Purpose: To determine if carbon dioxide (CO₂) is a better alternative to room air (RA) for colonic insufflation due to its rapid absorption, vasodilating effects and lack of combustibility.

Background: Dr. Brandt and colleagues were interested in the rapid absorption and clearance of CO₂, particularly for use in patients with suspected colon ischemia who were to be colonoscoped. They posited that diminishing the duration of colon distention might help minimize reductions in colon blood flow resulting from the distention. The known vasodilating effect of CO₂ in many vascular beds provided an additional incentive for the group to study the response of colon blood flow to intraluminal insufflation with CO₂.

Materials and Methods: Inferior mesenteric artery blood flow in greyhound dogs was measured before, during and after insufflation of the colon with RA and CO₂ under conditions of transient and constant elevations of intraluminal pressures. In addition to our own research, we reviewed other published studies comparing CO₂ insufflation with that of RA.

Conclusion: In our study, intraluminal pressures remained elevated for briefer periods after CO₂ administration, and blood flow was far less compromised, than with RA. Based upon these results and the evaluation of several other published studies comparing CO₂ insufflation with that of RA, we concluded that CO₂ is the preferred agent for colonic insufflation. In addition, an automated insufflation system has several advantages over a manual technique and should be the preferred method of administration.

Introduction
Most physicians do not critically evaluate their use of RA to insufflate the GI tract during endoscopic procedures yet, many of them have also been faced with a patient who after endoscopy (usually colonoscopy) complains of abdominal pain and distention, sometimes for days after the procedure. CO₂ is an attractive alternative insufflation agent compared with RA because its rapid absorption leads to a more comfortable recovery.

Room air is a mixture of gases (78% nitrogen, 20% oxygen, and trace amounts of other gases). The presence of oxygen makes it potentially explosive. Use of CO₂ as an insufflating agent was first suggested to minimize the risk of explosion with electrosurgical polypectomy. Colonic explosions, although rare, are still reported and recently have been documented during argon plasma coagulation of adenomas and radiation proctitis. The greater safety of CO₂ is based primarily upon its inability to support combustion, in contrast to RA in which the O₂ content allows such a reaction. But, CO₂ also serves to reduce the concentrations of the other bacterially-derived combustible gases in the lower bowel, including hydrogen, methane, ammonia and hydrogen sulfide, which might accompany poor preparation for the procedure. The presence of any stool in the colon, including stool in the right colon when electrical current is used in the left colon or rectum, constitutes a potential danger for explosion.
Advantages of Carbon Dioxide

Carbon dioxide is absorbed 150x faster than nitrogen and is promptly eliminated via the lungs.\(^3\) It, therefore, results in a more comfortable examination and its use has been recommended not only for colonoscopy but also for double-contrast barium enema examinations.\(^4-5\) In 1984, Hussein and colleagues reported that with CO\(_2\) insufflation during colonoscopy, there was no significant residual gas on plain films taken 30 minutes after the procedure. In contrast, patients examined after RA insufflation showed excessive distention of the small and large bowel.\(^6\) It is surprising how much gas actually is instilled into the colon during colonoscopy. In a study by Bretthauer et al, insufflation of ~8.2 liters with a range of 1.2-19.8 liters was documented during routine colonoscopy.\(^6\)

Another advantage of the rapid absorption of CO\(_2\) is the lack of need to aspirate gas upon withdrawal. This may result in a decrease in miss-rate of polyps that otherwise might have been obscured behind a collapsed fold.

Study Results: Carbon Dioxide vs. Room Air

The rapid absorption and clearance of CO\(_2\) seemed particularly advantageous in patients with suspected colon ischemia who were to be colonoscoped. We postulated that by diminishing the duration of colon distention, any reduction in colon blood flow resulting from the distention would be minimized. Previous studies had shown that distention of the bowel and elevation of intraluminal pressure >30 mmHg diminished intestine/colon blood flow (Figure 1), and it was known that such intraluminal pressures may be generated during colonoscopy.\(^7-8\)

The known vasodilating effect of CO\(_2\) in many vascular beds provided an additional incentive for the group to study the response of colon blood flow to intraluminal insufflation with this agent.\(^9-10\)

In our study, inferior mesenteric artery blood flow in greyhound dogs was measured before, during and after insufflation of the colon with RA and CO\(_2\) under conditions of transient and constant elevations of intraluminal pressures.\(^11\) Intraluminal pressures remained elevated for briefer periods after CO\(_2\) administration and blood flow was far less compromised than with RA. Baseline pressure was reached >30 minutes after transient elevation of intraluminal pressure to 35 mmHg with RA, and blood flow was reduced for the entire period of observation (Figure 2). When CO\(_2\) was used to reach the same levels of intraluminal pressure, blood flow was increased above control values and baseline pressure was attained in <10 minutes (Figure 3). At somewhat higher levels of transient (40 mmHg) and constant (60-70 mmHg) intraluminal pressure elevation, colonic blood flow actually increased. At a constant intraluminal pressure of 65 mmHg maintained with CO\(_2\) and with RA, blood flow stabilized at 179% and 68% respectively, of control values (Figure 4).

CO\(_2\) also shifts the oxyhemoglobin dissociation curve to yield a higher pO\(_2\) for any given fractional saturation.\(^12\) Such rheologic benefits of CO\(_2\) are especially important when colonoscopying anyone with colon ischemia and may be of great value in older patients predisposed to colonic ischemia.
Literature Review

In a study by Sumanac and colleagues, using a commercially available CO₂ delivery system, the effects of CO₂ and RA insufflation on residual bowel gas and post-procedural pain were compared in 97 patients (Figure 5).¹³ Both parameters were less in the CO₂ group at 1 and 6 hours. Seventy-one percent of patients given RA had colon distention >6 cm compared with only 4% in the CO₂ group. Ninety-four percent of patients insufflated with CO₂ had minimal residual gas compared with 2% in subjects given RA. Of patients insufflated with RA, 45% and 31% had pain at 1 and 6 hours respectively, whereas 7% and 9% of those in whom CO₂ was used had pain at the same time periods.

In a study by Bretthauer et al, no rise in end-tidal pCO₂, a non-invasive parameter of arterial pCO₂, was observed in routinely unsedated patients who were given CO₂, although patients with severe heart or lung disease were excluded from the study (Figure 6).¹⁴ Patients in the CO₂ group also had significantly less pain for up to 6 hours after the procedure, as evaluated by a visual analog scale (Figure 7). In a follow-up study, Bretthauer and colleagues showed that CO₂ insufflation is also safe in sedated patients without significant difference between patients in whom RA or CO₂ was used.¹⁵

Carbon Dioxide Administration

Carbon dioxide itself is fairly inexpensive. A 1350-liter tank costs about $10-20 and can be used for ~675 minutes of procedure time. There are two methods of insufflation; manual and automated. The manual method involves using a simple regulatory connection at a minimal cost. Some disadvantages to this method are that the system must be assembled on site, requires close monitoring and lacks certain safety and gas-saving features. In addition, pressures must be set by hand. The CO₂EFFICIENT® endoscopic insufflator is a fully automated system that offers several advantages over manual insufflation. Carbon dioxide volumes are digitally displayed. The system features two flow modes and redundant pressure relief valves to protect against over-inflation. In our experience, the CO₂EFFICIENT insufflator is simple to use and potentially safer than the manual system.

Conclusion

Carbon dioxide offers several advantages over room air, including; lack of combustibility, rapid absorption and vasodilating effects. These benefits help to ensure a more comfortable examination for the patient. Because CO₂ is rapidly absorbed, there is no need to aspirate gas upon withdrawal. The CO₂EFFICIENT® endoscopic insufflator is a fully automated system that has benefits over a manual system due to its many safety features and ease-of-use.
References:
1. Rogers BHG. Gastrointest Endos 1974; 20:115-117.