REVIEW
Clin Endosc 2016;49:444-448
http://dx.doi.org/10.5946/ce.2016.132
Print ISSN 2234-2400 • On-line ISSN 2234-2443

CLINICAL ENDOSCOPY

Open Access

Painless Colonoscopy: Available Techniques and Instruments

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During colonoscopy, air insufflation to distend the lumen and facilitate careful inspection and scope insertion can induce pain and cause discomfort. Carbon dioxide (CO_2) insufflation can decrease abdominal pain and discomfort during and after colonoscopy. The advantage of CO_2 insufflation is the rapid absorption of the gas across the intestine. Another painless option is water-assisted colonoscopy. Two methods for water-assisted colonoscopy are available: water immersion and water exchange. In a recent direct comparison, the water exchange method was superior to water immersion, CO_2 insufflation, and air insufflation with respect to pain during colonoscopy, although it still had the disadvantage of being a time-consuming procedure. Cap-assisted colonoscopy is a simple technique involving the use of a small transparent cap attached to the tip of the scope. Three studies showed an advantage of this technique in terms of reduced patient discomfort compared with the conventional method. Three robotic colonoscopy systems (Endotics System [Era Endoscopy], NeoGuide [NeoGuide Systems Inc.], and Invendoscope [Invendo Medical]) have been introduced to evaluate pain reduction during colonoscopy, but none has been widely adopted and used in practice. In this review, clinical trials of several techniques and new devices for painless colonoscopy are described and summarized. **Clin Endosc 2016;49:444-448**

Key Words: Colonoscopy; CO_2 insufflation; Water-assisted colonoscopy

INTRODUCTION

Careful inspection is important in detecting precancerous lesions during colonoscopy. Adequate bowel preparation and appropriate luminal distention are essential for inspection, allowing visualization of the entire colonic mucosa, and performance of adequate colonoscopy, defined as an adenoma detection rate ≥25%.[1] Total insufflated air volume during colonoscopy is typically 8 to 18 L.[2] However, air insufflation (AI) can cause pain and discomfort, especially when the scope is passed through the sigmoid or transverse colon. Several methods to avoid painful colonoscopy have been introduced, and new robotic methods, although not widely used, have also been introduced. This review describes various techniques for painless colonoscopy, including gaseous methods, water-immersion methods, and others.

Received: September 6, 2016 **Revised:** September 19, 2016
Accepted: September 19, 2016

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CARBON DIOXIDE INSUFFLATION

Carbon dioxide (CO_2) gas causes less pain than room air during colonoscopy. CO_2 is absorbed across the intestine 160 times more rapidly than nitrogen and 13 times faster than oxygen.[3] The first use of CO_2 insufflation in endoscopic procedures was in colonoscopy. In a 1984 report, Hussein et al.[4] compared postcolonoscopy discomfort in a CO_2 insufflation group and an AI group. The CO_2 insufflation group showed no significant residual abdominal gas on plain radiographs 30 minutes after 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 CO_2 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 CO_2 gas

in colonoscopy practice.[5-8] According to the latest meta-analysis, based on 24 RCTs, and previous meta-analyses and a systematic review, CO_2 gas insufflation is significantly superior to AI in terms of intraprocedural pain and discomfort.[8] Early postprocedural pain at 2 hours after colonoscopy, intermediate pain at 6 hours after colonoscopy, and late pain at 24 hours after colonoscopy were compared, and CO_2 insufflation was superior to AI at all times for reducing postprocedural pain and flatus.[6]

In colonoscopy performance, CO_2 insufflation did not show an improvement in cecal intubation time or rate compared with AI.[8] Regarding safety, end-tidal CO_2 ($ETCO_2$) levels during and after the procedure were not significantly different between the CO_2 and AI groups.[6] Sedation during colonoscopy also did not affect the $ETCO_2$ level in the CO_2 and AI groups.[9] Other than the $ETCO_2$ level, adverse events related to CO_2 insufflation during colonoscopy have not been reported, or showed no difference compared with conventional AI colonoscopy.[8]

Evidence for the safety of CO_2 insufflation colonoscopy in high-risk conditions, including chronic obstructive pulmonary disease, severe cardiac disease, sleep apnea, and morbid obesity, is still very limited, and caution should be exercised in using CO_2 insufflation during in these groups. Regarding exposure to CO_2 during colonoscopy, recent evidence showed that there was no difference in intraprocedural or postprocedural pain levels between a scope extubation-only CO_2 insufflation group and a whole-procedure CO_2 insufflation group; thus, both partial-procedure CO_2 insufflation and extubation-only CO_2 insufflation can be used to decrease postprocedural discomfort and pain.[10] Although CO_2 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 procedures. In conclusion, CO_2 insufflation during colonoscopy can decrease the symptoms of abdominal pain and discomfort during and after colonoscopy, but is more effective in reducing postprocedural pain than real-time insertion pain. Thus, CO_2 insufflation can even be helpful for decreasing postprocedural pain in sedated procedures, after the sedative effect wears off. Moreover, there was no impact on procedure quality, including cecal intubation and procedure time. Although CO_2 insufflation did not increase procedure-related complications or $ETCO_2$ levels, there is very limited evidence for safety of CO_2 use in high-risk patient groups. Thus, CO_2 insufflation, instead of room air, can be used routinely for colonoscopy in patients without specific risk factors.

WATER-ASSISTED COLONOSCOPY

Water-assisted colonoscopy was first reported in 1984 as a water immersion (WI) method, which facilitated passage through a sigmoid colon with diverticulosis.[11] In this method, water was infused while minimizing AI during intubation to facilitate scope passage. The basic concept of WI 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 angulation is reduced compared to that with AI. Air pockets encountered during scope insertion can also be suctioned with sufficient

Table 1. Comparison of Water Assisted Method and Air Insufflation Method Regarding Pain Reduction

Study	Number	Sedation	Pain score reduction (WI–AI)	*p*-value
WI method				
Brocchi et al. (2008)[18]	170	None	–1.7	0.001
Park et al. (2010)[19]	39	None	–0.2	0.894
Leung et al. (2010)[20]	114	Minimal	–1.2	0.001
Hsieh et al. (2011)[21]	90	Minimal	–0.9	0.021
Hsieh et al. (2011)[22]	51	Minimal	–1.4	0.004
Radaelli et al. (2010)[23]	114	On-demand	–1.1	0.001
Pohl et al. (2011)[16]	58	On-demand	–1.9	<0.05
WE method				
Leung et al. (2009)[24]	28	Minimal	–2.8	0.0002
Leung et al. (2010)[25]	40	None	–3	0.002
Leung et al. (2011)[26]	50	On-demand	–2.6	0.012
Cadoni et al. (2015)[17]	209	On-demand	–2.9	<0.0005

WI, water immersion; AI, air insufflation; WE, water exchange.

water infusion. After the scope reaches the cecum, suction removal of water is performed during the withdrawal phase of colonoscopy, allowing inspection of the mucosa. However, the method has varied in the literature. Since WI was introduced in the 1980s, several later studies reported advantages and methodologies, 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 sedated and unsedated groups, suggesting the possibility of WI as a pain-reducing technique without sedation.[14,15] Several later RCTs comparing pain scores for WI and AI with minimal sedation have been reported (Table 1).[16-26] Beyond comparing pain scores, most studies evaluated the impact on colonoscopy procedures, including cecal intubation and the adenoma detection rate. Although most published RCTs showed reduced pain during colonoscopy, WI could be affected if the bowel preparation was inadequate.[16] The water exchange (WE) method, modified from WI, was developed by Leung et al.[27] as the least painful, scheduled unsedated colonoscopy procedure. The WE method involves continuous water infusion and suction of residual feces and air to clear the view, with no AI. Maintaining suction and water infusion cleared the view of residual feces and enhanced the adenoma detection rate, but suctioning dirty water and replacing clean water during insertion is time-consuming. WE has major limitations in terms of time, with WE during insertion and a longer learning period, but is superior to WI for painless colonoscopy and an improved adenoma detection rate, based on a limited number of RCTs.[28,29] A meta-analysis and systematic review compared AI and water-aided methods, including WI and WE, for pain score, adenoma detection rate, and requirements for sedation; both WI and WE were superior to AI regarding procedure pain.[30,31] Recently, several trials have compared water-aided colonoscopy with CO_2 insufflation, and performed head-to-head comparisons using WI, WE, and CO_2.[17,32-34] Compared with AI and CO_2, WI and WE significantly reduced colonoscopy insertion pain, and WE was the least painful technique.

ROBOTIC COLONOSCOPY

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

Endotics

The Endotics System (Era Endoscopy, Peccioli, Italy) 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 prolonged insertion times and a relatively low cecal intubation rate need to be overcome.[35,36]

NeoGuide Endoscopy System

The NeoGuide Endoscopy System (NES; NeoGuide Systems Inc., Los Gatos, CA, USA) 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 for cecal intubation, but still a high looping incidence (40%). There has been no further trial.[37]

Invendoscope

The Invendoscope (Invendo Medical, Garden City, NY, USA) is a single-use, hand-held controlled colonoscope, with a 10-mm inner sheath. This disposable 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.[38]

CONCLUSIONS

The CO_2 insufflation method is used widely during colonoscopy, including therapeutic procedures. Previous RCTs have shown that CO_2 gas is a good option for reducing pain and discomfort during and after a procedure. However, a recent meta-analysis showed that CO_2 insufflation was more effective in reducing postprocedure pain than pain during the procedure. There is still limited evidence for the safe use of CO_2 insufflation in high-risk patients.

WI, and the recently modified WE method, are good options for reducing intra- and postprocedural pain and dis-

comfort compared with AI and CO_2 insufflation. Moreover, there is no safety limitation in using either technique. WE is the best modality to reduce patient discomfort and enhance the adenoma detection rate, although the WE procedure itself is time-consuming and requires a learning period.

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

Conflicts of Interest

The author has no financial conflicts of interest.

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