Original Article

MEDICINE PALLIATIVE CARE

DOI: 10.47582/jompac.1346914

J Med Palliat Care. 2023;4(5):505-510

Does end-tidal carbon dioxide monitoring in gastrointestinal endoscopy have a clinical advantage?

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Cite this article as: Özden MGN, Karslı S, Bakan N. Does end-tidal carbon dioxide monitoring in gastrointestinal endoscopy have a clinical advantage?. *J Med Palliat Care*. 2023;4(5):505-510.

Received: 20.08.2023 ◆ **Accepted**: 26.09.2023 ◆ **Published**: 27.10.2023

ABSTRACT

Aims: In current guidelines recommended CO_2 monitoring for patient safety and comfort in sedation for gastrointestinal endoscopy. We aimed to investigate whether carbon dioxide monitoring, which was developed for the early detection of adverse respiratory events shows the expected benefit in its clinical use.

Methods: ASA I-II patients, average age 48±15, were divided into two groups, standard monitoring was performed on Group S (n=30), and $EtCO_2$, Integrated Pulmonary Index measurements were added to the Group K (n=30). Patients received Fentanyl 1µgr/kg, propofol 1 mg/kg and propofol 10-30 mg in a bolus by providing BIS to be 60-85. Adverse respiratory events were recorded. The time to Fast-tracking score being 14 was recorded and patients with two consecutive Fast-tracking scores of 14 were discharged. Patient satisfaction was questioned the next day.

Results: There is no difference between groups in heart rate and mean arterial pressure, and decreased during the procedure compared to baseline in both groups. While $EtCO_2$ was similar at all times, IPI was lower than baseline. While the processing time was 21±6 in Group S, it was 38±11 in Group K. No adverse respiratory events occurred. Recovery heart rates, peripheral oxygen saturation, mean arterial pressure and scores were similar. There was no difference in patient satisfaction.

Conclusions: There wasn't a clinical advantage with measuring $EtCO_2$ added to the standard monitoring in gastrointestinal tract endoscopy. We believe that more studies are needed on optimum monitoring during moderate sedation in patients with less clinical risk.

Keywords: Capnography, gastrointestinal endoscopy, sedation.

Oral Presentation: 1st International Anesthesiology and Reanimation Symposium (it was included in the oral presentation competition)

INTRODUCTION

Endoscopic interventions are very important in the investigation of the gastrointestinal tract and in the diagnosis of pathologies. However, these procedures can be uncomfortable and painful for the patient. Sedation is required for patient comfort and ease of invention.[1]

Sedation is applied to relieve the patient's anxiety and discomfort by creating a depression at the conscious level, to ensure the best application of the procedure, and to prevent the patient from remembering the procedure. For safe sedation, patients need close observation and appropriate monitoring should be provided for this.[2]

Sedation applied for gastrointestinal procedures is moderate sedation that responds to verbal or tactile stimuli, does not require airway intervention, provides adequate spontaneous breathing, and preserves cardiac functions.[3] However, deep sedation or general anesthesia situations requiring intervention may occur during moderate sedation.

In recent years, monitoring techniques showing ventilation by measuring end-tidal carbon dioxide and sedation level by measuring electrical activity of brain have been developed. In current guidelines, CO_2 monitoring is recommended for moderate and deep sedation.[4] The formation of deep sedation or general anesthesia and the undesirable respiratory events prolong the recovery time of the patients after the invention.[5]

In our study, we aimed to investigate whether carbon dioxide monitoring, which was developed for the early detection of adverse respiratory events that may develop in patients who received moderate sedation during the endoscopic intervention in the gastrointestinal system, shows the expected benefit in its clinical use.

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METHODS

This prospective randomized study was carried out with the permission of the Health Sciences University Sureyyapasa Chest Diseases and Thoracic Surgery Training and Research Hospital Clinical Researches Ethics Committee (Date: 09.05.2019, Decision No: 053). The necessary informed consents of the patients were completed before the procedure. All procedures were carried out under the ethical rules and the principles of the Declaration of Helsinki.

The study was completed with a total of 60 ASA I-II patients, aged between 18-70 years, undergoing esophagogastroduodenoscopy in an education and research hospital. Patients with heart disease, lung disease, liver failure, kidney failure, psychiatric drug use, history of malignancy, morbidly obese, pregnant or breastfeeding patients were not included in the study. The study was finished with 60 patients who were sedated during the gastrointestinal endoscopy examination between May and December 2019. Randomization was performed by the computer as Group S (n=30) with standard monitoring and Group K (n=30) with end-tidal carbon dioxide ($EtCO_2$) monitoring in addition to standard monitoring. While the heart rate (HR), mean arterial pressure (MAP), peripheral oxygen saturation (SpO_2) measurements and respiratory rate (RR) were recorded in Group S patients; $EtCO_2$, RR, SpO_2, HR and Integrated Pulmonary Index (IPI) interval data were recorded by the capnography (Capnostream® 20p/Covidien) in Group K patients in the endoscopy unit. The IPI score is calculated by the device, and the actual figures of $EtCO_2$, RR and SpO_2, PR values are reduced to a number by mathematical analysis. The device is evaluated in 6 categories ranging from 1 to 10 IPI Score. As seen in the figure; Between 5-10 green areas (safe), 3-4 yellow areas (requiring intervention) and 1-2 red areas (requiring urgent intervention) are accepted (Figure 1).

IPI	Patient Status
10	Normal
8-9	Within normal range
7	Close to normal range – requires attention
5-6	Requires attention and may require intervention
3-4	Requires intervention
1-2	Requires immediate intervention

Figure 1. IPI (integrated pulmonary index)

Ronen M, Weissbrod R Overdyk FJ, Ajizian S. Smart respiratory monitoring: clinical development and validation of the IPI™ (Integrated Pulmonary Index) algorithm. J Clin Monit Comput. 2017; 31(2): 435–442. Published online 2016 Mar 9.

Bispectral index (BIS) monitoring was also performed to monitor the sedation level of all patients participating in the study. Before the invention, propofol (2 mg/kg-1; Polifarma, Istanbul, Turkey) 1 mg/kg i.v. and fentanyl (1 mcg/kg-1; Vem, Istanbul, Turkey) 1 µgr/kg i.v. were administered to patients admitted to the endoscopy unit. The endoscopic invention was allowed to begin at the appropriate sedation depth, and propofol 10-30 mg i.v. was administered if needed, keeping the BIS values of 60-85 until the procedure was completed. Apnea; A cessation of breathing for more than 30 seconds and $EtCO_2$=0 mmHg measured during this time was defined as RR=0. Desaturation is defined as a decrease in the initial SpO_2 value of 4% and below, and this lasted for at least 4 minutes. When apnea and desaturation were observed or IPI <6, it was planned to intervene with a verbal warning, chin-lift maneuver, and increasing oxygen flow for supporting respiration. If the apnea and desaturation times of the patients were prolonged or the SpO_2 value fell below 10% of the initial value despite the interventions, the procedure was terminated and intervention was planned to ensure airway safety and support respiration.

Processing time was defined as the endoscopic intervention time and recorded. Patients who completed the endoscopic procedure were taken to the recovery unit and HR, MAP and SpO_2 of patients were recorded till discharged at 10-minute intervals. The Fast-tracking recovery score was calculated and recorded at 10-minute intervals. Time to Fast-tracking score of 14 was recorded, and patients with two consecutive Fast-tracking scores of 14 were discharged.[6]

The patients were called 24-48 hours later invention and questioned whether they had symptoms such as abdominal distension, fever, pain at the injection site, nausea-vomiting, dizziness and weakness. At the same time, satisfaction from sedation was asked with 5 points Likert scale (1: Very dissatisfied, 2: Dissatisfied, 3: Neutral, 4: Satisfied, 5: Very satisfied).

Statistical Analysis

In order to determine the number of samples, a power analysis was performed using the G*Power (v3.1.7) program. The power of the study is expressed as 1-β (β=probability of type II error), and in general studies should have 80% power. According to Cohen's effect size coefficients; In order to determine the clinical superiority of end-tidal carbon dioxide monitoring in gastrointestinal endoscopies, the calculation made by assuming that the evaluations to be made between two independent groups will have a large effect size (d=0.80), there should be at least 26 people in the groups. Considering that there may be losses during the working process, it was decided to recruit 30 people each.

While evaluating the findings obtained in the study, IBM SPSS Statistics 22 (IBM SPSS, Turkey) program was used for statistical analysis. While evaluating the study data, the conformity of the parameters to the normal distribution was evaluated with the Shapiro Wilks Test. While evaluating the study data, in addition to descriptive statistical methods (mean, standard deviation, frequency), Student's t-test was used for comparisons of normally distributed parameters between two groups, and Mann Whitney U test was used for comparisons of non-normally distributed parameters between two groups. Paired Sample t-test was used for in-group comparisons of normally distributed quantitative data, and Wilcoxon Signed Ranks test was used for in-group comparisons of non-normally distributed parameters. Fisher's Exact test, Fisher Freeman Halton test and Continuity (Yates) Correction were used to compare qualitative data. Significance was evaluated at the p<0.05 level.

RESULTS

There was no difference in demographic data between groups. While the amount of propofol used in Group K was found to be statistically higher than in Group S (p=0.008), the processing time of the K Group was also statistically significantly longer (p<0.001). There was no statistically significant difference between the groups in terms of patient satisfaction distribution rates (Table 1).

Table 1. Demographic data and distribution of general characteristics

	Group K Median±SD1	Group S Median±SD	p
Age (year)	45.7±17.73	50.3±12.94	0.256
Weight (kilogram)	69±13.24	69.2±9.99	0.948
	n (%)	n (%)	
Sex Male Female	12 (40%) 18 (60%)	12 (40%) 18 (60%)	1.000
Mallampati I II III	8 (26.7%) 22 (73.3%) 0 (0%)	9 (30%) 20 (66.7%) 1 (3.3%)	0.779
ASA 2 I II	8 (26.7%) 22 (73.3%)	10 (33.3%) 20 (66.7%)	0.778
Initial Recovery FT3 (median)	13.1±0.8 (13)	13.07±0.78 (13)	0.800
Time FT3 is 14 (minute) (median)	3.37±3.42 (2.5)	3.43±3.44 (2.5)	0.952
Patient satisfaction (median)	4.87±0.35 (5)	4.83±0.38 (5)	0.720
Fentanil (µg)	72.17±13.88	74.5±13.09	0.506
Propofol (mg)	177±59.26	138.33±50.11	0.008*
procedure time (minute)	38.83±11.19 (35)	21.0±5.93 (20)	0.000*
	n (%)	n (%)	
Patient satisfaction 4	4 (13.3%)	5 (16.7%)	0.500
Patient satisfaction 5	26 (86.7%)	25 (83.3%)	

1Standard Deviation, 2American Society of Anesthesiologists Classification, 3 Fast-tracking recovery score., *p<0.05

There was no statistically significant difference between the groups in terms of HR. In Group K, decreases were significant at all times compared to the initial HR values (p<0.001, p=0,001, p=0,005). While the decreases observed in the 1st, 5th, 10th, 15th and 20th minute HR values in Group S were significant compared to the initial HR values (p<0.001, p=0.001, p<0.001, p=0.001, p=0.004) (Figure 2). There was no statistically significant difference in MAP measurements between the groups at all times. In both groups, it was found to be statistically significantly lower than the initial MAP values in all-time measurements (p<0.001, p=0.002, p=0.023).

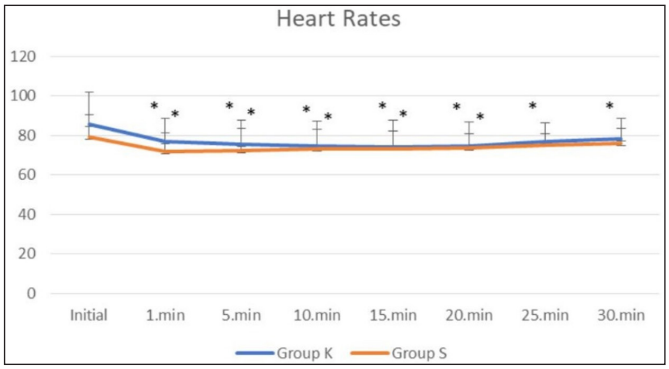

Figure 2. Heart rates of groups

When the SpO_2 values between the groups were compared, there was no statistically significant difference at all times. Compared with the baseline SpO_2 values in Group K, it was statistically significantly lower at other times (p=010, p=0.006, p<0.001, p=0.014, p=0.013). While the decreases observed in SpO_2 values at the 1st, 5th, 10th, 15th and 20th minutes were significant (p=0.006, p=0.018, p=0.038, p=0.002, p=0.031) at the baseline SpO_2 values in Group S (Figure 3). There was no statistically significant difference between the groups in terms of mean RR at all times. There was no statistically significant change in RR at all times compared to the initial RR in Group K. While there was no statistically significant change in the 25th and 30th minute RR in Group S, it was lower when compared to the baseline for other time measurements (p<0.001, p=0.001, p=0.003, p=0.012, p=0.033) (Figure 4).

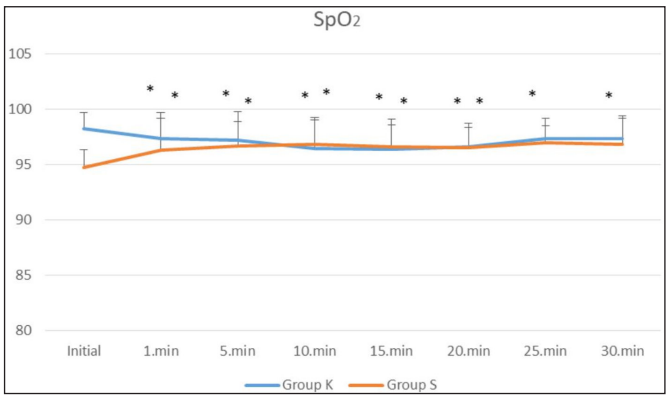

Figure 3. Peripheral oxygen saturation (SpO_2) of groups

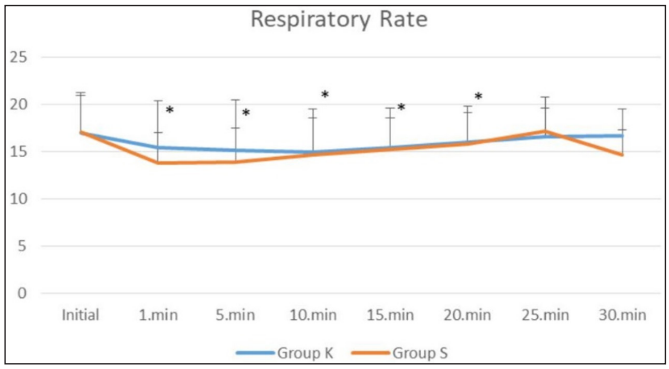

Figure 4. Respiratory rates of groups

There was no statistically significant change in $EtCO_2$ values at all times in group K. IPI values were found to be statistically low at all times compared to the baseline value (p=0.002, p=0.003, p<0.001, p=0.001, p<0.001, p=0.001, p=0.047), and measured between 7-10, they did not fall below 7 in any of the cases (**Figure 5**). There was no statistically significant difference in BIS measurements at all times, except for the 15th minute BIS values (p=0.016). No adverse respiratory events were observed in any patient during the procedure.

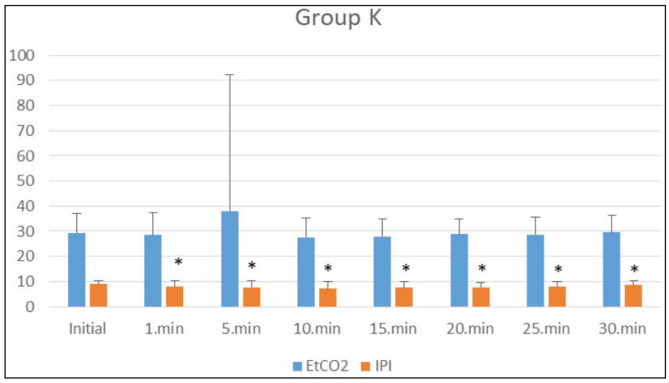

Figure 5. End-tidal carbon dioxide ($EtCO_2$) and IPI values of groups

There was no statistical difference between the groups in terms of HR, SpO_2 and MAP during the recovery period.

DISCUSSION

In gastrointestinal procedures, sedation is applied to reduce the patient's anxiety and discomfort caused by the procedure. The drugs used for sedation may differ according to the procedure, the patient and the center. Undesirable depressing effects of these different drugs on the respiratory system can be observed.[7] Propofol with rapid-onset and short-acting properties also has adverse effects on respiration.[8] Although we used fentanyl together with propofol to reduce pain during moderate sedation in our study, we did not detect any desaturation and/or apnea periods that required intervention in any of the patients. We think that because the processing time of the group monitoring for carbon dioxide was longer than the group with standard monitoring, so the amount of propofol consumed was higher.

It is necessary to monitor the vital functions of the patient in order to detect complications that may develop during sedation. Heart rate and blood pressure for hemodynamic monitoring, peripheral oxygen saturation and respiratory rate for respiratory functions are among the parameters used for this purpose.[9]

The development of capnography technology, which measures the amount of carbon dioxide in breathing air, has provided ease of use and reduced the cost. In the meta-analysis of Waugh et al.[10] they calculated that respiratory depression was detected 17.6 times more when oximetry was used together with capnography in patients who underwent deep sedation. Klare et al.[11] on the other hand, found that carbon dioxide monitoring did not reduce the incidence of hypoxemia, but was useful in detecting apnea periods. In addition, Beitz et al.[12] found that carbon dioxide monitoring in addition to respiratory rate decreased the incidence of desaturation and hypoxemia during propofol sedation applied in colonoscopy procedures. Qadeer et al.[13] showed that monitoring the respiratory activity of ERCP/EUS patients with capnography did not reduce the frequency of hypoxemia, severe hypoxemia, and apnea. There were no adverse events in our patients during our study.

IPI is a value that is used in respiratory function by calculating capnography and pulse oximetry parameters mathematically. It is thought that it can be used in the early detection of adverse respiratory events that may develop in sedated patients.[14,15] There are studies supporting that using the IPI value is beneficial in the sedation of different procedures.[16,17] However, Riphaus et al.[18] showed that the IPI value did not provide clinical benefit in addition to standard monitoring in the evaluation of the respiratory activity of sedated patients in endoscopic interventions in their study with patients who were deeply sedated.

In their study, Oba et al.[19] examined arterial blood gas samples while applying sedation to colonoscopy cases and found that the follow-up of $EtCO_2$ was compatible with $PaCO_2$ values in arterial blood gas samples. In addition, they stated that IPI monitoring did not provide clinical benefit in the early recognition of hypoventilation. In our study, IPI values were calculated above 7 in general during the procedure, and it was evaluated as a situation that is close to the normal limit but requires attention.

In our study, we applied BIS monitoring to our patients to measure the depth of sedation and adjust the drug dose and it was in the sedation range of 60-85 for all patients. It has been shown that BIS monitoring for sedation applied in endoscopy procedures reduces hypoxia, shortens the procedure time, and increases the satisfaction of the patient and the operator.[20] There was no difference in BIS values between the groups in our study.

In many studies, it has been shown that there was no difference in heart rate, arterial pressure, and peripheral oxygen saturation values between the groups with standard monitoring and the groups with standard monitoring with additional carbon dioxide monitoring.[11,12,19] Similar results were obtained in our study.

The use of propofol for sedation seems to be more advantageous than other agents as it shortens the recovery time. It is also a safe agent in terms of complications and side effects. However, close follow-up after sedation is needed and the patient should not be discharged before full recovery.[20]

In previous studies, it has not been shown that carbon dioxide monitoring during sedation has an advantageous effect on recovery time.[11,12,18] In our study, there was no difference between the groups in the discharge of the patients we followed up with the Fast-tracking recovery score. There was no difference in the hemodynamic and respiratory measurements of the patients at recovery.

When they were called and questioned later by phone to evaluate the satisfaction, it was seen that there was no difference between the groups in terms of patient satisfaction. These results are consistent with the results of the studies of Klare et al and Riphaus et al.[11,18]

There are some limitations of our study. Of these, none of the patients, the doctor performing the procedure, and the anesthetist administering the sedation were blind. Therefore, errors may occur during the observation. In addition, the number of samples used in the study may not have been sufficient to detect adverse respiratory events. We think that carbon dioxide monitoring can be effective in the early detection of respiratory complications with studies involving more patients.

CONCLUSION

In our study, the advantage of using capnography in addition to standard monitoring during sedation in the endoscopic examination of the gastrointestinal tract was not demonstrated in terms of patient safety, early recovery and patient satisfaction. At appropriate BIS levels of moderate sedation provided with propofol; we think that it does not increase the likelihood of adverse respiratory events in patients with low comorbidity.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of the Health Sciences University Sureyyapasa Chest Diseases and Thoracic Surgery Training and Research Hospital Clinical Researches Ethics Committee (Date: 09.05.2019, Decision No: 053).

Informed Consent: Written consent was obtained from the patient participating in this study.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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