Painless Colonoscopy: Water Immersion, Novel Colonoscopies, and Others

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Introduction

Careful inspection is important in detecting precancerous lesions during a colonoscopy. Adequate bowel preparation and appropriate luminal distention are essential steps for such inspections, allowing visualization of the entire colonic mucosa, and to make a qualified colonoscopy, defined as an adenoma detection rate ≥ 25%. Overall insufflated air volume during a colonoscopy is typically 818 L. However, air insufflation (AI) can cause pain and discomfort, especially when the scope is passed through the sigmoid or transverse colon. To date, several methods to avoid painful colonoscopy have been introduced, and new robotic methods, although not widely used yet, have also been introduced. This topic is described focusing on various techniques for painless colonoscopy, including gaseous methods, water immersion methods, and others.

Carbon dioxide (CO2) insufflation

The mechanism of CO2 gas, which is advantageous over room air in terms of pain during colonoscopy, is rapid absorption across the intestine. According to early evidence, CO2 is absorbed across the intestines 160 times more rapidly than nitrogen and 13 times faster than oxygen. The first use of this method, with CO2, in endoscopic procedures was in colonoscopy. In 1984, Hussein et al. compared postprocedure discomfort between a CO2 insufflation group and an air insufflation group during colonoscopy procedures. The CO2 insufflation group showed no significant residual abdominal gas on plain radiographs 30 min after the colonoscopy and much less discomfort than the AI group, which showed large amounts of gas on radiographs. Since these data were reported, more than 20 randomized controlled trials (RCTs) on the effectiveness of CO2 versus AI have been published. Moreover, three metaanalyses and one systematic review based on previous RCTs have recently provided useful information on clinical outcomes of CO2 gas in colonoscopy practice. According to the latest meta-analysis, based on 24 RCTs, and previous meta-analyses and a systematic review, CO2 gas insufflation is significantly superior to AI in terms of intraprocedural pain and discomfort. Procedure-related pain was compared as early postprocedural pain at 2 h after the colonoscopy, intermediate pain at 6 h after the colonoscopy, and late pain at 24 h after the colonoscopy. CO2 insufflation was also superior to AI at all times for postprocedural pain and flatus.
In colonoscopy performance, CO2 insufflation did not show an improvement in cecal intubation time or rate compared with AI.\(^8\) Regarding safety, end-tidal CO2 (ETCO2) levels during and after the procedure were not significantly different between the CO2 and AI groups.\(^6\) Sedation during colonoscopy also did not affect the ETCO2 level in the CO2 and air groups.\(^9\) Beyond the ETCO2 level, adverse events related with the CO2 insufflation during colonoscopy have not been reported, or showed no difference compared with conventional air-insufflated colonoscopy.\(^8\)

Evidence for CO2 insufflation colonoscopy in high-risk groups, including chronic obstructive pulmonary disease, severe cardiac disease, sleep apnea, and morbid obesity, is still very limited and, thus, caution should be exercised in using CO2 insufflation during colonoscopy in these groups. Regarding the problem of exposure to CO2 during colonoscopy, recent evidence showed that there was no difference in pain levels, intraprocedure or postprocedure, between a scope extubation-only CO2 insufflation group and a whole-procedure CO2 insufflation group, and so not-whole-procedure CO2 insufflation but only extubation CO2 insufflation can be useful to decrease postprocedural discomfort and pain.\(^\text{10}\) Although CO2 exposure can be decreased during colonoscopy by following this study’s procedure, the study also had several limitations, such as the small number of enrolled cases and the fact that a colonoscopy expert performed the procedure. In conclusion, CO2 insufflation during colonoscopy can decrease the symptoms of abdominal pain and discomfort during and after colonoscopy, but is more effective in reducing postprocedural pain, not real-time insertion pain. Thus, CO2 insufflation could be helpful, even in sedative procedures for decreasing postprocedural pain, after the sedative effect wears off. However, there was no impact on procedure quality, including cecal intubation and procedure time. Although CO2 insufflation did not increase procedure-related complications or ETCO2 levels, there is very limited evidence of CO2 use in high-risk patient groups. CO2 insufflation, instead of room air, can be used routinely for colonoscopy in patients without specific risks.

**Water-assisted colonoscopy**

Water-assisted colonoscopy was first reported in 1984 as a water immersion (WI) method, which facilitated passage through the sigmoid colon with diverticulosis.\(^11\) In the method, water was infused while minimizing AI during intubation to facilitate scope passage. The basic concept of water immersion is that water is used instead of gas to distend the colon to visualize the way forward during intubation. A lumen distended with water appears to be minimally distended and reduces angulation, compared with AI. Air pockets encountered during scope insertion can also be suctioned with sufficient water infusion. After the scope reaches the cecum, suction removal of water is performed during the withdrawal phase of the colonoscopy, allowing inspection of the mucosa. However, the method has varied in the previous literature. Since WI was introduced in the 1980s, several later studies reported advantages and methodologies of WI, such as speeding up intubation and providing warm water instillation to counter colonic spasm.\(^12,13\) In retrospective studies, WI showed a higher cecal intubation rate than the air method and similar pain scores between the sedative group and the non-sedative group, suggesting the possibility of WI as a pain-reducing technique without sedation.\(^14,15\) Several later RCTs comparing pain scores between WI and AI with minimal sedation have been reported. Beyond comparing pain scores, most studies evaluated the impact on colonoscopy procedures, including cecal intubation and the adenoma detection rate. Although most published RCTs about WI showed reduced pain during colonoscopy, WI
could be interfered with if the bowel preparation was inadequate. The water exchange (WE) method, modified from WI, was developed by Leung as the least painful colonoscopy procedure for use in scheduled unsedated colonoscopy. The WE method involves continuous water infusion, with continued suction of residual feces and air to clear the view, with no AI. Maintaining suction and water infusion had a clinical impact, clearing the view of residual feces and enhancing the adenoma detection rate. Suctioning dirty water and replacing clean water during insertion is time-consuming. Although WE has major limitations in terms of time, with water exchange during insertion, and a learning curve, WE is superior to WI in painless colonoscopy, based on a limited number of RCTs, and the adenoma detection rate. A meta-analysis and systematic review, focused on comparing AI and water-aided methods, including WI and WE, in terms of pain score, adenoma detection rate, and requirements for sedation, showed the superiority of both WI and WE over AI regarding procedure pain. Recently, several trials have compared water-aided colonoscopy with CO₂ insufflation, and head-to-head comparisons of WI, WE, and CO₂. Compared with AI and CO₂, WI and WE reduced colonoscopy insertion pain markedly, and WE was the least painful among the techniques.

Robotic colonoscopy

Recent advances in robotic colonoscopies can also overcome insertion pain as compared to conventional colonoscopy. Several robotic colonoscopy systems have now been introduced with limited human studies. These systems generate internal forces and need no or minimal external pushing actions, which helps to limit discomfort and pain during insertion of the scope. Although presently the evidence is very limited, some reports of robotic techniques have shown pain reduction in the procedures.

1. Endotics (ERA endoscopy)

The Endotics system consists of a sterile, disposable probe (E-Worm) and a workstation. The probe has a head, a steerable tip, a flexible body, and a thin tail. The workstation allows the endoscopist to control the disposable probe using a hand-held console. The operator can steer the probe head in any direction, elongate the probe body to move it forward, and control rinsing, insufflation, and suction. Small-scale studies have been reported with Endotics, showing superiority in pain reduction versus conventional colonoscopy, but they had prolonged insertion times and a relatively low cecal intubation rate that need to be overcome with further investigations.

2. NES (NeoGuide System)

The NES system is similar to a conventional endoscope connected to a PC workstation. The system was designed to traverse the natural shape of the colon, based on a computerized map, so that less pressure is needed, and it can reduce the incidence of looping significantly. Only one clinical trial has been reported on the feasibility of the NES system, showing a high success rate of cecal intubation but still a high looping incidence (40%), and there has been no further trial.

3. Invendoscope

The Invendoscope is a single-use, hand-held controlled colonoscope, with a 10-mm inner sheath. This dis-
posable device is similar to conventional endoscopes, allowing for insufflation, rinsing, and suction with a 3.1-mm working channel. Insertion and withdrawal of the colonoscope is controlled by a hand-held control unit. According to the reported evidence, the Invendoscope showed a low pain/discomfort score.  

Conclusions

The CO₂ insufflation method is used widely during colonoscopy, including therapeutic procedures. Previous RCTs have shown that CO₂ gas is a good option for reducing pain and discomfort during and postprocedure. However, a recent meta-analysis showed CO₂ insufflation was more beneficial in reducing postprocedure pain rather than pain during the procedure. There is still limited evidence for the use of CO₂ insufflation in high-risk patients regarding safety for CO₂ exposure.

WI, and the recently modified WE method, are good options for reducing intra- and postprocedural pain and discomfort compared with AI and CO₂ insufflation. Moreover, there is no limitation, in terms of safety, in using either technique. Regarding the effectiveness of colonoscopy, including quality and pain reduction, WE is the best modality to reduce patient discomfort and enhance the adenoma detection rate, although the WE procedure itself is time-consuming and needs a learning period.

Several robotic colonoscopies have shown favorable results in reducing procedure-related pain and discomfort. They have not yet been widely adopted and have very limited supporting evidence.

References