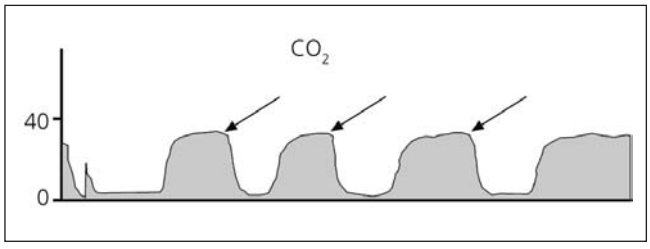

Fig. 1. Normal capnogram. Peaks correspond to expiration while troughs represent inspiration. Arrows indicate the highest concentration of CO_2 at the end of expiration ($EtCO_2$).

Episodes of disordered respiration (apnea or hypoventilation) were compared with the occurrence of hypoxemia. Apnea was defined as the cessation of respiratory activity for 30 or more seconds and hypoventilation as an end tidal CO_2 value at least 25% greater than the baseline value. Hypoxemia was defined as a pulse oximetry value less than 90%.

Each patient gave informed consent. The study protocol was reported to the local ethics committee review board.

Statistical analysis

All continuous data were expressed as mean ± SD. The Student's t test was used to analyze continuous data. Nominal data were analyzed with the chi-squared test or Fisher's exact test. When indicated, the p value was adjusted for multiple comparisons. A p value < 0.05 was considered significant. Data analysis was performed on a personal computer with a statistical software package (SPSS 11).

RESULTS

Demographic data are showed in table I. There was no difference between patients with and without disordered respiration in terms of clinical and demographic features. Also there was no difference in the duration of colonoscopies, basal respiratory parameters and sedation regimens between patients with and without disordered respiration. The combination of three drugs (propofol, opioids and/or midazolam) was significantly associated with the appearance of ventilatory disorders when compared to single-drug or two-drug sedation regimens (Table II). Average doses of petidine, midazolam and propofol were slightly greater in patients with some type of respiratory event, although this difference did not reach statistical significance.

The episodes of disordered respiration detected by each technique have been described in table III. Capnography detected 29 episodes of anomalous ventilation in 16 patients (range 1-3), average length 54.4 seconds (range 25-130 seconds). Pulse oximetry detected oxygen

Table I. Demographic and clinical data from patients with and without respiratory disorders during endoscopic procedures

	Overall	*Disordered respiration absent*	*Disordered respiration present*
Gender (male/female)	27/23	18/16	9/7
Age (yr)	56 ± 14.4	54 ± 15.2	59 ± 12.4
History of smoking	11	10	1
Outpatient/inpatient	43/7	30/4	13/3
ASA I-II/III-IV	39/11	29/5	10/6
Co morbid diseases			
COPD	5	5	0
Kidney disease	1	1	0
Ischemic heart disease	8	5	3
Liver disease	2	0	2
Alcohol use	2	2	0
Narcotic use	1	0	1
Benzodiazepine use	8	5	3
Other sedatives or psychotropic drugs	11	8	3

Table II. Monitored parameters and sedation regimen in both groups (disordered respiration absent or present)

	Disordered respiration absent (n = 34)	*Disordered respiration present (n = 16)*
Procedural length (min)	20.6 ± 9	20.3 ± 9.6
Basal SaO_2	97 ± 2.7	96 ± 2.3
Respiratory rate	18.2 ± 3.4	19.3 ± 5.7
$EtCO_2$	33.7 ± 4.2	33.5 ± 3.7
Sedation procedure (bolus/PCS)	28/6	16/0
Sedation regimen		
Petidine + midazolam[a]	19	2
Propofol[b]	7	1
Propofol + fentanyl + midazolam[c]	8	13

PCS: patient controlled sedation; $EtCO_2$: end tidal CO_2. [a]vs. [b]NS; [a]vs. [c]p = 0.0001; [b]vs. [c]p = 0.015.

Table III. Detection of respiratory anomalies by capnography and pulse oximetry

	Disordered respiration pattern		
	Overall	*Hypoventilation episodes*	*Apnea episodes*
Capnography detection	29	12	17
Pulse oximetry detection	11	6	5
Episode length (seconds)	54.4 ± 29.7	64.5 ± 35.9	46.7 ± 20.6
Mean delay (pulse oximetry detection in seconds)	38.6 ± 30.3	35.8 ± 34.9	42 ± 23.1
Simultaneous detection (capnography and pulse oximetry)	2	2	0

desaturation only in 38% of those episodes (11 episodes in 9 patients).

Hypoxemia occurred on average 38.6 seconds after hypoventilation or apnea was present (range 0-90 seconds). In fact, just two episodes of disturbed ventilation were simultaneously detected by capnography and pulse oximetry.

Most patients under propofol reached a deep sedation level. The sedation level was moderate in the remainder. During the procedures, no patient with disordered respiration required aggressive maneuvers to recover, and discontinuation of colonoscopy was never needed.

DISCUSSION

The current prospective study shows that during colonoscopies performed under sedation, the occurrence of respiratory disorders is frequent. These anomalies are detected to a greater extent and earlier by capnography as compared to conventional pulse oximetry.

The main cause of morbidity associated with sedation/analgesia is respiratory depression and airway obstruction (5). Morbidity increases concurrently with increases in the degree of depth of sedation. We believe that this is the explanation for the fact that in our study the procedures in which the sedation scheme was based on the combination of propofol with two other drugs showed a significant association with the occurrence of respiratory disorders. Like other authors, we found a high rate of respiratory disturbances (6), and all had no significant clinical impact. Also in agreement with previously published data, the average doses of the drugs used did not differ significantly between patients with episodes of respiratory disturbance and those without such episodes (6). Currently, recommendations for basic respiratory monitoring in patients under sedation/analgesia include visual assessment of respiratory movements (2,5). However, the environment of an endoscopy suite frequently has soft lighting, which along with occupation of physical space by endoscopy equipment and the staff makes visual inspection of these ventilatory movements difficult. In addition to direct assessment, pulse oximetry is the recommended method to conventional instrumental monitoring of respiratory function in patients referred for endoscopy and sedation (1,5).

Pulse oximetry effectively detects oxygen desaturation and hypoxemia, but it would be inaccurate and potentially risky to assume that it is an appropriate parameter to detect alveolar hypoventilation, as this can occur in the presence of normal SaO_2 measured by pulse oximetry (6). Ventilation and oxygenation are separate physiological processes. Moreover the use of supplemental oxygen, which is essential in the event of deep sedation and should be considered during moderate sedation (5), may further interfere with detection of respiratory depression (4).

Therefore, we need an additional method for early detection of respiratory complications that may occur during colonoscopy under sedation. Capnography is a non-invasive method to monitor respiratory activity based on the principle that CO_2 absorbs infrared light at a wavelength of 4,200 nm. The amount of light absorbed is proportional to the concentration of CO_2 in the sample. The quantification of this absorption generates a continuous curve which represents the breathing of a patient in real time and thus allows early detection of respiratory depression (7).

The present study shows that capnography has these advantages over pulse oximetry in patients undergoing sedated colonoscopy. Our results are comparable to those obtained by Vargo et al. in patients undergoing upper endoscopy (6). However, we believe it is important to know whether this difference in efficiency in statistical terms between both respiratory monitoring techniques translates into real clinical benefits. In fact, although the application of capnography to general anesthesia procedures results in a substantial decline in mortality (8), currently available evidence is insufficient to support the use of capnography for routine upper endoscopies and colonoscopies in adults. However, there are data supporting a clinical benefit from the use of capnography in endoscopic cholangiopancreatography (ERCP) and endoscopic ultrasonography (EUS) in adults and in routine upper endoscopy and colonoscopy in the pediatric population. Two randomized controlled studies support this issue. In a recent work, Qadeer et al. found a significant reduction of hypoxemia in patients undergoing ERCP and EUS monitored with capnography when compared with conventional methods (9). Furthermore, Lightdale et al. reached similar conclusions in pediatric patients undergoing colonoscopies and upper endoscopies under moderate sedation (10). From our point of view, the detection of ventilatory abnormalities by capnography is not always a direct reflection of the clinical impact of these changes on the health of patients undergoing sedated colonoscopy, but rather a graphical early detector of such anomalies that allows us to act on the patient before these disorders become clinically significant. This could be an explanation for the high frequency of respiratory disturbances detected by monitors both in our results and those obtained by other authors (6).

In conclusion, episodes of respiratory disturbance during colonoscopies performed under sedation are frequent. Capnography provides a continuous graphic record of respiratory activity and complements visual assessment and pulse oximetry in the respiratory monitoring of patients undergoing sedated colonoscopies. This non-invasive technique is more sensitive than pulse oximetry in detecting respiratory abnormalities and allows earlier detection of these changes. Specifically designed studies are needed to clarify the role of capnography in routine sedated endoscopic procedures in the adult population.

REFERENCES

1. López Rosés L and Subcomité de Protocolos of the Spanish Society of Gastrointestinal Endoscopy. Sedation/analgesia guidelines for endoscopy. Rev Esp Enferm Dig 2006; 98: 685-92.
2. Simón MA, Bordas JM, Campo R, González-Huix F, Igea F, Monés J. Documento de consenso de la Asociación Española de Gastroenterología sobre sedoanalgesia en la endoscopia digestiva. Gastroenterol Hepatol 2006; 29: 131-49.
3. López Rosés L, Olivencia Palomar, P. Colonoscopia. Rev Esp Enferm Dig 2008; 100: 372.
4. Radaelli F, Terruzzi V, Minoli G. Extended/advanced monitoring techniques in gastrointestinal endoscopy. Gastrointest Endoscopy Clin N Am 2004; 14: 335-52.
5. Practice Guidelines for sedation and analgesia by non-anesthesiologists. An updated report by American Society of Anesthesiologists task force on sedation and analgesia by non-anesthesiologists. Anesthesiology 2002; 96: 1004-17.
6. Vargo JJ, Zuccaro G, Dumot JA, Darwin LC, Morrow JB, Shay SS. Automated graphic assessment of respiratory activity is superior to pulse oximetry and visual assessment for the detection of early respiratory depression during therapeutic upper endoscopy. Gastrointest Endosc 2002; 55: 826-31.
7. ASGE. Sedation and anesthesia in GI endoscopy. Gastrointest Endosc 2008; 68: 815-26.
8. Eichhorn JH. ASA Standards amend: CO2 seen after intubation now the standard of care. Anesthesia Patient Safety Foundation Newsletter 1991; 6: 1-12.
9. Qadeer MA, Vargo JJ, Dumot JA, Lopez R, Trolli PA, Stevens T, et al. Capnographic monitoring of respiratory activity improves safety of sedation for endoscopic cholangiopancreatography and ultrasonography. Gastroienterology 2009; 136: 1568-76.
10. Lightdale JR, Goldmann DA, Feldman HA, Newburg AR, DiNardo JA, Fox VL. Microstream capnography improves patient monitoring during moderate sedation: a randomized, controlled trial. Pediatrics 2006; 117: e1170-e1178.