# Carbon Dioxide versus Room Air for Colonoscopy: a Single Center Study

**Ahmed Altonbary[1], Elsayed Khalil[1], Enas Othman[2]**
[1]*Department of Gastroenterology and Hepatology*
*Mansoura Specialized Medical Hospital, Mansoura University, Mansoura, Egypt*
[2]*Department of Gastroenterology and Hepatology*
*Althawra teaching Hospital, Omar Almokhtar University, Libya*

*Corresponding Author*
*Ahmed Altonbary*
*ORCID 0000-0001-8850-9829*

*Mobile:*
*+201005100091*

*Email:*
*a.tonbary@gmail.com*

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**Background and study aim:** Abdominal pain and bloating sensations can occur after colonoscopy. Theoretically, a faster rate of absorption is expected to reduce abdominal pain and bloating when using carbon dioxide (CO2). However, some clinical studies have found that CO2 is not superior to room air (RA). The aim of this study was to compare abdominal pain and bloating sensations after colonoscopy using RA versus CO2 insufflation.

**Patients and Methods:** A single blinded randomized controlled trial performed on 128 patients who needed diagnostic colonoscopy between July 2021 and March 2023. Eligible patients were randomized into two groups. Group 1 underwent colonoscopy using RA insufflation and Group 2 underwent colonoscopy using CO2 insufflation. Abdominal pain and bloating after the procedure were assessed by a 10-point visual analogue scale (VAS). The participants were asked about abdominal pain and bloating at 15, 60, 180 minutes and 24 hours post-procedural.

**Results:** There was statistically significant increase in the abdominal pain with RA compared to CO2 insufflation [34.4% vs 9.4% (p=0.024), 43.8% vs 21.9% (p=0.011), and 37.5% vs 9.4%, (p=0.017)] at 15-, 60-, and 180-minutes post-procedural. Also, there was statistically significant increase in the abdominal bloating at 60 minutes post-procedural with RA compared to CO2 insufflation (68.7% vs 18.8%, p=0.018). No statistically significant difference between RA and CO2 regarding cecal intubation time (8.2±1.4 vs 8.7±2.1, p=0.318) and total examination time (18.9±3.5 vs 19.4 ± 2.9, p=0.23).
**Conclusion:** CO2 insufflation is associated with significantly less abdominal pain and bloating after diagnostic colonoscopy compared to RA insufflation.

## INTRODUCTION

Colonoscopy is a commonly used diagnostic and therapeutic procedure for evaluating the lower gastrointestinal tract. Room air (RA) insufflation was the first method used to inflate the intestine and efficiently inspect the mucosa. Additional methods such as carbon dioxide ($CO_2$) insufflation, water immersion, and water exchange have been gradually introduced to increase efficiency and safety [1]. However, RA still the most frequently used method for insufflation during colonoscopy [2]. This could be attributed to variations in clinical practice, knowledge of endoscopists and availability of $CO_2$ insufflators. Abdominal pain and bloating sensations after colonoscopy are correlated to the volume of gas used during colonoscopy. Unlike RA, which is poorly absorbed from the intestinal lumen, $CO_2$ can be quickly absorbed into the blood stream and easily exhaled [3]. Given its rapid absorption, it can be assumed that a higher volume of $CO_2$ would be utilized during the procedure, which may alleviate some of its advantages. However, experienced endoscopists can utilize similar volumes of RA and $CO_2$ [4]. Theoretically, a faster rate of absorption is expected to reduce abdominal pain and bloating sensations when using $CO_2$. However, some clinical studies have found that $CO_2$ is not superior to RA in post-procedural abdominal pain sensation [5, 6]. The aim of this study was to compare abdominal pain and bloating sensations after colonoscopy using RA versus $CO_2$ insufflation.

## PATIENTS/MATERIALS AND METHODS

This was a single blinded randomized controlled trial performed at our endoscopy unit on 128 patients who needed diagnostic colonoscopy between July 2021 and March 2023. The inclusion criteria were patients > 18 years presenting for colonoscopy for different indications including chronic diarrhea, chronic constipation, colorectal cancer screening, iron deficiency anemia, bleeding per rectum, and assessing disease activity in inflammatory bowel disease. The exclusion criteria were inability to give informed consent for the procedure, concurrent multiorgan failure, previous history of partial or total colectomy, need for therapeutic colonoscopy, acute diverticulitis, and intestinal obstruction.

Enrolled patients were randomized into two groups with block randomization design using computer generated random number sequences in concealed envelopes. Group 1 underwent colonoscopy using RA insufflation and Group 2 underwent colonoscopy using $CO_2$ insufflation. This was a single blinded trial, as only the patients were not aware of the type of gas used for colon insufflation. Informed written consent was gotten from each participant in the study after assuring secrecy. The study protocol and consent form were approved by the Institutional Review Board of our university under the code MS.21.05.1514.

### *Endoscopic procedure*

Before endoscopy, all patients were subjected to clinical assessment including history taking, physical examination, and laboratory investigations including complete blood count, International Normalized Rate (INR), viral markers for hepatitis B and C, and serum creatinine. Split-dose polyethylene glycol (PEG) was used for bowel preparation in all patients as the following: 2 Litres of PEG the day before the procedure at 6 PM, and 2 Litres of PEG on the day of the procedure 6 hours before the scheduled colonoscopy time. All colonoscopies were performed by single expert endoscopist using Pentax EC38-i10F2 (PENTAX medical, Tokyo, Japan) with patients in left lateral position under conscious sedation using Midazolam (2.5-5 mg). RA was used with standard endoscopic insufflation processor Pentax EPK-i5000 (PENTAX medical, Tokyo, Japan) and $CO_2$ was used with the Fujifilm GW-100 endoscopic regulator (Fujifilm, Tokyo, Japan) connected to a $CO_2$ gas cylinder. During endoscopy, all patients were observed for heart rate and oxygen saturation. Abdominal compression and changing patient's position were used when needed during colonoscopy navigation till completion of the procedure. Complete colonoscopy was defined as recognition of the appendiceal orifice and/or ileal intubation. Cecal intubation time, withdrawal time and total procedure time were recorded.

### *Pain assessments*

Abdominal pain sensation after colonoscopy, as the primary outcome measure, was assessed by a 10-point visual analogue scale (VAS), a numerical scale rated from 0 (no pain) to 10 points (maximal pain). The VAS was explained to each patient before the procedure and confirmed that it is completely understood. The participants were asked about abdominal pain face-to-face at 15, and 60 minutes, and by phone at 180 minutes and 24 hours post-procedural. Abdominal pain was considered mild with VAS score (1-3), moderate with score (4-7) and severe with score (8-10). Abdominal bloating after the procedure, as the secondary outcome measure, was also assessed by a 10-point visual analogue scale (VAS), a numerical scale rated from 0 (no bloating) to 10 points (maximal bloating). The participants were asked about abdominal bloating face-to-face at 60 minutes post-procedural. In the same sequence, abdominal bloating was considered mild with VAS score (1-3), moderate with score (4-7) and severe with score (8-10).

### *Statistical analysis*

Power Analysis and Sample Size software program (PASS) version 15.0.5 for windows was used to calculate sample size. A sample size of 64 patients in each group for is needed to attain 80% power (1-β or the probability of rejecting the null hypothesis when it is false) in the proposed study and detect an effect size of 0.5 using a two-sided two-sample equal-variance t-test with a significance level (α or the probability of rejecting the null hypothesis when it is true) of 5%. All data were collected, tabulated, and statistically analysed using (IBM SPSS Statistics for Windows, Version 23.0). Quantitative data were expressed as the mean ± SD & median (range), and qualitative data were expressed as numbers and percentage. Difference and association of qualitative variable by Chi square

test (X2). Paired t test was used to compare between paired continuous normally distributed variables. Anova test was used to compare between more than two groups of normally distributed variables. Pearson' correlation (r) was used to correlate the quantitative parameters. P-value <0.05 was considered statistically significant, and p-value ≥0.05 was considered statistically non-significant.

## RESULTS

Out of 174 colonoscopy patients, 46 patients were excluded (44 patients not meeting the inclusion criteria and 2 patients declined to participate) and 128 were enrolled in the study. Enrolled patients were randomized in two groups as the following: Group 1 (64 patients) underwent colonoscopy using RA insufflation and Group 2 (64 patients) underwent colonoscopy using $CO_2$ insufflation, **Figure 1**. There were no statistically significant differences in the baseline demographic characteristics and laboratory investigations between the two groups including age, gender, complete blood count, INR, and viral markers for hepatitis B and C, **Table 1**. Also, there was no statistically significant difference between the studied groups regarding indications for colonoscopy, **Table 2**.

Regarding the abdominal pain after colonoscopy, there was statistically significant increase in the abdominal pain sensation in group 1 at 15-, 60-, and 180-minutes post-procedural as the following: 22 patients (34.4%) in group 1 compared to 6 patients (9.4%) in group 2 at 15 minutes (p=0.024), 28 patients (43.8%) in group 1 compared to 14 patients (21.9%) in group 2 at 60 minutes (p=0.011), and 24 patients (37.5%) in group 1 compared to 6 patients (9.4%) in group 2 at 180 minutes (p=0.017), **Figure 2**. At all-time points, the VAS score severity for pain was considered mild and none experienced severe pain in group 2. Nevertheless, the VAS score severity for pain was considered moderate to severe in 8, 10, 14 patients in group 1 at 15-, 60-, and 180-minutes, respectively. None of the patients in the two studied groups experienced abdominal pain at 24 hours post-procedural, **Table 3**. Similarly, there was statistically significant increase in the abdominal bloating at 60 minutes post-procedural in group 1 compared to group 2 (68.7% vs 18.8%, p=0.018). There was no statistically significant difference between group 1 and group 2 regarding cecal intubation time (8.2±1.4 vs 8.7±2.1, p=0.318) and total examination time (18.9±3.5 vs 19.4 ± 2.9, p=0.23). No adverse events were recorded in any patient in both groups.

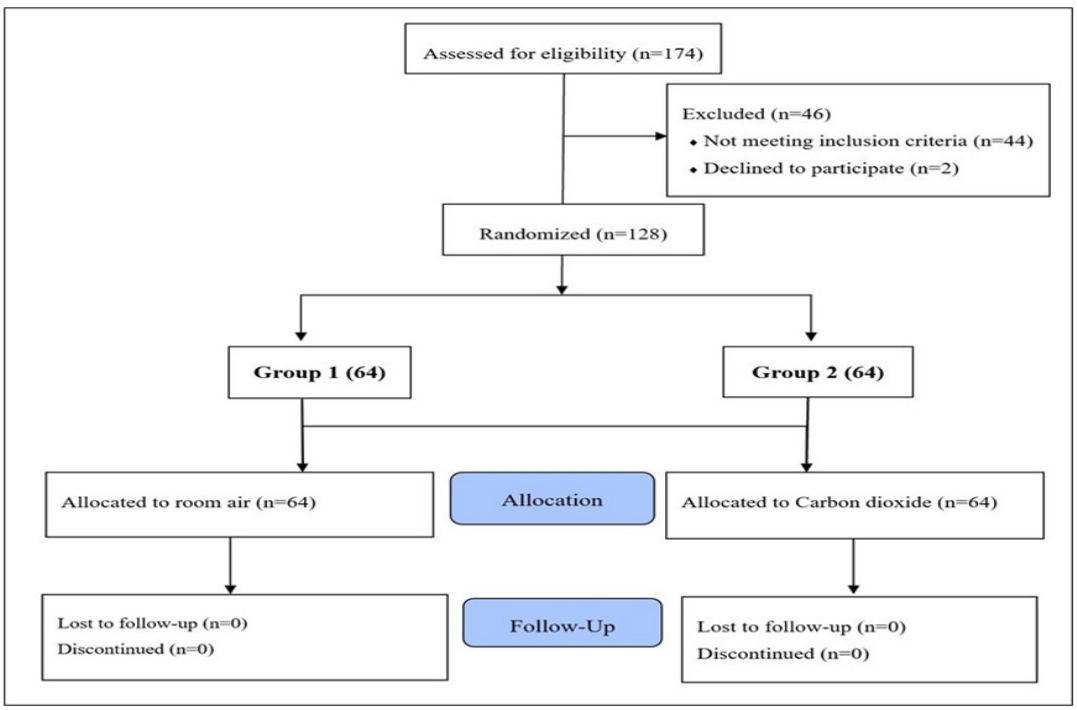


**Figure 1.** Flowchart of enrolled cases.

**Table 1.** Comparison of demographic characteristics and laboratory investigations between the studied groups.

| | Group 1 | Group2 | Test of significance |
|---|---|---|---|
| **Age/years mean±SD** | 50.29±17.69 | 48.27±16.13 | t=0.466 p=0.643 |
| **Sex N (%)** | | | |
| **Male** | 28 (43.8%) | 34 (53.1%) | x2=0.563 |
| **Female** | 36 (56.2%) | 30 (46.9%) | p=0.453 |
| **Viral serology N (%)** | | | |
| **-ve serology** | 44 (68.8%) | 46 (71.8%) | $x^2$=3.83 |
| **+ve HBV** | 2 (3.1%) | 1 (1.6%) | p=0.280 |
| **+ve HCV** | 18 (28.1%) | 17 (26.6%) | |
| **INR mean±SD** | 1.097±0.202 | 1.11±0.204 | t=0.303 p=0.763 |
| **HB (g/dl) mean±SD** | 9.90±1.99 | 9.41±2.39 | t=0.864 p=0.391 |
| **WBC ˣ$10^3$/ $mm^3$ mean±SD** | 11.0±3.21 | 9.1±5.86 | t=1.53 p=0.132 |
| **Platelet ˣ$10^3$/ $mm^3$ mean±SD** | 226.31±69.69 | 227.89±83.71 | t=0.078 p=0.938 |

t: student t test, $x^2$: Chi-Square test, SD: standard deviation, N: number, HBV: hepatitis B virus, HCV: hepatitis C virus, INR: international normalization ratio, HB: hemoglobin, WBC: white blood cells

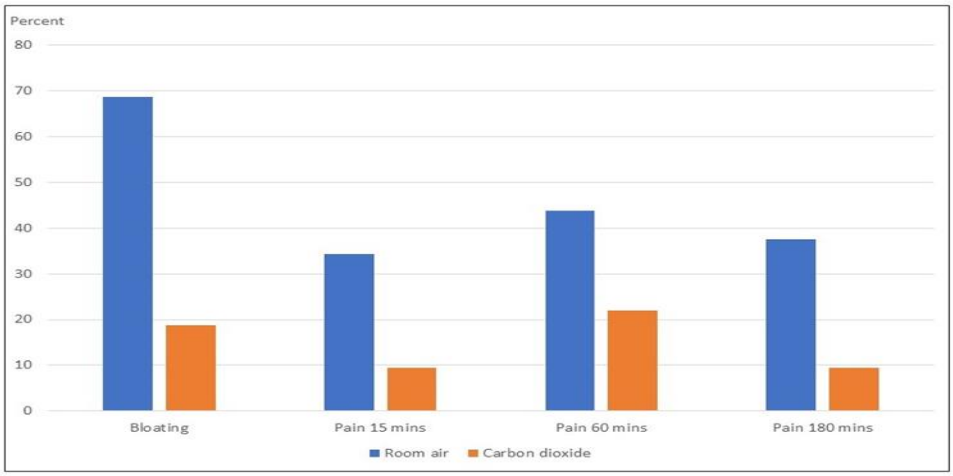


**Figure 2.** Abdominal bloating and pain percents among studied groups.

**Table 2.** Comparison of indications for colonoscopy between the studied groups.

| | Group1 | Group2 | Test of significance |
|---|---|---|---|
| **Indications of colonoscopy n (%)** | | | |
| Follow up ulcerative colitis | 8 (12.5%) | 6 (9.4%) | p=0.450 |
| Abdominal pain | 12 (18.8%) | 10 (15.6%) | p=0.790 |
| Chronic diarrhea | 10 (15.6%) | 8 (12.5%) | p=0.251 |
| Hematochezia | 8 (12.5%) | 6 (9.4%) | p=0.450 |
| Chronic constipation | 6 (9.4%) | 8 (12.5%) | p=0.536 |
| Weight loss | 6 (9.3%) | 4 (6.2%) | p=1.35 |
| Iron deficiency Anemia | 4 (6.2%) | 10 (15.6%) | p=0.732 |
| Altered bowel habit | 6 (9.4%) | 6 (9.4%) | p=1.0 |
| Before liver transplantation | 0 (0%) | 2 (3.1%) | p=0.536 |
| +ve Fecal occult blood test (FOBT) | 4 (6.2%) | 4 (6.2%) | p=1.0 |

**Table 3:** Comparison of abdominal pain, bloating, cecal intubation time and total examination time between the studied groups.

| | Group 1 | Group 2 | Test of significance |
|---|---|---|---|
| **Abdominal bloating** | | | |
| -ve | 20 (31.3%) | 52 (81.2%) | $x^2$=9.99 |
| Mild | 22 (34.4%) | 6 (9.4%) | **p=0.018** |
| Moderate | 12 (18.7%) | 4 (6.3%) | |
| Severe | 10 (15.6%) | 2 (3.1%) | |
| **Abdominal pain 15 mins** | | | |
| -ve | 42 (65.6%) | 58 (90.6%) | $x^2$=3.25 |
| Mild | 14 (21.9%) | 4 (6.3%) | **p=0.024** |
| Moderate | 6 (9.4%) | 2 (3.1%) | |
| Severe | 2 (3.1%) | 0 (0%) | |
| **Abdominal pain 60 mins** | | | |
| -ve | 36 (56.2%) | 50 (78.1%) | $x^2$=5.72 |
| Mild | 18 (28.1%) | 12 (18.8%) | **p=0.011** |
| Moderate | 6 (9.4 %) | 2 (3.1%) | |
| Severe | 4 (6.3%) | 0 (0%) | |
| **Abdominal pain 180 mins** | | | |
| -ve | 40 (62.5%) | 58 (90.6%) | $x^2$=4.15 |
| Mild | 10 (15.6%) | 4 (6.3%) | **p=0.017** |
| Moderate | 10 (15.6%) | 2(3.1%) | |
| Severe | 4 (6.3%) | 0 (0%) | |
| **Abdominal pain 24 hours** | 0 (0%) | 0 (0%) | p=1.0 |
| **Cecal intubation time (mins)** | 8.2±1.4 | 8.7±2.1 | t=1.01 p=0.318 |
| **Total examination time (mins)** | 18.9±3.5 | 19.4 ± 2.9 | t=1.15 p=0.23 |

T: STUDENT T TEST, $X^2$: CHI-SQUARE TEST, MINS: MINUTES

## DISCUSSION

A higher diagnostic yield could be associated with adequate colonic insufflation and above all, a higher adenoma detection rate. Comfort during and after colonoscopy is an important consideration issue of patient's acceptance and tolerance. More air insufflation during the recommended withdrawal time is usually associated with patient discomfort [7]. When compared to RA, $CO_2$ is absorbed into the blood stream from the intestinal lumen 150 times faster. The first use of $CO_2$ was in 1953 in electrosurgery to prevent gas explosion in the large bowel then it was used in double contrast barium enema in 1986 to minimize the risk of bowel ischemia [7]. Meanwhile, $CO_2$ was utilized for insufflation during laparoscopic surgeries for decades [8]. The initial use of $CO_2$ in colonoscopy was shown in a small study that first reported the benefit of using $CO_2$ insufflation, owing to the advantage of fast absorption that could improve adverse events related to abdominal distention, since then $CO_2$ has been widely used for different endoscopic procedures [9]. Nevertheless, a survey conducted in 2009 concluded that most of the endoscopists worldwide continue to use RA insufflation as supplied by the manufacturer owing to the challenges to implement additional equipment for $CO_2$ utilization and the absence of significant advantages of $CO_2$ over RA insufflation [10].

Multiple studies had compared $CO_2$ to RA insufflation in colonoscopy. These studies were heterogeneous in terms of patient's population, study design, and results. This could be attributed to variations in clinical practice, experience of endoscopists and the sedation approach used. Several randomized controlled trials have reported a reduction in abdominal pain sensation after colonoscopy with $CO_2$ compared to RA insufflation [11-15]. This is in line with our study that showed statistically significant increase in the abdominal pain sensation with RA compared to $CO_2$ insufflation [34.4% vs 9.4% (p=0.024), 43.8% vs 21.9% (p=0.011), and 37.5% vs 9.4%, (p=0.017)] at 15-, 60-, and 180-minutes post-procedural, respectively. At all-time points, the VAS score severity for pain was considered mild and none experienced severe pain with $CO_2$ insufflation. Also, we observed increase in the VAS score from 15 to 60 minutes in both groups which could be explained by the diminished effect of the sedative after 60 minutes. These results are in match with previously published meta-analyses that favours $CO_2$ to RA insufflation for colonoscopy [2, 16-19]. In contrast, several studies showed that $CO_2$ have no advantages over RA insufflation [5, 6, 20].

In our study, there was statistically significant increase in the abdominal bloating at 60 minutes post-procedural with RA compared to $CO_2$ insufflation (68.7% versus 18.8%, p=0.018). This was also reflected in other studies that used different methods for assessment of bloating. Similar to our study, questionnaires with different scales of points were used to assess bloating in some studies [7]. Others used abdominal radiography to measure distension of the intestinal lumen and they reported that nearly three-quarters of patients who underwent RA insufflation had a colon diameter greater than 6 cm one hour post procedure, compared to 4% of patients with $CO_2$ insufflation [21]. In pediatric population, measuring abdominal circumference can used to assess bloating and bowel distension. However, this was reported in a pediatric study to be inaccurate method for assessment of over distended bowel [22]. The correlation between the duration of colonoscopy and the post-procedural abdominal pain and bloating was not assessed in our study as there was no statistically significant difference between RA and $CO_2$ insufflation regarding cecal intubation time (8.2±1.4 vs 8.7±2.1, p=0.318) and total examination time (18.9±3.5 vs 19.4 ± 2.9, p=0.23). However, prolonged duration of total examination due to technical difficulties or inexperience of the endoscopist was positively correlated with the severity of post-procedural abdominal pain in another study [23].

There were several limitations in our study. First, this was a single center study with relatively small sample size. Second, midazolam was used as a sedative in all patients which have analgesic effect that could affect the perception of pain after colonoscopy. Finally, we did not record the pathological findings in colonoscopy as polyps or severe inflammation which could play role in the pain perception after colonoscopy.

## CONCLUSION

In conclusion, $CO_2$ insufflation is associated with significantly less abdominal pain and bloating after diagnostic colonoscopy compared to RA insufflation. Further studies are needed to verify the influence of $CO_2$ on pain perception after colonoscopy and to widely implement $CO_2$ in clinical practice.

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**Conflict of Interest:** None.

**Ethical approval: IRB:** MS.21.05.1514 (approval date: 8/7/2021)

**Availability of data and materials:**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### HIGHLIGHTS

- Abdominal pain and bloating sensations can occur after colonoscopy.
- A faster rate of absorption with Carbon dioxide ($CO_2$) is expected to reduce abdominal pain and bloating.
- $CO_2$ insufflation is associated with significantly less abdominal pain and bloating after diagnostic colonoscopy compared to RA insufflation.

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