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Cardiorespiratory parameters monitoring during moderate sedation at different oxygen flow rates in patients undergoing endoscopic intervention

Abstract

Background: Cardiorespiratory parameters before, during and after administration of sedation/analgesia in patients undergone endoscopic procedure should have monitored.

Aim of the study: In this study we evaluated the effect of different O_2 flow rates on the non-invasive CO_2 monitoring ($EtCO_2$) in patients that are breathing spontaneously under moderate sedation undergoing endoscopic procedures.

Methods: 120 patients of both sexes aged between 25 and 60 years with ASA- I and II scheduled for undergoing upper GIT endoscopy for gastric ulcer patients. Patients were randomized to three equal groups. **Group I:** 40 patients will receive O_2 supply at rate of 2 liters per minute and then cabnographic and other measures will be recorded throughout the procedure. **Group II:** 40 patients will receive O2 supply at rate 4 liters per minute and then cabnographic and other measures will be recorded throughout the procedure. **Group III:** 40 patients will receive O_2 supply at rate 6 liters per minute and then cabnographic and other measures will be recorded throughout the procedure.

Results: $EtCO_2$ differences between the three studied groups were statistically significant at preoperative, induction, 5, 10, 20 and 30 min but with no any clinical significance or adverse outcome. HR, MBP, RR and Spo_2 difference between group were statistically insignificant throughout the procedure with no serious complications were recorded and patients satisfaction results were comparable between the three studied groups.

Conclusion: Our study demonstrated that different O_2 flow rates did not affect noninvasive $EtCO_2$ measurement during moderate sedation in patients undergoing upper GIT endoscopy for gastric ulcer patients.

Keywords: $EtCO_2$, sedation, analgesia, Capnography, O_2 flow.

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Introduction

Sedation is a drug-induced depression in the level of consciousness, procedural sedation and analgesia (PSA) typically involves the intravenous administration of sedative or dissociative agents, sometimes in combination with short-acting opioids. Ideal drugs for PSA have a rapid onset and short duration of action, maintain hemodynamic stability and do not cause major side effects. Several medications are commonly used and no single drug is ideal for all situations.[1] Multiple randomized trials and prospective observational studies have found propofol to be safe and effective for PSA in the emergency department. Even in the contentious area of nurse-administered propofol sedation, where typically the only physician present is performing the procedure (e.g. outpatient endoscopy), there is a large body of evidence documenting the safety and efficacy of propofol. Studies comparing propofol to alternative medications for PSA are limited.[2] The clinical purposes of administering sedation for gastrointestinal endoscopy are to relieve patient anxiety and discomfort, improve the outcome of the examination, and diminish the patient's memory of the event.[3] American Society of Anesthesiologists (ASA) guidelines, recommending Carbon dioxide (CO_2) monitoring for patients undergoing both moderate and deep sedation, so familiarity with capnography may become necessary.[4] Patients are at risk of respiratory depression and acute hypercapnia during sedation and recovery from anesthesia. Desaturation on pulse oximetry for monitoring of hypoventilation is a late sign. Moreover, hypoventilation is masked by administration of supplemental oxygen (O_2). Oxygenation and ventilation are distinct physiologic functions that must be assessed in both intubated and spontaneously breathing patients. Pulse oximetry provides instantaneous feedback about oxygenation. Capnography provides instantaneous information about ventilation (how effectively CO_2 is being eliminated by the pulmonary system), perfusion (how effectively CO_2 is being transported through the vascular system), and metabolism (how effectively CO_2 is being produced by cellular metabolism). CO_2 monitors measure gas concentration, or partial pressure, using one of two configurations: mainstream or side stream. Mainstream devices measure respiratory gas (in this case CO_2) directly from the airway with the sensor located on the airway adapter at the hub of the endotracheal tube.[5]

Side stream devices measure respiratory gas via nasal or nasal-oral cannula by aspirating a small sample from the exhaled breath through the cannula tubing to a sensor located inside the monitor. Mainstream systems are configured for intubated patients. Sidestream systems are configured for both intubated and non-intubated patients.[6] PSA may be used for any procedure in which a patient's pain or anxiety may be excessive and may impede performance. PSA is often useful for procedures where deep relaxation facilitates performance (e.g. closed reduction of a dislocated joint). Common procedures in which PSA may be beneficial include electrical cardioversion, closed joint reduction, complicated laceration repair, abscess incision and drainage and lumbar puncture.[6] There are no absolute contraindications to PSA. Relative contraindications may include old age, significant medical comorbidities and signs of a difficult airway.[7]

Fasting should be considered before performing PSA, proper monitoring of patients during the performance of PSA is crucial. The patient's blood pressure, heart rate and respiratory rate should be measured at frequent regular intervals. Oxygen saturation (SpO_2),

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end-tidal carbon dioxide ($EtCO_2$) level and cardiac rhythm should be monitored continuously.[8] The patient's response to medications and the procedure must also be closely monitored during PSA. The patient's level of alertness, depth of respiration and response to painful stimuli (e.g. fracture reduction) are all important factors in determining subsequent medication doses. Sedation scales such as the Ramsay Score and Likert satisfaction scale may be useful in determining the appropriate titration of sedatives.[1]

Patients and methods

This study was approved by the University's Institutional Review Board (IRB) and written informed consent was obtained from all subjects participating in the study. The prospective double-blind, randomized, controlled study was held in November 2020 to December 2021 at the department of anesthesia and intensive care unit; El- Minia University Hospital. The study included 120 adult patients of both sexes between 25 and 60 years old with I or II ASA physical status scheduled for undergoing upper GIT endoscopy for gastric ulcer patients. Exclusion criteria included: Patients with abnormal renal function test, history of asthma or COPD, patients with uncontrolled hypertension and diabetes and cardiac patients. Two days before surgery, patients will visit the outpatient clinic for history taken, clinical assessment and explanation about the study protocol. Laboratory investigations will be performed and patients will be informed that they can stop participation in the study at any time without any loss of service. Patients will receive conscious sedation via propofol 1.5 mg/kg and lidocaine 1 mg/kg and CO_2 monitored through non-invasive method.

Study design

The patients were randomly allocated to three equal groups according to the computer-generated random numbers to receive the study protocol. The outcome measures were collected by an anesthesiologist not included in giving the anesthetic technique. Neither the anesthesiologist collecting data nor the patients themselves were aware of group allocation to ensure blindness of the study.

Preoperative assessment and evaluation of all patients participating in the study was done in preoperative anesthesia clinic. In the preoperative room, electrocardiogram, pulse oximetry and non-invasive arterial blood pressure were applied. Vital signs were examined and subsequent values were obtained throughout the operation. Then an intravenous 18G cannula was inserted and preloading with Nacl 0.9% was started at the calculated volume and rate. The patients were preoxygenated for 3 minutes before inducing sedation with propofol 1-1.5 mg/kg and lidocaine. Moderate sedation was maintained with oxygen via nasal cannula and intermittent of (0.25 to 0.5 mg/kg) propofol every 2 to 5 minutes. Noninvasive monitoring of $EtCO_2$ were done through Dual Guard device (FlexiCare) which incorporates an endoscopy bite block with oxygen delivery and CO_2 monitoring from both the mouth and nose simultaneously.

Measured parameters

Heart rate (HR), non-invasive blood pressure, oxygen saturation and $EtCO_2$ were recorded every 5 minutes throughout the procedure. At the end of procedure patient was transferred to recovery area where Ramsay scale[9] and operative adverse effect were assessed (postoperative nausea, vomiting, headache dizziness, somnolence, vertigo and confusion).

Richmond agitation sedation scale (RASS)

At the end of procedure patient was transferred to recovery area where RASS was determined. The agitation or sedation level of the patient was assessed using RASS with a score ranging from 11 till 6 as following.[10]

Patient is anxious and agitated or restless, or both.

i. Patient is co-operative, oriented, and tranquil.

ii. Patient responds to commands only.

iii. Patient exhibits brisk response to light glabellar tap or loud auditory. stimulus.

iv. Patient exhibits a sluggish response to light glabellar tap or loud. auditory stimulus.

v. Patient exhibits no response.

The 5-point Likert satisfaction scale[11]

i. Strongly not satisfied.

ii. Not satisfied.

iii. Neutral.

iv. Satisfied.

v. Strongly satisfied.

After meeting the discharge criteria, the patient was discharged to be taken home and cared for by a responsible adult.

Assessment of possible complications

Any complications like postoperative nausea, vomiting, headache, dizziness, somnolence, vertigo, confusion were observed, recorded and managed accordingly.

Statistical analysis

The analysis of the data was performed using the IBM SPSS 24.0 statistical package software. Data were displayed as mean ± SD for quantitative parameters in addition to both number and percentage for categorized data. Analysis of variance (ANOVA) was performed to test the mean difference of the data that follow normal distribution and two way repeated measure. ANOVA (RM-ANOVA) test was calculated to test the mean differences of the data that follow normal distribution and had repeated measures. Post –hoc test with Bonferroni correction was used for part wise comparisons. P-value of 0.05 or less was set for significance.

Sample size calculation

Sample size was calculated using G power software, with study power of 80% and type 1 error of 5% (α= 0.05 and β= 80%) on two tailed test, the minimum required sample was 120 patients assigned randomly into one of three equal groups to detect an effect size of 0.2 in the main recovery outcome.

Results

The current study was carried out on 120 adult patients underwent upper GIT endoscopy for gastric ulcer patients. All results were tabulated and analyzed statistically. The enrolled patients were randomly allocated into three groups (Figure 1).

Demographic data and clinical characteristics of the studied patients:

All groups are comparable with no statistically significant differences (p-value > 0.05) regarding age, sex and weight (Table 1).

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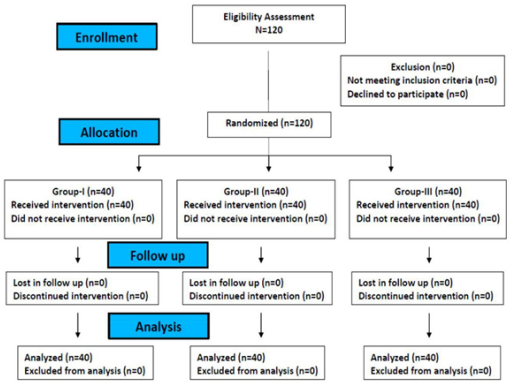

Figure 1 CONSORT flow diagram of the study patients.

Table 1 Baseline data differences between the studied groups

	Group I (2L) (n = 40)	Group II (4L) (n = 40)	Group III (6L) (n = 40)	P-value
Age/ years	42.16 ± 12.5	48.55 ± 11.4	52.18 ± 11.9	= 0.054*
P-value**	1 vs. 2 = 0.120	2 vs. 3 = 0.346	1 vs. 3 = 0.030	
Sex				
·Female	16 (40%)	18 (45%)	21 (52.5%)	= 0.528***
· Male	24 (60%)	22 (55%)	19 (47.5%)	
Weight/ kg	80.53 ± 7.5	83.55 ± 9.6	87.50 ± 7.7	= 0.072*
P-value**	1 vs. 2 = 0.656	2 vs. 3 = 0.083	1 vs. 3 = 0.030	

Data were presented as mean ± SD, number of patients, or percentages.

P-value < 0.05 was considered significant.

* ANOVA test was used to compare the mean difference between groups. **Post-hoc test was used for pairwise comparison with Bonferroni correction.

***Chi-square test was used to compare the frequency difference between groups.

Clinical Data differences between the studied groups:

Table 2 showed the comparison the duration of sedation, procedure duration and ASA status between all study groups. All cases were of ASA-II status. The sedation time was 42.40 ± 11.1 min in group I, 41.90 ± 12.4 min in group II, and 40.52 ± 11.1 min in group III; with no statistically significant difference between all groups (p-value = 0.754). The procedure time was 29.53 ± 8.9 min in group I, 29.23 ± 9.8 min in group II, and 28.15 ± 8.9 min in group III; with no statistically significant difference between all groups (p-value = 0.783).

Difference in the mean HR over time between the studied sample

The HR differences between groups were statistically significant at 10 and 20 minutes after induction of anesthesia without any clinical significance or adverse effects (P-value = 0.035 at both times). Inside Group I, HR showed increase in values after induction which remained elevated till the end. The difference was statistically insignificant between periods (P-value = 0.059). Group II showed inside increase in HR after the induction which remained elevated till the end. The difference was statistically significant between periods (P-value = 0.006). Group III showed increase in HR after the induction which remained elevated till the end. The difference was statistically insignificant between periods (P-value = 0.159) (Figure 2).

Table 2 Clinical data differences between the studied groups

	Group I (2L) (n = 40)	Group II (4L) (n = 40)	Group III (6L) (n = 40)	P-value
ASA-II	40 (100%)	40 (100%)	40 (100%)	= 1.000*
Duration of Procedure/ minutes				
Mean ± SD	29.53 ± 8.9	29.23 ± 9.8	28.15 ± 8.9	
Median (Range)	30 (20 - 45)	30 (20 - 47)	29.5 (20 - 46)	= 0.783**
P-value***	1 vs. 2 = 0.945	2 vs. 3 = 0.601	1 vs. 3 = 0.562	
Duration of Sedation/ minutes				
Mean ± SD	42.40 ± 11.1	41.90 ± 12.4	40.52 ± 11.1	
Median (Range)	30 (20 - 45)	30 (20 - 45)	30 (20 - 45)	= 0.754*
P-value***	1 vs. 2 = 0.847	2 vs. 3 = 0.595	1 vs. 3 = 0.469	

Data were presented as mean ± SD, number of patients, or percentages.

P-value < 0.05 was considered significant. *Chi-square test was used to compare the frequency difference between groups **ANOVA test was used to compare the mean difference between groups ***Post-hoc test was used for pairwise comparison with Bonferroni correction

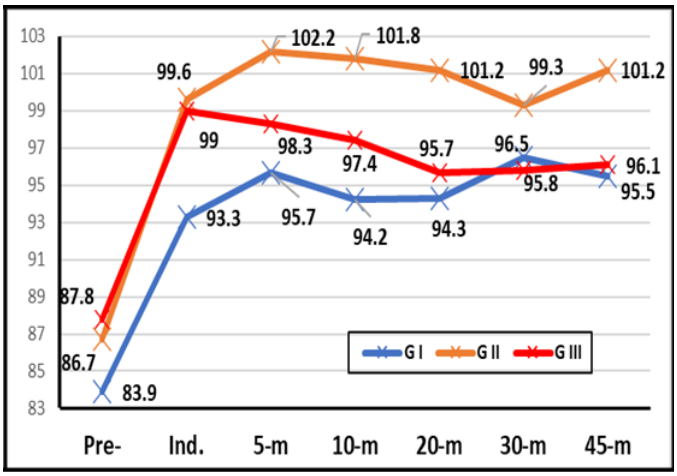

Figure 2 Difference in the mean HR over time between the Studied Sample.

Blood pressure differences between the studied groups

The SBP and DBP differences between the study groups were statistically insignificant throughout the whole study periods (P-value > 0.05), also, The MBP differences between the study groups were statistically not significant throughout the whole study periods (P-value > 0.05) (Table 3).

Citation: Attia JZ, Hassanin AAM. Cardiorespiratory parameters monitoring during moderate sedation at different oxygen flow rates in patients undergoing endoscopic intervention. *J Anesth Crit Care Open Access.* 2022;14(4):103–110. DOI: 10.15406/jaccoa.2022.14.00518

Table 3 Mean blood pressure differences between the studied groups

	Group I (2L) (n = 40)	Group II (4L) (n = 40)	Group III (6L) (n = 40)	P-value
MBP (mmHg)				
Pre-operative	93.13 ± 10.3	91.88 ± 10.6	95.05± 12.9	= 0.321*
P-value**	1 vs. 2 = 0.632	2 vs. 3 = 0.140	1 vs. 3 = 0.322	
Induction	89.68 ± 9.8	89.83 ± 13.8	90.65± 12.1	= 0.941*
P-value**	1 vs. 2 = 0.960	2 vs. 3 = 0.785	1 vs. 3 = 0.747	
5-min	88.50 ± 10.5	90.01 ± 13.1	86.83± 9.2	= 0.441*
P-value**	1 vs. 2 = 0.546	2 vs. 3 = 0.202	1 vs. 3 = 0.500	
10-min	86.05 ± 10.4	88.80 ± 13.1	86.45± 11.3	= 0.533*
P-value**	1 vs. 2 = 0.300	2 vs. 3 = 0.376	1 vs. 3 = 0.880	
20-min	85.68 ± 10.1	89.03 ± 11.6	87.65± 10.8	= 0.391*
P-value**	1 vs. 2 = 0.174	2 vs. 3 = 0.575	1 vs. 3 = 0.421	
30-min.	86.08 ± 6.2	87.25 ± 12.3	89.29± 11.3	= 0.571*
P-value**	1 vs. 2 = 0.705	2 vs. 3 = 0.523	1 vs. 3 = 0.295	
45-min.	86.13 ± 3.8	89.70 ± 12.4	91.01± 5.1	= 0.642*
P-value**	1 vs. 2 = 0.478	2 vs. 3 = 0.803	1 vs. 3 = 0.377	
P-value***	=0.559	=0.98	=0.829	= 0.498$

Data were presented as mean ± SD.

P-value < 0.05 was considered significant.

* ANOVA test was used to compare the mean difference between groups. **Post-hoc test was used for pairwise comparison with Bonferroni correction.

***Mean differences Within Group Comparison.

$Two-way Repeated Measure ANOVA was used to compare the mean differences over time.

Oxygen pressure differences between the studied groups

The SpO_2 differences between the study groups were statistically not significant throughout the whole study periods (P-value > 0.05). Inside Group I, SpO_2 showed increase in values after induction which remained elevated till the end of the procedure. The difference was statistically significant between periods (P-value = 0.011). Group II showed inside increase in SpO_2 after the induction which remained elevated till the end. The difference was statistically significant between periods (P-value = 0.004). Group III showed increase in SpO_2 after the induction which remained elevated till the end. The difference was statistically significant between periods (P-value = 0.043) (Table 4).

Table 4 Oxygen pressure differences between the studied groups

	Group I (2L) (n = 40)	Group II (4L) (n = 40)	Group III (6L) (n = 40)	P-value
SpO2%				
Pre-operative	97.63 ± 0.7	97.85 ± 0.7	97.65 ± 0.7	= 0.306*
P-value**	1 vs. 2 = 0.161	2 vs. 3 = 0.213	1 vs. 3 = 0.876	
Induction	99.48 ± 0.6	99.73 ± 0.6	99.25 ± 0.6	= 0.222*
P-value**	1 vs. 2 = 0.255	2 vs. 3 = 0.569	1 vs. 3 = 0.089	
5-min	99.68 ± 0.6	99.53 ± 0.6	99.58 ± 0.6	= 0.558*
P-value**	1 vs. 2 = 0.290	2 vs. 3 = 0.224	1 vs. 3 = 0.480	
10-min	99.50 ± 0.7	99.73 ± 0.5	99.48 ± 0.6	= 0.137*
P-value**	1 vs. 2 = 0.103	2 vs. 3 = 0.071	1 vs. 3 = 0.856	
20-min	99.74 ± 0.5	99.75 ± 0.5	99.73 ± 0.5	= 0.975*
P-value**	1 vs. 2 = 0.956	2 vs. 3 = 0.829	1 vs. 3 = 0.873	
30-min.	99.79 ± 0.5	99.76 ± 0.4	99.67 ± 0.5	= 0.667*
P-value**	1 vs. 2 = 0.836	2 vs. 3 = 0.521	1 vs. 3 = 0.385	
45-min.	99.63 ± 0.5	99.90 ± 0.3	100.00 ± 0.0	= 0.122*
P-value**	1 vs. 2 = 0.117	2 vs. 3 = 0.574	1 vs. 3 = 0.054	
P-value***	=0.011	=0.004	=0.043	= 0.395$

Data were presented as mean ± SD.

P-value < 0.05 was considered significant.

*ANOVA test was used to compare the mean difference between groups. **Post-hoc test was used for pairwise comparison with Bonferroni correction.

***Mean differences Within Group Comparison.

$Two-way Repeated Measure ANOVA was used to compare the mean differences over time.

Citation: Attia JZ, Hassanin AAM. Cardiorespiratory parameters monitoring during moderate sedation at different oxygen flow rates in patients undergoing endoscopic intervention. *J Anesth Crit Care Open Access.* 2022;14(4):103–110. DOI: 10.15406/jaccoa.2022.14.00518

Mean EtCO2 differences over time between the studied samples

The $EtCO_2$ differences between three studied groups were statistically significant at pre-operative, induction, 5, 10, 20 and 30 min but with no any clinical significance (P-value < 0.05). Inside Group I, $EtCO_2$ showed increase in values at 5 min which remained to increase till the end. The difference was statistically significant between periods (P-value = 0.034). Group II showed inside increase in $EtCO_2$ values after the induction which remained to increase till the end. The difference was statistically significant between periods (P-value = 0.001). Group III showed increase in $EtCO_2$ after the induction which also remained to increase till the end. The difference was statistically significant between periods (P-value = 0.047) (Figure 3).

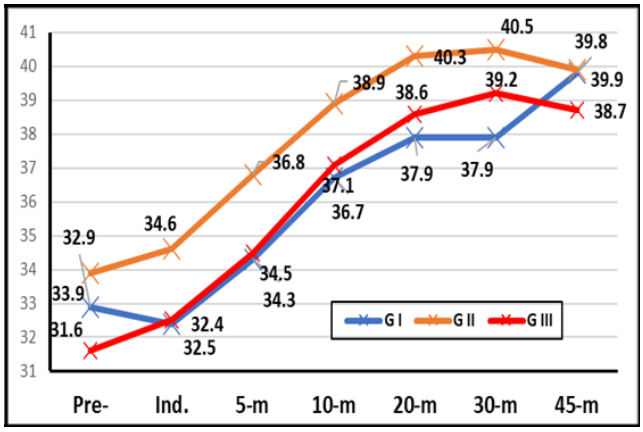

Figure 3 Mean $EtCO_2$ Differences over time between the studied sample.

Respiratory rate differences between the studied groups

The RR differences between the study groups were statistically not significant throughout the whole study periods (P-value > 0.05). Inside Group I, RR showed increase in values after induction which remained elevated till the end. The difference was statistically insignificant between periods (P-value = 0.064). Group II showed inside increase in RR after the induction which remained elevated till the end. The difference was statistically significant between periods (P-value = 0.016). Group III showed increase in RR after the induction which remained elevated till the end. The difference was statistically significant between periods (P-value = 0.001) (Table 5).

Arterial blood gases evaluations between the studied groups:

As shown in Figure 4-6, the pH, PCO_2 and HCO_3 differences between groups were shown at both induction and recovery periods. As regard PCO_2, there were statistically significant differences between the three study groups but still within the normal range readings. While regarding pH and HCO_3, there were statistically insignificant differences between the three groups.

Group I showed decrease in pH, increase in PCO_2 and slight decrease in HCO_3 values during recovery compared to induction. There were statistically significant differences between periods (P-value 0.001).

Group II showed decrease in pH, increase in PCO_2 and slight decrease in HCO_3 values during recovery compared to induction. There were statistically significant differences between periods (P-value 0.001).

Group III showed decrease in pH, increase in PCO_2 and slight decrease in HCO_3 values during recovery compared to induction. There were statistically significant differences between periods (P-value 0.001).

Table 5 Respiratory rate differences between the studied groups

	Group I (2L) (n = 40)	Group II (4L) (n = 40)	Group III (6L) (n = 40)	P-value
RR (Cycle/min.)				
Pre-operative	17.01 ± 2.1	17.95 ± 1.7	17.63 ± 1.8	= 0.082*
P-value**	1 vs. 2 = 0.028	2 vs. 3 = 0.448	1 vs. 3 = 0.146	= 0.319*
Induction	24.90 ± 3.1	24.88 ± 3.0	24.20 ± 2.7	
P-value**	1 vs. 2 = 0.141	2 vs. 3 = 0.306	1 vs. 3 = 0.649	
5-min	25.86 ± 3.3	25.08 ± 3.1	24.63 ± 3.9	= 0.408*
P-value**	1 vs. 2 = 0.445	2 vs. 3 = 0.562	1 vs. 3 = 0.183	
10-min	25.95 ± 2.3	25.23 ± 2.6	24.95 ± 3.1	= 0.234*
P-value**	1 vs. 2 = 0.231	2 vs. 3 = 0.649	1 vs. 3 = 0.100	
20-min	24.43 ± 3.0	24.10 ± 3.0	24.28 ± 3.2	= 0.794*
P-value**	1 vs. 2 = 0.637	2 vs. 3 = 0.799	1 vs. 3 = 0.828	
30-min.	23.25 ± 2.0	23.10 ± 2.8	24.75 ± 3.8	= 0.209*
P-value**	1 vs. 2 = 0.862	2 vs. 3 = 0.111	1 vs. 3 = 0.140	
45-min.	23.01 ± 1.8	22.90 ± 2.6	24.29 ± 3.8	= 0.578*
P-value**	1 vs. 2 = 0.942	2 vs. 3 = 0.334	1 vs. 3 = 0.392	
P-value***	=0.064	=0.016	=0.001	= 0.172$

Data were presented as mean ± SD.

P-value < 0.05 was considered significant.

*ANOVA test was used to compare the mean difference between groups. **Post-hoc test was used for pairwise comparison with Bonferroni correction.

***Mean differences Within Group Comparison.

$Two-way Repeated Measure ANOVA was used to compare the mean differences over time.

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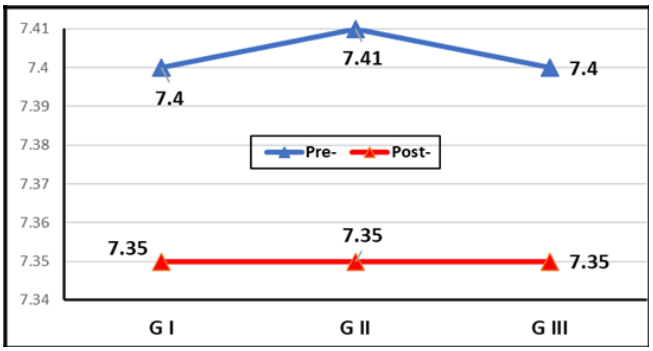

Figure 4 Difference in the mean pH over time between the studied sample.

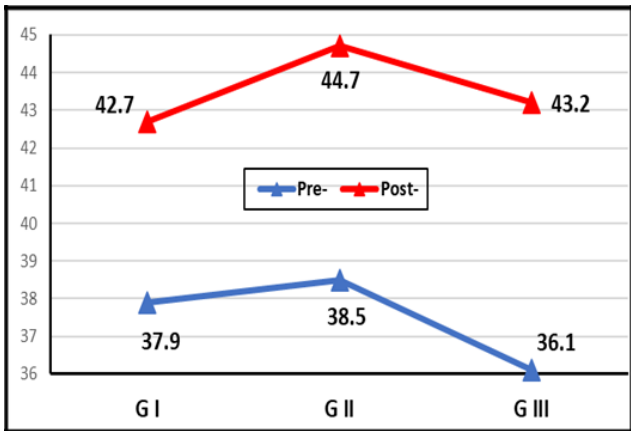

Figure 5 Difference in the mean $PaCO_2$ over time between the studied sample.

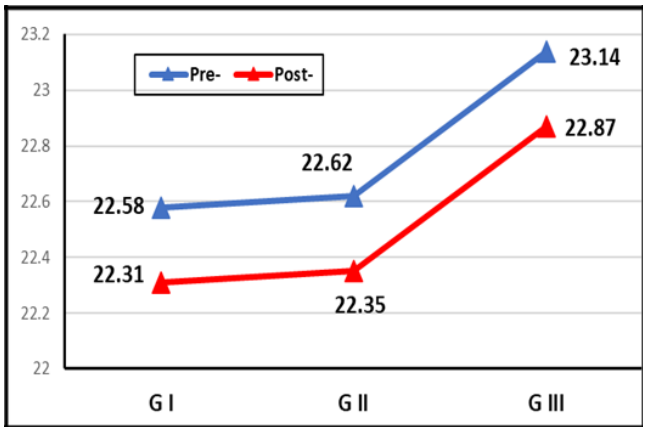

Figure 6 Difference in the mean HCO_3 over time between the studied sample.

Discussion

This study was conducted to assess the effect of different O_2 flow rates on non-invasive CO_2 monitoring in those patients who were undergoing upper GIT endoscopy for gastric ulcer, operation was under moderate sedation. The results of this study demonstrated that different O_2 flow rates through nasal route did not affect the non-invasive CO_2 measurements.

It was found that HR increased after induction of sedation in all study groups. As regarding RR, it also increased after induction in all groups. Also $EtCO_2$ increased statistically after induction in all groups. The increase in $EtCO_2$ could be explained by the fact that patients during prone position under sedation usually show hypoventilation. As regarding hemodynamic parameters (SBP, DBP and MBP) they all decreased post-induction. The observed fall in hemodynamic parameters can be explained by the fact that propofol is cardio-depressant and peripheral vasodilator drug. In addition, we observed that the longer the duration of anesthesia and the higher the total intravenous propofol dose, the longer the time to recovery was required to the patients.

Yanagidate and Dohi[12] found that their modified nasal cannula can provide continuous monitoring of end-tidal CO_2 without affecting oxygen delivery in sedated, spontaneously breathing patients. They have studied whether this cannula can provide oxygenation similar to a standard cannula without affecting end-tidal CO_2 monitoring. Eighty-six patients were studied during spinal anesthesia and sedation. In 15 patients, arterial blood was sampled while O_2 was delivered at flow rates of 0, 2 and 4 L/min, with or without clamping between the prongs of their modified nasal cannula. In the remaining 71 patients, arterial O_2 was measured while using their modified nasal cannula with the clamp applied. End-tidal CO_2 was recorded on a capnograph and the correlation between end-tidal and arterial values with their modified nasal cannula was investigated. No end-tidal CO_2 waveforms were found with oxygen flow greater than 2L.

The results of our study are comparable with the results of Ebert et al.[13] who found that nasal cannula design differences can influence their ability to deliver O_2 and their ability to accurately sample $EtCO_2$ at higher fresh gas flows. A design where O_2 is delivered through one nasal prong and CO_2 is detected from the other prong was found to be most effective and accurate for these purposes. Subjects were instructed to breathe normally during a protocol of step increases in Fresh gas flow with each nasal cannula. The research assistant positioned the first nasal cannula, and nasal breathing was confirmed by the presence of an acceptable CO_2 tracing. The Hauge Airway was placed and the subject breathed room air while $EtCO_2$ and posterior pharyngeal O_2 data were collected continuously throughout the period. In the 11 volunteers with an arterial catheter, PaO_2 and $PaCO_2$ also were measured. The O_2 FGF then was set to 2 L/m, and again, data were collected after achieving stable recordings. This procedure was repeated at O_2 FGF of 4 and 6 L/m. After data collection at 6 L/m, the first nasal cannula was removed and the second nasal cannula was placed. Procedures were then repeated with room air, 2, 4, these same step-up procedures were repeated with the third and fourth nasal cannula. The Hauge Airway was briefly removed if the subject needed to swallow or was simply uncomfortable between nasal cannula placements. The additional time for sampling and processing of arterial blood samples from the subset of 11 volunteers caused us to omit blood sampling during the 6 L/m study period, resulting in blood gas data at room air, 2, and 4 L/m FGF.[13]

Vargo et al.[14] demonstrated the usefulness of capnography in adults during procedural sedation. They revealed that the extended monitoring provided by capnography resulted in an accurate assessment of respiratory rate when compared to auscultation with a pretracheal stethoscope as the reference standard. Apnea and disordered respiration occurred in over 50% of patients and frequently proceeded by the development of hypoxemia. Potentially important abnormalities in respiratory activity are undetected with pulse oximetry and visual assessment.[14] Li et al.[15] were in agreement to the findings of our study. They found that the addition of $EtCO_2$ monitoring to the standard monitoring during propofol-based sedation can improve patient safety by decreasing the incidence of CO_2 retention, and therefore the risk of hypoxemia through the early recognition of apnea, and can also shorten the recovery time. Two hundred female patients aged 18 to 65 years and scheduled for lumpectomy under deep

sedation. Participants were randomly assigned to a control (standard monitoring) group or an experimental (additional $EtCO_2$ monitoring) group using a computer-generated randomization strategy. The aim of the study was to evaluate the efficacy of $EtCO_2$ monitoring to reduce the incidence of retention of carbon dioxide during lumpectomy under propofol-based and sufentanil-based sedation. The CO_2 retention occurred significantly less often in the $EtCO_2$ monitoring group.[15]

Miner et al.[16] found that monitoring $EtCO_2$ during procedural sedation could detect respiratory depression. Nearly half (44.6%) of the 74 adults undergoing procedural sedation in an experienced respiratory depression. All episodes were identified by capnography. They found that $EtCO_2$ may add to the safety of procedural sedation by quickly detecting hypoventilation during procedural sedation in the experienced respiratory depression.

Ebert et al.[17] demonstrated that ventilation monitoring may provide an element of safety for early and more reliable detection of reduced ventilation in patients undergoing sedation for gastrointestinal procedures in an Out-of-OR setting. Sedation of patients in the GI suite is common place, but confirming the adequacy of ventilation can be challenging due to patient positioning and the necessity of maintaining nasal cannula positioning. Adequacy of ventilation can be monitored crudely by direct observation of abdominal and chest wall motions and by several surrogates for ventilation, e.g. pulse oximetry and $EtCO_2$. Decreases in oxygenation are typically not time sensitive measures due to existing reserves of lung oxygen referred to as the functional residual capacity and occasionally due to the passive exchange of oxygen from an open conduit between the nasal prongs and lungs. More rapid detection of apnea would be a safer approach to ventilation monitoring during sedation because of the rapid increase in $EtCO_2$ that occurs during apnea, averaging 3–5 mmHg per min, and the subsequent untoward effects of hypercarbia on sedation and blood pressure. But the most important value of monitoring for hypercarbia is the underlying hypoventilation that is driving the change, ultimately leading to poor oxygenation of patients.[17]

Deitch et al.[18] found that in adults receiving propofol sedation, the addition of capnography to standard monitoring reduced hypoxia and provided advance warning for all hypoxic events.

Qadeer et al.[19] found that capnographic monitoring of respiratory activity improves patient safety during procedural sedation for elective endoscopic retrograde cholangiopancreatography and endoscopic ultrasonography under procedural sedation with a combination of opioid and benzodiazepine by reducing the frequency of hypoxemia, severe hypoxemia, and apnea.

Oberg et al.[20] found that reliable recordings of carbon dioxide concentrations during spontaneous respiration can be obtained from a catheter positioned in the hypopharynx. They investigated the possible influence on ET CO_2 measurement of nasal oxygen administration, position of the sampling catheter and mouth breathing. The study demonstrated that not only can reliable capnographic tracings be obtained from a thin catheter placed in the unintubated airway.

Beitz et al.[21] concluded that additional capnographic monitoring of ventilatory activity reduces the incidence of oxygen desaturation and hypoxemia during propofol sedation for colonoscopy.

Friedrich-Rust et al.[22] reported that in patients undergoing colonoscopy during propofol-based sedation capnography monitoring with a simple and inexpensive device reduced the incidence of hypoxemia.

The results of our study are comparable with the results of Tai et al.[23] who found that end-tidal CO_2 measurement by side-stream capnometry through nasal cannula could provide an accurate and noninvasive estimate of $PaCO_2$ levels in non-intubated neonate.

Mehta et al.[24] concluded that capnographic monitoring in routine esophagogastroduodenoscopy or colonoscopy does not reduce the incidence of hypoxemia. A total of 452 patients were randomized; 218 in the esophagogastroduodenoscopy and 234 in the colonoscopy groups; 75 subjects in the esophagogastroduodenoscopy group (35.9%) and 114 patients (49.4%) in the colonoscopy group were male, and average body mass index was 27.9 and 29.1 (kg/m (2)), respectively. The blinded and open alarm groups in each study arm were similar in regards to use of opioids and/or benzodiazepines. There was no significant difference in rates of hypoxemia between the blinded and open capnography arms for EGD (54.1% vs. 49.5; P=0.5) or colonoscopy (53.8 vs. 52.1%; P=0.79).

Klare et al.[25] were in agreement with our study as regarding hemodynamic parameters (SBP, DBP MBP and HR), they found that there were no differences regarding rates of bradycardia and hypotension.

Gillham et al.[26] found that there were no episodes of desaturation below an arterial blood oxygen level of 93% (while receiving oxygen at 2 L/min via nasal cannulae) and no instances of hemodynamic compromise.

Langhan et al.[27] were in agreement with our study as regarding complications they found no serious adverse events were recorded. Because their study was not powered to detect these rare events, they were unable to predict how capnography may impact staff behavior and patient outcomes for these less frequent events.

Conclusion

Our study demonstrated that different O_2 flow rates did not affect non-invasive $EtCO_2$ measurement during moderate sedation in patients undergoing upper GIT endoscopy for gastric ulcer patients without any serious adverse effects. Non-invasive $EtCO_2$ monitoring can provide an early warning sign of hypoventilation during moderate sedation.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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