ORIGINAL ARTICLE

AG-2022-18
doi.org/10.1590/S0004-2803.202203000-69

Volumetric capnography for respiratory monitoring of patients during routine colonoscopy with room-air and carbon dioxide insufflation

Michel Gardere **CAMARGO**[1], Marcos Mello **MOREIRA**[2], Daniéla Oliveira **MAGRO**[1], José Olympio Meirelles **SANTOS**[1] and Maria de Lourdes Setsuko **AYRIZONO**[1]

Received: 14 January 2022
Accepted: 5 May 2022

ABSTRACT – Background – Capnography and carbon dioxide (CO_2) insufflation during gastrointestinal endoscopy under sedation are associated with safety and comfort improvements, respectively. Capnography can provide early detection of apnea and hypoxemia, whereas CO_2 insufflation causes lower periprocedural discomfort. This is the first study to report the application of volumetric capnography in colonoscopy. **Objective –** This study aimed to evaluate the use of volumetric capnography with room air (RA) and CO_2 insufflation during routine colonoscopy. **Methods –** In this prospective cohort study, 101 patients who underwent routine colonoscopy under sedation with volumetric capnography monitoring were included. Insufflation with RA was used to distend the intestinal lumen in group 1 (n=51), while group 2 (n=50) used CO_2 insufflation. The primary endpoints were episodes of hypoxia, alveolar hypoventilation, and end-tidal CO_2 ($EtCO_2$). The secondary endpoints were tidal volume per minute, consumption of sedation medications, and post-procedure pain using the Gloucester modified pain scale. **Results –** The number of episodes of hypoxia (SpO_2<90%) was similar between the groups: four episodes in Group 1 and two episodes in Group 2. The duration of hypoxia was significantly longer in group 2 (P=0.02). Hypoalveolar ventilation ($EtCO_2$) occurred more frequently in Group 2 than in Group 1 (27 vs 18 episodes, P=0.05). Regarding $EtCO_2$, Group 2 showed higher values in cecal evaluation (28.94±4.68 mmHg vs 26.65±6.12 mmHg, P=0.04). Regarding tidal volume per minute, Group 2 had significantly lower values at the cecal interval compared to Group 1 (2027.53±2818.89 vs 970.88±1840.25 L/min, P=0.009). No episodes of hypercapnia ($EtCO_2$ > 60 mmHg) occurred during the study. There was no difference in the consumption of sedation medications between the groups. Immediately after colonoscopy, Group 2 reported significantly less pain than Group 1 (P=0.05). **Conclusion –** In our study, volumetric capnography during colonoscopy was feasible and effective for monitoring ventilatory parameters and detecting respiratory complications. CO_2 insufflation was safe and associated with less pain immediately after colonoscopy.

Keywords – Colonoscopy; capnography; carbon dioxide; volumetric capnography; safety.

INTRODUCTION

Colonoscopy has been established as an indispensable procedure for the investigation and management of large bowel diseases, particularly colorectal cancer[1,2]. An increasing number of colonoscopies are being performed, either for screening or for therapeutic purposes. Different issues in colonoscopy are under constant research and improvement, especially patient safety and comfort. Colonoscopy is an invasive procedure and, although considered safe, complications and discomfort can occur[3,4]. In Western countries, most colonoscopies are performed under sedation[5,6], including routine procedures such as screening and follow-up procedures. Sedation contributes to technical success and quality in colonoscopy practice[7,8] as it improves patient comfort and tolerance. The endoscopy team also benefits from colonoscopy under sedation, as the examination is not compromised by patient movements. Nevertheless, sedation for colonoscopy is associated with a considerable risk of cardiopulmonary complications (including death)[9,10], occurring in 0.33% of all procedures and accounting for nearly half of the serious adverse events during colonoscopies. Levels of consciousness are less predictable under sedation, increasing the risk of hypoventilation and apnea during deep sedation[11]. According to previous studies[12-15], capnography, in addition to standard monitoring during procedural sedation, significantly increases the detection of adverse respiratory events, such as respiratory depression, hypoxemia, apnea, and airway obstruction. Volumetric capnography is a modality that provides continuous and noninvasive monitoring of the partial pressure of expired carbon dioxide ($EtCO_2$) versus exhaled volume[16]. The use of volumetric capnography in colonoscopy has yet to be established, as the literature is still scarce. To our knowledge, this is the first study to report the application of volumetric capnography in colonoscopy. Luminal distension during colonoscopy is mandatory for optimal visualization of the intestinal mucosa. Air insufflation during the procedure can cause discomfort in the post-colonoscopy period, with approximately 11% of individuals reporting abdomi-

Declared conflict of interest of all authors: none
Disclosure of funding: no funding received
[1] Universidade Estadual de Campinas, Faculdade de Ciências Médicas, Gastrocentro, Campinas, SP, Brasil. [2] Universidade Estadual de Campinas, Faculdade de Ciências Médicas, Departamento de Clínica Médica, Disciplina de Pneumologia, Campinas, SP, Brasil.
Corresponding author: Michel Gardere Camargo. E-mail: myxn@me.com

nal pain post-procedure[17]. In contrast to room air (RA), carbon dioxide (CO_2) insufflation has been shown to reduce pain because of its rapid absorption by the intestines, causing less bowel wall tension[18,19], Despite a number of reports[20-24] finding no relevant occurrence of respiratory complications with CO_2 insufflation, concerns remain[25-27]. In Brazil, capnography and CO_2 insuffation during colonoscopy have not been widely adopted, and currently there is a lack of local data. We aimed to evaluate the feasibility, safety, and efficacy of volumetric capnography and CO_2 insufflation in our colonoscopy unit.

METHODS

The present prospective cohort study was performed at the outpatient endoscopy unit from June to September 2019, including 101 patients who underwent colonoscopy under volumetric capnography (VCap) and oximetry monitoring (SpO_2), of which 51 had insufflation with RA (Group 1) and 50 had CO_2 insufflation (Group 2), as shown in CHART 1. The exclusion criteria were as follows: age ≤18 and ≥70 years; symptomatic aortic stenosis; serious chronic obstructive pulmonary disease as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD classification 3 and 4*)*; patients with basal SpO_2 <85%; assessment risk classification ASA (American Society of Anesthesiologists) ≥4; inadequate complete bowel preparation (Boston Bowel Preparation Score ≤6); emergency colonoscopies; and realization of complex colorectal endoscopic resections during the present procedure.

CHART 1. Definition of experimental groups.

Group 1 N=51	SpO_2 + VCap Colonoscopy with RA insufflation
Group 2 N=50	SpO_2 + VCap Colonoscopy with CO_2 insufflation

The sample size was obtained by convenience, a non-probabilistic and non-alleatory technique, which facilitated patients to enter the study during a determined period of time (from June to September 2019). All eligible patients that consented to participate in our study were recruited during this period. Nevertheless, to our knowledge, there are no previous reports on volumetric capnography during colonoscopy, which also difficults sample size calculation. For patient selection in both groups, we used an online randomization generator. The allocation was concealed in sealed envelopes, and the research team opened each envelope only after patients had already signed the informed consent. The research team was not blinded to the insufflation method to be used.

The procedures were performed by a team of three experienced senior colonoscopists and four medical residents. All colonoscopies were performed with complete bowel preparation under sedation on an outpatient basis using a Fujinon® high-definition endoscopy system. All patients received continuous oxygen (O_2) administration through a nasal catheter with 2 L/min flow. The system device used for SpO_2 and VCap monitoring was the CO_2SMO Plus 8100® Dixtal/Novametrix (FIGURE 1). The VCap sensor was attached to an anesthetic mask (FIGURE 2), continuously recording respiratory mechanical variables during colonoscopy. Insufflation was performed exclusively with RA from the internal gas network of the endoscopy unit (Group 1) or CO_2 (Group 2) using the Biocam SICO® CO_2 insufflation system.

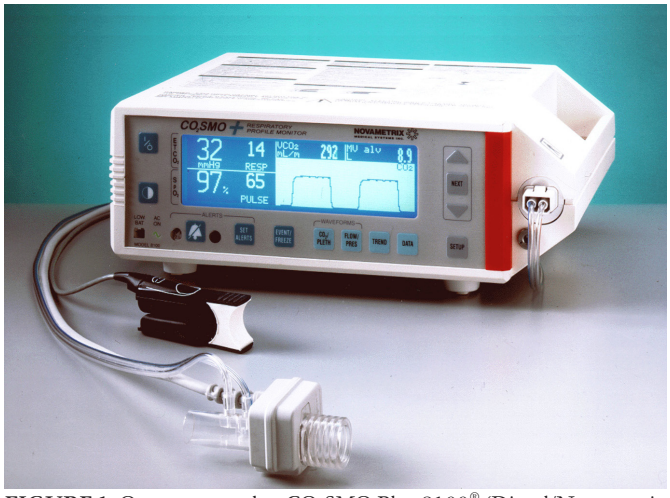

FIGURE 1. Oxycapnographer CO_2SMO Plus 8100® (Dixtal/Novametrix Inorporation, Wallingford, CT, USA).

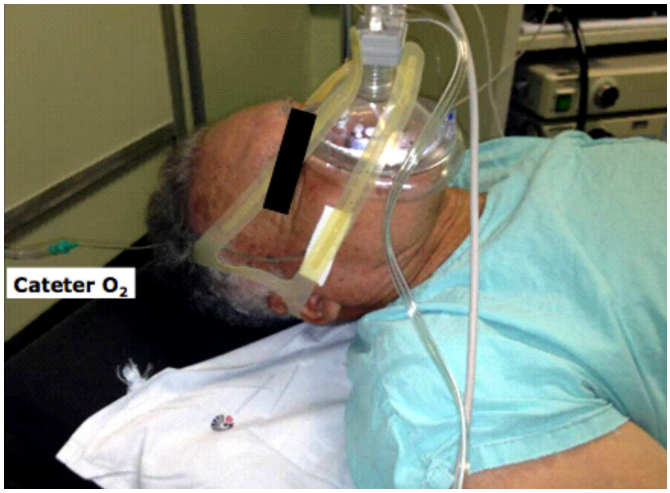

FIGURE 2. Patient under VCap monitoring and with O_2 nasal catheter.

The primary endpoints were episodes of hypoxia (SpO_2 <90%), episodes of alveolar hypoventilation ($EtCO_2$ ≥25% from baseline), and $EtCO_2$ (baseline, maximum, average, at the beginning of the procedure, when cecal intubation was achieved, when the rectum was reached during colonoscope retrieval, and 3 min post-end of the procedure). Secondary endpoints were to evaluate alveolar tidal volume per minute (Valv min) (baseline, when cecal intubation was achieved, and when the rectum was reached during colonoscope retrieval) and to evaluate pain after colonoscopy using the Gloucester Modified Pain Scale[28] (immediately after, 1 h, and 24 h after the procedure), as shown in CHART 2. The baseline variables analyzed were sex, age, body mass index (BMI), ASA classification, and procedure duration. Data on cardiac and respiratory rates (baseline, when cecal intubation was achieved, and when the rectum was reached during colonoscope retrieval) and sedation (types of medications and dosage needed) were also collected.

CHART 2. Gloucester Modified Pain Scale.

1	No pain
2	Minimum pain
3	Mild pain
4	Moderate pain
5	Intense pain

Modified from Valori et al.[28].

Statistical analysis for quantitative variables with normal distribution was presented as median and standard deviation (dp), and Student's *t*-test was used to compare two independent samples. Fisher's exact test was used for an expected small number of frequencies (n<20) when the chi-square test (χ^2) was not appropriate. The statistical significance level was set at $P \leq 0.05$. IBM SPSS Statistics v20.0 was used for the analysis.

All patients signed an informed consent form and the study was approved by the Research Ethics Committee of the Faculty of Medical Sciences of State University of Campinas (UNICAMP) under the registered approval number 1504388 (CAAE 52940315.9.0000.5404).

RESULTS

The study included 101 patients who underwent colonoscopy under VCap monitoring, using insufflation with RA (Group 1) or CO_2 (Group 2). TABLE 1 shows the main baseline characteristics of the two groups.

TABLE 1. Baseline variables of study participants in both groups.

	Group 1 RA (N=51)	Group 2 CO_2 (N=50)	*P*-value
Age			
years, median±SD	55.63±12.38	50.76±13.60	0.53
Men/women (N)	30/21	21/29	0.09
BMI			
Kg/m^2 median±SD	28.3±4.6	26.51±4.2	0.73
ASA			
I (N,%)	38 (74.5%)	37 (74.0%)	0.71
II (N,%)	9 (17.6%)	8 (16.0%)	0.85
III (N,%)	4 (7.85%)	5 (10.0%)	1
Procedure time (min)	28.74±2.53	22.78±3.67	0.06

BMI: body mass index; ASA: American Society of Anesthesiologists.

TABLE 2 lists oximetry and VCap data. No abnormal cardiac and respiratory rates were observed during the study, and both groups showed no differences in either of the three different time points captured (basal, cecal, and rectal at colonoscope withdrawal). In relation to oximetry data, basal SpO_2 was similar between the two groups (median, 98%). Four episodes of hypoxia (SpO_2 <90%) were observed in Group 1 and two episodes in Group 2. There was no statistical difference between the number of episodes of hypoxia (P=0.67), Group 1 had a significantly longer duration of hypoxia (2.59±14.01 vs 0.2±1.01 seconds, P=0.02). FIGURE 3 shows the VCap results for two different patients, including one episode of hypoxia. Alveolar hypoventilation occurred significantly more frequently in Group 2 than in Group 1 (27 vs 18 episodes, P=0.05). The $EtCO_2$ data demonstrated a significant difference only in cecal $EtCO_2$: Group 2 showed higher values than Group 1 (28.94±4.68 vs 26.65±6.12 mmHg, P=0.04). The maximum and average $EtCO_2$ values, as well as the other four values, were similar in both groups. No episodes of hypercapnia ($EtCO_2$ >60 mmHg) occurred during the study. With reference to Valv min, Group 2

TABLE 2. Oxicapnography parameters in both groups.

Oxicapnography parameters	Group 1 RA (N=51)	Group 2 CO_2 (N=50)	*P*-value
Cardiac rate (bpm, median±sd))			
Basal	77.43±16.10	77.50±14.23	0.60
Cecal	76.98±15.48	78.58±16.30	0.34
Rectal (vithdrawal)	76.75±17.08	81.90±14.83	0.40
Respiratory rate (bpm, median±sd)			
Basal	16.78±3.80	15.60±3.59	0.65
Cecal	19.29±6.02	17.82±4.34	0.09
Rectal (vithdrawal)	18.86±4.69	18.62±4.10	0.22
Basal SpO_2 (%)	98.14±0.80	98.40±0.90	0.34
Episodes of hypoxia (n)	4	2	0.67
Duration of hypoxia episodes (seconds, median±sd)	2.5±14.01	0.2±1.01	0.02
Episodes of alveolar hypoventilation	18	27	0.05
$EtCO_2$ (mmHg, median±sd)			
Basal	28.55±3.78	27.18±3.80	0.78
Initial	27.14±4.36	25.84±4.85	0.38
Cecal	26.65±6.12	28.94±4.68	0.04
Rectal (withdrawal)	28.65±4.36	31.28±4.35	0.93
3min post-procedure	28.33±4.12	31.00±4.54	0.60
Maximum	34.86±4.06	35.34±4.02	0.89
Average	26.43±4.23	26.82±4.12	0.78
Valv min (L/min, median±sd)			
Basal	3413.43±3582.79	1660.56±2407.68	0.06
Cecal	2027.53±2818.89	970.88±1840.25	0.009
Rectal (withdrawal)	2521.13±2636.41	2139.46±2973.22	0.08

Cardiac rate bpm, beats per minute; respiratory rate, breathings per minute; hypoxia, SpO_2 <90%; alveolar hypoventilation, $EtCO_2$ ≥25% from baseline; $EtCO_2$, end-tidal CO_2; Valv min, alveolar tidal volume per minute.

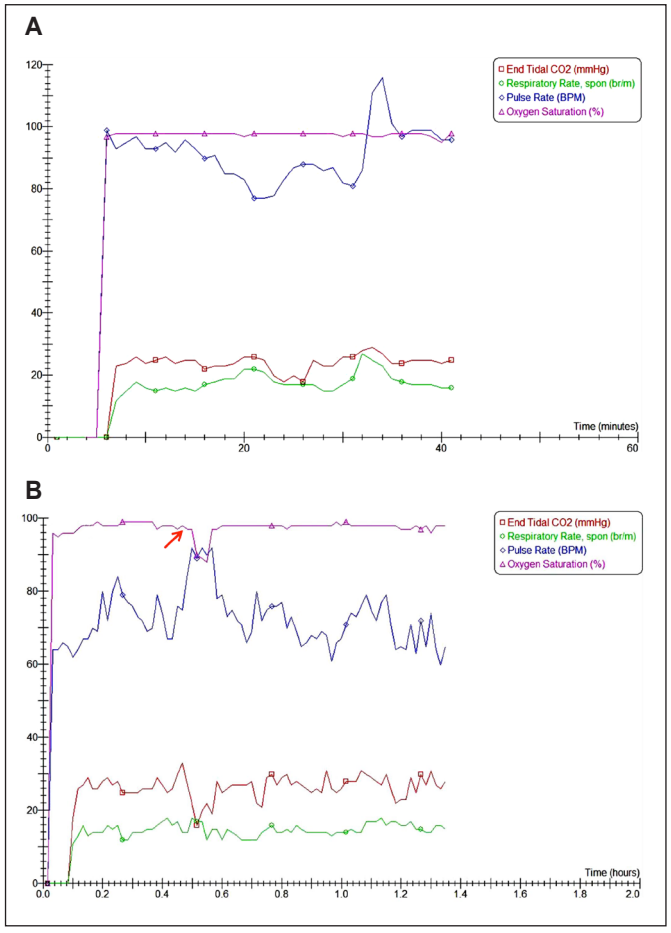

FIGURE 3. Final VCap results ($EtCO_2$, respiratory rate, pulse rate, and oxygen saturation) of two different patients during colonoscopy. Patient B presented with hypoxia during the procedure (red arrow points to the exact interval and duration).

had significantly lower values of cecal Valv min when compared to Group 1 (2027.53±2818.89 vs 970.8±1840.25 L/min, *P*=0.009). The two groups had similar Valv min data on the other two time points captured: basal and rectal at colonoscope withdrawal.

There was no difference between the groups regarding the consumption of sedation medications, as observed in TABLE 3. Post-colonoscopy pain was evaluated immediately, 1 h, and 24 h after the procedure, and the data are presented in TABLE 4. Immediately after colonoscopy, significantly more patients in Group 2 had no pain than those in Group 1 (38 vs 29 patients, *P*=0.05). Although not statistically significant, Group 2 reported lower pain scores 1 h post-procedure. Regarding the 24 h post-colonoscopy pain scores, both groups reported similar results.

TABLE 3. Sedation medications and dosages used.

Sedation medication	Group 1 RA (N=51)	Group 2 CO_2 (N=50)	*P*-value
Midazolam (mg, median±SD)	4.15±1.31	4.21±1.51	0.71
Meperidine (mg, median±SD)	34.12±16.69	37.1±15.35	0.59
Propofol (mg, median±SD)	156.9±424.8	114.00±406.5	0.51

TABLE 4. Distribution of referred pain scores in both groups, according to Gloucester Modified Pain Scale immediately, 1 h, and 24 h after colonoscopy.

Pain Scores	Group 1 RA (N=51)	Group 2 CO_2 (N=50)	*P*-value
Immediate pain			
1	29 (56.9%)	38 (76%)	0.05
2	11 (21.7%)	10 (20%)	0.88
3	8 (15.5%)	2 (4%)	0.1
4	3 (5.9%)	–	–
Pain after 1 h			
1	37 (72.5%)	45 (90%)	0.37
2	10 (19.6%)	4 (8%)	0.16
3	2 (3.9%)	1 (2%)	0.56
4	1 (2%)	–	–
5	1 (2%)	–	–
Pain after 24 h			
1	48 (94.1%)	47 (94%)	0.91
2	2 (3.9%)	3 (6%)	0.65
3	1 (2%)	–	–

Pain scores. 1, no pain; 2, minimum pain; 3, mild pain; 4, moderate pain; 5, intense pain.

DISCUSSION

Colonoscopy is an invasive procedure and although the risk of complications is low, they are frequently observed in endoscopy units due to the high volume of colonoscopies performed, especially for colorectal cancer screening indications[29]. In a recent study, Patel et al.[30] reported that colonoscopy was the main cause of malpractice lawsuits in gastroenterology. Different areas of colonoscopy, such as patient safety and comfort, can be explored and improved. Our study aimed to contribute to the use of VCap monitoring and CO_2 insufflation during colonoscopy. Besides being the first publication reporting the use of volumetric capnography during colonoscopy, our study has significant strengths, such as being prospective and evaluating VCap and CO_2 insufflation in a typical Brazilian tertiary endoscopy unit.

Our study has limitations, as the endoscopists were not blinded to the insufflation method, as well as there was no comparison between VCap and conventional capnography, neither between VCap and no capnography. We also included seven endoscopists, which can be interpreted as an excessive number of examinators. Our aim was to perform a single-center and real-life study, which reflected our daily endoscopic practice. Therefore, we did not interfere on the routine schedule of endoscopists.

Sedation during colonoscopy can induce respiratory complications, and capnography is more effective than pulse oximetry and visual inspection[12,13] in detecting hypoventilation, airway obstruction, and apnea, allowing early measures of correction. Although continuous O_2 administration and pulse oximetry reduce hypoxemia during procedures under sedation, they can delay the detection of apnea and hypoventilation[31,32]. In our study, all colonoscopies were performed under continuous O_2 administration and sedation, and a total of six episodes of hypoxia occurred similarly in both groups (four in Group 1 and two in Group 2, P=0.67), but Group 1 reported longer periods of hypoxia (P=0.02). Regarding alveolar hypoventilation, Group 2 presented significantly more episodes than Group 1 (27 vs 18 episodes, P=0.05). We hypothesized that RA induces more pain during the procedure, which requires more vigorous administration of sedatives. Vargo et al.[13] reported 54 altered respiration events detected by capnography, of which pulse oximetry detected only 27 events during the endoscopic procedure in 49 patients.

VCap is considered a mainstream modality of capnography because it detects CO_2 directly from the alveoli ($EtCO_2$) and reflects ventilation in real-time, which is different from and superior to sidestream capnography (transcutaneous). In addition to alveolar hypoventilation, $EtCO_2$ elevations can occur secondary to rapid intestinal absorption of CO_2 used for insufflation during colonoscopy. In fact, no cases of hypercapnia were observed in our study, and the $EtCO_2$ maximum values were similar between the groups. Of all five moments of $EtCO_2$ monitoring, a significant difference was observed only when the colonoscope reached the cecum: Group 2 showed higher $EtCO_2$ values compared to Group 1 (28.94±4.68 vs 26.65±6.12 mmHg, P=0.04). It is possible that patients in Group 1, even though under sedation, had more pain during colonoscope insertion than those in Group 2, leading to more hyperventilation and lower $EtCO_2$ values. Although not significantly different (P=0.09), Group 1 had a lower respiratory rate when the cecum was reached compared to Group 2. There was no significant difference between the cardiac and respiratory rates in either group. Although Group 2 used continuous CO_2-insufflation, no significant or pathological changes were observed in $EtCO_2$. Few studies have been published that evaluated $EtCO_2$ in colonoscopy, and all of them used sidestream capnography. We performed the first study using mainstream volumetric capnography, measuring $EtCO_2$ directly from the airway. Arterial blood samples collected during endoscopic procedures were used in the study by Luigiano et al.[33], which did not demonstrate significant elevations of $PaCO_2$ with CO_2 insufflation. Two studies by Bretthauer et al.[18,21] showed no significant increase in $EtCO_2$ with CO_2 insufflation compared to RA. Chao et al.[26] obtained similar results, with a significant increase in $EtCO_2$ in deeply sedated patients independent of the insufflation method. Diez-Redondo et al.[25] reported one case of asymptomatic hypercapnia during colonoscopy with CO_2 insufflation in 129 patients. In our study, both groups had comparable sedative consumption, which facilitates the interpretation of the $EtCO_2$ data.

VCap can evaluate the Valv min, which is important for monitoring the air volume entering and exiting the alveoli for one minute and does not include the anatomic dead space. Valv min monitors the actual amount of O_2 entering and CO_2 leaving the body. In our study, Group 1 had a lower Valv min compared to Group 2 at the three evaluation intervals, although it was statistically significant only at the cecal interval (2027.53±2818.89 vs 970.88±1840.25 L/min, P=0.009). Therefore, we can assume that in Group 1, due to more pain secondary to RA insufflation, hyperventilation caused higher Valv min and CO_2 elimination. In fact, as mentioned above, Group 1 had significantly lower cecal $EtCO_2$ than Group 2 (P=0.04). To the best of our knowledge, there are no studies evaluating Valv min available to compare our data.

All patients in our study were sedated during colonoscopy; therefore, we did not monitor intraprocedural pain. Furthermore, residual air causes pain after colonoscopy. RA insufflated during colonoscopy has very poor absorption in the large bowel and is eliminated mainly through the flatus. In contrast, CO_2 insufflation during colonoscopy should be associated with less post-procedure pain due to its rapid absorption by the intestinal mucosa. To evaluate post-colonoscopy pain, we used the Gloucester-modified Pain Scale. Although not formally validated, this scale is frequently used for the evaluation of intra- and post-colonoscopy pain due to its ease of application. In our study, the benefits of CO_2 insufflation were observed immediately after colonoscopy. Group 2 had significantly more patients without pain than Group 1 (38 vs 29 patients, P=0.05). There was no statistical difference between the groups 1 h and 24 h after colonoscopy. In the literature, the main benefit of CO_2 insufflation appears to be during the first hour after colonoscopy, and the majority of studies show benefits up to 6 h post-colonoscopy. Although several studies[22,34-37] have reported significantly lower pain scores with CO_2 insufflation 1 h after colonoscopy, we did not find the same results in our study. Similar to our results, Diez-Redondo et al.[25] also reported significantly lower pain scores immediately after colonoscopy and found no benefit at 24 h with CO_2 insufflation. In contrast with our data, the same authors reported lower pain scores 1 h after colonoscopy (as well as 3 and 6 h post-procedure) with CO_2-insufflation. In the randomized study of De-Quadros et al.[38], insufflation of CO_2 during colonoscopy was superior to RA, as it caused less post-procedure abdominal distension and provided more comfort during the 24 h period after colonoscopy. The medical literature appears to demonstrate the greatest benefit of CO_2-insufflation during the first hour post-colonoscopy, and most studies report some benefit up to 6 h after the procedure. Although studies[34,35] have reported mixed results, the benefits of CO_2-insufflation have been described at 24 h after colonoscopy pain assessment.

Our study has two themes that certainly can contribute to daily colonoscopy practice: CO_2 insufflation and capnography monitoring. The CO_2 insufflation causes less post-volumetric colonoscopy discomfort and better follow-up compliance. For advanced therapeutic procedures, CO_2 insufflation is preferred because of its rapid absorption, providing more comfort during longer procedures and more safety in case of iatrogenic perforation. Volumetric capnography provides more safety to endoscopic procedures due to prevention and early detection of respiratory complications. VCap is more complex and expensive than standard capnography, and maybe is more suitable in more difficult scenarios than routine colonoscopy, such as longer therapeutic procedures, patients with serious comorbidities (especially lung disease) and intensive care units.

CONCLUSION

In conclusion, VCap during colonoscopy was feasible and effective for monitoring ventilatory parameters and detecting respiratory complications, and CO_2 insufflation was associated with

less pain immediately after colonoscopy. More data are required to establish the role of volumetric capnographic monitoring during routine colonoscopy.

ACKNOWLEDGEMENTS

This manuscript is the result of a PhD thesis by the main author, and we deeply appreciate the *Programa de Pós-Graduação em Ciências da Cirurgia da Faculdade de Ciências Médicas da Universidade Estadual de Campinas* (FCM/UNICAMP) for all their support. We are grateful to all the teams at *Gastrocentro/UNICAMP* who made this work possible. Our special thanks to Rogério Ulbrich, engineer and owner of Biocam, who donated the CO_2 insufflator SICO to us. We would like to thank Editage (www.editage.com) for English language editing.

Authors' contribution

Camargo MG conceived and designed the analysis, collected data, performed the analysis, and wrote the paper. Moreira MM conceived and designed the analysis, collected the data, and contributed to the analysis tools. Santos JOM performed conception, design, and data collection. Magro DO performed statistical analyses. Ayrizono MLS contributed data, manuscript review, and guidance.

Orcid

Michel Gardere Camargo: 0000-0001-6820-8164.
Marcos Mello Moreira: 0000-0002-2148-5479.
Daniéla Oliveira Magro: 0000-0002-8180-6254.
José Olympio Meirelles Santos: 0000-0001-9491-3246.
Maria de Lourdes Setsuko Ayrizono: 0000-0002-7035-2568.

Camargo MG, Moreira MM, Magro DO, Santos JOM, Ayrizono MLS. Capnografia volumétrica para monitoração respiratória de pacientes submetidos a colonoscopia diagnóstica com insuflação de ar comprimido e gás carbônico. Arq Gastroenterol. 2022;59(3):383-9.

RESUMO – Contexto – A capnografia e a insuflação de gás carbônico (CO_2) durante endoscopia digestiva sob sedação são associados à maior segurança e conforto do paciente, respectivamente. A capnografia pode detectar precocemente a apneia e hipoxemia, enquanto a insuflação de CO_2 causa menor desconforto periprocedimento. Relatos da aplicação da capnografia volumétrica em colonoscopias são escassos. **Objetivo –** Avaliar o uso de capnograifa volumétrica durante colonoscopia diagnóstica com insuflação de ar comprimido e CO_2. **Métodos –** Em estudo prospectivo de coorte, foram incluídos um total de 101 pacientes submetidos a colonoscopia diagnóstica sob sedação com monitoração respiratória por meio de capnografia volumétrica. Insuflação com ar comprimido foi usado para distender o lúmen intestinal no Grupo 1 (n=51), enquanto o Grupo 2 (n=50) utilizou CO_2 para insuflação. Objetivos primários foram avaliar episódios de hipóxia, hipoventilação alveolar e CO_2 expirado ($EtCO_2$). Objetivos secundários foram avaliar o volume alveolar por minuto, consumo de sedativos e a dor pós-colonoscopia por meio da Escala de Dor Modificada de Gloucester. **Resultados –** O número de episódios de hipóxia (SpO_2 <90%) foi semelhante entre os grupos: quatro episódios no Grupo 1 e dois episódios no Grupo 2. A duração da hipóxia foi significativamente maior no Grupo 2 (*P*=0,02). A hipoventilação alveolar ($EtCO_2$ ≥25% do valor basal) ocorreu mais frequentemente no Grupo 2 quando comparado ao Grupo 1 (27 vs 18 episódios, *P*=0,05). Em relação ao $EtCO_2$, o Grupo 2 apresentou valores maiores no momento de aferição cecal (28.94±4.68 vs 26.65±6.12 mmHg, *P*=0,04). Quanto ao volume alveolar por minuto, o Grupo 2 apresentou valores significativamente menores no momento de aferição cecal quando comparado ao Grupo 1 (2027.53±2818.89 vs 970.88±1840.25 L/min, *P*=0,009). Não houve ocorrência de hipercapnia durante o estudo ($EtCO_2$ >60 mmHg). Não houve diferença em relação ao consumo de sedativos entre os dois grupos. Imediatamente após a colonoscopia, o Grupo 2 apresentou significativamente menos dor que o Grupo 1 (*P*=0,05). **Conclusão –** Em nosso estudo, a capnografia volumétrica durante colonoscopia foi factível e eficaz para monitorar parâmetros ventilatórios e detectar complicações respiratórias, e a insuflação com CO_2 foi segura e associada a menor dor imediatamente pós-colonoscopia.

Palavras-chave – Colonoscopia; capnografia; dióxido de carbono; capnografia volumétrica; segurança.

REFERENCES

1. Zauber AG, Winawer SJ, O'Brien MJ, Lansdorp-Vogelaar I, Ballegooijen M, Hankey BF, et al. Colonoscopic polipectomy and long-term prevention of colorectal-cancer deaths. N Engl J Med. 2012;366: 687-96.
2. Rabeneck L, Paszat LF, Saskin R, Stukel TA. Association between colonoscopy rates and colorectal cancer mortality. Am J Gastroenterol. 2010;105:1627-32.
3. Ko CW, Dominitz JA. Complications of colonoscopy: magnitude and management. Gastrointest Endosc Clin N Am. 2010;20:659-71.
4. Warren JL, Klabunde CN, Mariotto AB, Meekins A, Topor M, Brown ML, et al. Adverse events after outpatient colonoscopy in the Medicare population. Ann Intern Med. 2009;150:849-57.
5. Liu H, Waxman DA, Main R, Mattke S. Utilization of anesthesia services during outpatient endoscopies and colonoscopies and associated spending in 2003-2009. JAMA. 2012;307:1178-84.
6. Froehlich F, Harris JK, Wietlisbach V, Burnand B, Vader JP, Gonvers JJ. Current sedation and monitoring practice for colonoscopy: an Intenational Observational Study (EPAGE). Endoscopy. 2006;38;461-69.
7. Zhao S, Deng XL, Wang L, Ye JW, Liu ZY, Huang B, et al. The impact of sedation on quality metrics of colonoscopy: a single-center experience of 48,838 procedures. Int J Colorectal Dis. 2020;35:1155-61.
8. Cohen LB, Wecsler JS, Gaetano JN, Benson AA, Miller KM, Durkalski V, et al. Endoscopic sedation in the United States: results from a nationwide survey. Am J Gastroenterol. 2006;101:967-74.
9. Sharma VK, Nguyen CC, Crowell MD, Lieberman DA, De Garmo P, Fleischer DE. A national study of cardiopulmonary unplanned events after GI endoscopy. Gastrointest Endosc. 2007;66:27-34.
10. Vargo JJ 2nd. Sedation-related complications in gastrointestinal endoscopy. Gastrointest Endosc Clin N Am. 2015;25:147-58.
11. Riphaus A, Rabofski M, Wehrmann T. Endoscopic sedation and monitoring practice in Germany: results from the first Nationwide survey. Z Gastroenterol. 2010;48:392-7.
12. Lam T, Nagappa M, Wong J, Singh M, Wong D, Chung F. Continuous Pulse Oximetry and Capnography Monitoring for Postoperative Respiratory Depression and Adverse Events: A Systematic Review and Meta-analysis. Anesth Anag. 2017;125: 2019-29.
13. Vargo JJ, Zuccaro G Jr, Dumot JA, Conwell DL, 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.

14. 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. Gastroenterology. 2009;136:1568-76.
15. Friedrich-Rust M, Welte M, Welt C, Albert J, Meckbach Y, Herrmann E, et al. Capnographic monitoring of propofol-based sedation during colonoscopy. Endoscopy. 2014;46:236-44.
16. Suarez-Sipmann F, Bohm SH, Tusman G. Volumetric capnography: the time has come. Curr Opin Crit Care. 2014;20:333-9.
17. Ko CW, Riffle S, Shapiro JA, Saunders MD, Lee AD, Tung BY, et al. Incidence of minor complications and time lost from normal activities after screening or surveillance colonoscopy. Gastrointest Endosc. 2007;65:648-56.
18. Bretthauer M. Turning science into clinical practice – the case of carbon dioxide insufflation. Endoscopy. 2010;42:1104-5.
19. Brandt LJ, Boley SJ, Sammartano R. Carbon dioxide and room air insufflation of the colon. Effects on colonic blood flow and intraluminal pressure in the dog. Gastrointest Endosc. 1986;32:324-9.
20. Wu J, Hu B. The role of carbon dioxide insufflation in colonoscopy: a systematic review and meta-analysis. Endoscopy. 2012;44:128-36.
21. Bretthauer M, Lynge AB, Thiis-Evensen [E], Hoff [G], Fausa [O], Aabakken L. Carbon Dioxide Insufflation in Colonoscopy: Safe and Effective in Sedated Patients. Endoscopy. 2005;37:706-9.
22. Yamano HO, Yoshikawa K, Kimura T, Yamamoto E, Harada E, Kudou T, et al. Carbon dioxide insufflation for colonoscopy: evaluation of gas volume, abdominal pain, examination time and transcutaneous partial CO_2 pressure. J Gastroenterol. 2010;45:1235-40.
23. Church J, Delaney C. Randomized, controlled trial of carbon dioxide insufflation during colonoscopy. Dis Colon Rectum 2003;46:322-6.
24. Chen YJ, Lee J, Puryear M, Wong RK, Lake JM, Maydonovich CL, et al. A randomized controlled study comparing room air with carbon dioxide for abdominal pain, distention, and recovery time in patients undergoing colonoscopy. Gastroenterol Nurs. 2014;37:273-8.
25. Diez-Redondo P, Gil-Simon P, Alcaide-Suarez N, Atienza-Sanchéz R, Barrio--Andrés J, De-la-Serna-Higuera C, et al. Comparison between insufflation with air or carbon dioxide during the colonoscopy in sedated patients with propofol. Rev Esp Enferm Dig. 2012;104:411-7.
26. Chao IF, Chiu HM, Liu WC, Liu CC, Wang HP, Cheng YJ. Significant hypercapnia either in CO_2-insufflated or air-insufflated colonoscopy under deep sedation. Acta Anesthesiol Taiwan. 2010;48:163-6.
27. Chen PJ, Li CH, Huang TY, Shih YL, Chu HC, Chang WK, et al. Carbon dioxide insufflation does not reduce pain scores during colonoscope insertion in unsedated patients: a randomized, controlled trial. Gastrointest Endosc. 2013;77:79-89.
28. Valori R, Rey JF, Atkin WS, Bretthauer M, Senore C, Hoff G, et al. European guidelines for quality assurance in colorectal cancer screening and diagnosis. First Edition-Quality assurance in endoscopy in colorectal cancer screening and diagnosis. Endoscopy. 2012;44:SE88-105.
29. Rex DK, Johnson DA, Lieberman DA, Burt RW, Sonnenberg A. Colorectal cancer prevention 2000: Screening recommendations of the American College of Gastroenterology. Am J Gastroenterol. 2000;95:868-77.
30. Patel KS, Kothari P, Gantz O, Prabhu A, Ayyaswami V, Kono J, et al. Current Trends and Predictors of Case Outcomes for Malpractice in Colonoscopy in the United States. J Clin Gastroenterol. 2022;1;56:49-54.
31. Holm C, Rosenberg J. Pulse oximetry and supplemental oxygen during gastrointestinal endoscopy: a critical review. Endoscopy. 1996;28:703-11.
32. Pedersen T, Nicholson A, Hovhannisyan K, Moller AM, Smith AF, Lewis SR. Pulse oximetry for perioperative monitoring. Cochrane Database Syst Rev. 2014;CD002013.
33. Luigiano C, Ferrara F, Pellicano R, Fabbri C, Cennamo V, Bassi M, et al. Carbon dioxide insufflation versus air insufflation during endoscopic retrograde cholangiopancreatography under general anesthesia. Minerva Med. 2011;102:261-9.
34. Liu X, Liu D, Li J, Ou D, Zhou Z. Safety and efficacy of carbon dioxide insufflation during colonoscopy. Zhong Nan Da Xue Xue Bao Yi Xue Ban. 2009; 34:825-9.
35. Bretthauer M, Thiis-Evensen E, Huppertz-Hauss G, Gisselsson L, Grotmol T, Skovlund E, et al. NORCCAP (Norwegian colorectal cancer prevention): a randomized trial to assess the safety and efficacy of carbon dioxide versus air insufflation in colonoscopy. Gut. 2002;50:604–7.
36. Uraoka T, Kato J, Kuriyama M, Hori K, Ishikawa S, Harada K, et al. CO_2 insufflation for potentially difficult colonoscopies: efficacy when used by less experienced colonoscopists. World J Gastroenterol. 2009;15:5186-92.
37. Iida T, Okamura S, Kakizaki S, Sagawa T, Zhang Y, Kobayashi R, et al. Carbon dioxide insufflation reduces the discomfort due to colonoscopy as objectively analyzed by salivary stress markers. Acta Gastroenterol Belg. 2013;76: 219-22.
38. De-Quadros LG, Kaiser-Júnior RL, Felix VN, Villar L, Campos JM, Nogueira VQM, et al. Colonoscopy: randomized comparative study of insufflation with carbon dioxide versus air. ABCD Arq Bras Cir Dig 2017;30:177-81.