Clinical Study
Carbon Dioxide Insufflation in Colonoscopy Is Safe: A Prospective Trial of 347 Patients

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Available evidence suggests that the use of CO2 insufflation in endoscopy is more comfortable for the patient. The safety of CO2 use in colonoscopy remains contentious, particularly in sedated patients. The objective of the present prospective trial was to assess the safety of CO2 colonoscopies.

Methods. 109 patients from our previous randomized CO2 colonoscopy study and an additional 238 subsequent consecutive unselected patients who had a routine colonoscopy performed in a private practice were enrolled from April 2008 through September 2008. All but 2 patients were sedated. All patients were routinely monitored with transcutaneous CO2 measurement. Volumes of CO2 administered were correlated with capnographic measurements from transcutaneous monitoring.

Results. Of the 347 patients examined, 57% were women; mean (SD) age of participants was 60.2 years (12.8). Mean propofol dosage was 136 mg (64 mg). Mean CO2 values were 34.7 mm Hg (5.3) at baseline, 38.9 mm Hg (5.5) upon reaching the ileum, and 36.9 mm Hg (5.0) at examination's end. Mean maximum increase of CO2 was 4.5 mm Hg (3.6). No correlation was observed between volume of CO2 administered and increase in level of CO2 (correlation coefficient: 0.01; P value: 0.84). No complications were observed.

Conclusions. The present prospective study, which was based on one of the largest sedated patient sample reported to date in this setting, provides compelling evidence that CO2 insufflation in colonoscopy is safe and unassociated with relevant increases in transcutaneously measured levels of CO2.

1. Background
For almost 2 decades, CO2 insufflation with carbon dioxide (CO2) has been widely used in laparoscopic surgery. In contrast, insufflation with room air has remained the standard of care in the vast majority of endoscopy centers in both Europe and North America. Unfortunately, many patients still experience pain and discomfort after colonoscopy with room air insufflation. Studies [1–5] and one review [6] indicate that insufflation with CO2 can reduce periprocedural pain in different endoscopic settings (e.g., endoscopic retrograde cholangio-pancreatography [7], balloon enteroscopy [8], and endoscopic submucosal dissection [9]). However, in the setting of colonoscopy, current scientific data with regard to the safety of CO2 insufflation are limited. Small patient populations have characterized most studies, including those with sedated patients, and many physicians remain concerned that CO2 insufflation might lead to CO2 retention. In a previous randomized, controlled, double-blinded trial, we randomly allocated 219 patients to colonoscopy with CO2 versus room air, patients in the CO2 group experienced significantly less pain and bloating and a higher overall satisfaction score [10]. However, this study was not designed to definitively demonstrate the safety of CO2 insufflation in colonoscopy. In the present study, we sought to prospectively assess the safety of CO2 colonoscopy in a larger sample of patients.

2. Patients and Methods
This trial included all 109 patients from our previous CO2 colonoscopy study [10] plus 238 subsequent, consecutive,
nonselected, patients who had a routine colonoscopy performed in a private Swiss gastroenterology practice and were enrolled from April 2008 through September 2008. All patients who were deemed medically fit for an ambulatory colonoscopy were included in this study. In order to maximize the generalizability (external validity) of our study, we did not initially apply exclusion criteria, although one exclusion criterion emerged (due to a small earlap, CO2 measurement was not possible in 4 patients, which were excluded). All colonoscopies were done by the first author (M. G.) and carried out with standard Pentax endoscopes (EC-3885K and EC-380FKp) (Pentax Medical, Pentax of America, Inc., Montvale, NJ, USA) with an EPK 1000 processor. For CO2 insufflation, the CO2-Efficient Insufflator device (EZEM Company, Westbury, NY, USA) was used. The insufflator was connected to a 10-litre CO2 bottle and supplied over a tubing set connected with a branch connection to the water bottle tube, which was itself directly connected to the endoscope. The flow rate (basal flow rate 0.5 L/min, increasing to 3 L/min maximum) can be controlled on demand over the standard air valve. Oxygen was delivered to patients if the saturation dropped below 90% at a flow rate of 4 liters per minute. All but 2 patients were sedated with propofol using standard procedures previously described [11]. The total dose of propofol was registered for later analysis. A level of conscious sedation (“moderate sedation”) was targeted. All patients were routinely monitored with transcutaneous CO2 measurement on the ear, with the exception of those patients who were excluded due to insufficient earlap (n = 4). CO2 measurement was performed with the SenTec capnograph (SenTec AG, 4106 Thun, Switzerland) as described by Heuss et al. [12]. Our measurement technique followed that recommended by SenTec; internal validation was not performed as the system has been previously extensively validated [12–14]. Sensors were calibrated according to the first and second samples). None of the patients required ventilation or mechanical airway support, and no other complications (bleeding, perforation, loss of consciousness, hospital admission) were observed.

### 4. Discussion

The present prospective study, which was based on one of the largest sample of sedated patients to date, provides compelling evidence that CO2 insufflation colonoscopy is safe and is not associated with an increase in transcutaneously measured CO2 or with adverse respiratory effects. Our findings add to mounting scientific evidence demonstrating the safety and superiority of CO2 colonoscopy over room air [6, 10]. Given these findings, we believe that CO2 colonoscopy should be considered the procedure of choice.

### Table 1: Results (mean ± SD)1.

<table>
<thead>
<tr>
<th></th>
<th>1st sample (n = 109)</th>
<th>2nd sample (n = 238)</th>
<th>All (n = 347)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, female</td>
<td>62%</td>
<td>55%</td>
<td>57%</td>
</tr>
<tr>
<td>Propofol (mg)</td>
<td>134 ± 56</td>
<td>137 ± 68</td>
<td>136 ± 64</td>
</tr>
<tr>
<td>CO2 start (mm Hg)</td>
<td>33.4 ± 4.7</td>
<td>35.4 ± 5.4</td>
<td>34.7 ± 5.3</td>
</tr>
<tr>
<td>CO2 ileum (mm Hg)</td>
<td>37.3 ± 5.2</td>
<td>39.6 ± 5.5</td>
<td>38.9 ± 5.5</td>
</tr>
<tr>
<td>CO2 end (mm Hg)</td>
<td>35.2 ± 4.3</td>
<td>37.7 ± 5.1</td>
<td>36.9 ± 5.0</td>
</tr>
<tr>
<td>Amount CO2 (L)</td>
<td>51 ± 14</td>
<td>47 ± 15</td>
<td>48 ± 15</td>
</tr>
</tbody>
</table>

1 All P values > 0.05.
Although CO₂ insufflation has been used for different endoscopic procedures [1–9] and was found to be associated with less postprocedural pain and bloating [10, 15], most endoscopy units continue to use room air for screening colonoscopies and are unaware of the benefits of this relatively new technique [16].

In our first double-blinded randomized study—hitherto the largest reported sample of sedated and CO₂ monitored patients—239 patients were randomly allocated in a 1:1 ratio to colonoscopy with CO₂ versus room air. This study, which represented the first examination of sedated, unselected, and consecutive patients in this setting, yielded encouraging results: no difference in transcutaneous CO₂ values was observed with continuous capnography between groups, and there was no evidence of advanced hypercapnia as a possible problem with this technique [10]. However, we felt that this initial experience from our group needed to be confirmed in a study with larger sample size. By incorporating patients randomized to CO₂ insufflation in that previous study and an additional 238 consecutive patients, we achieved an even larger patient population, providing compelling evidence for the safety of CO₂ insufflation in sedated and monitored patients undergoing colonoscopy. Only 4 patients experienced a partial pressure of CO₂ in excess of 50 mm Hg (max. paCO₂ 52.8 mm Hg).

Our study shows that sedated patients had a small increase in CO₂ during colonoscopy until the terminal ileum was reached, after which CO₂ levels fell. We speculate from these observations that sedation per se, but not CO₂ insufflation in particular, appears to be the primary cause of the observed CO₂ increase during colonoscopy.

Many patients with severe chronic obstructive pulmonary disease (COPD) experience CO₂ retention, an inherent phenomenon of this disease. Until now, no studies have been performed to assess whether CO₂ is also safe to use in this high-risk population. But although COPD patients included in our study suffered no relevant adverse outcomes, they constituted only a small percentage of the study population and larger studies of CO₂ insufflation in patients with COPD should be performed to confirm its safety in this subset of patients.

A particularly noteworthy finding of this study is the lack of correlation between volume of insufflated CO₂ and the increase of CO₂ as measured by transcutaneous monitoring. Because CO₂ is very quickly exhaled, paCO₂ never reached clinically toxic value. It might be influenced more by individual factors not yet fully understood than by the amount of insufflated CO₂.
Because CO$_2$ is absorbed into the bloodstream 150 times faster than room air and also exhaled with an elimination of 0.2 L per minute [17], higher volumes of gas (e.g., 51 L) are usually needed when using CO$_2$ for colonoscopy insufflation, compared with room air [18]. Some physicians who are already using CO$_2$ insufflation for colonoscopy believe that briefly switching from CO$_2$ to room air to obtain a faster and better colonic distension can be useful in certain circumstances. This may be due to the fact that the flow rates of all commercial available CO$_2$ insufflators are still below the usual rates achieved with air insufflators.

From a practical point of view, there are no clinically relevant problems in handling CO$_2$ insufflation with modern insufflators; further, we believe that no safety concerns remain in patients devoid of COPD.

5. Conclusion

The present prospective study, which was based on one of the largest sedated patient sample reported to date, provides compelling evidence that colonoscopy with CO$_2$ insufflation is safe in patients devoid of COPD. Neither a relevant increase in transcutaneously measured CO$_2$ nor adverse respiratory effects were detected.

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References

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