Brief Comparison Between Water-Aided Colonoscopy and Air Insufflation Colonoscopy

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Article History: Received 10th June, Accepted 5th July, published online 10th July 2023

Abstract

Background: Colonoscopy continues to be the primary means of investigating lower gastrointestinal symptoms. Colonoscopy has been shown to reduce the risk of subsequent colorectal cancer (CRC) both in screening and in the symptomatic population. However, despite its popularity, colonoscopy is not perfect, and post colonoscopy cancer is a recognized feature. Colonoscopy is the most commonly performed endoscopic procedure in the United States and is the preferred method to screening for CRC. The term "water-assisted colonoscopy" or "water-aided colonoscopy" (WAC) encompasses different techniques that entail infusion of water as an adjunct to or in inplace of gas insufflation to allow insertion of the colonoscope to the cecum. Withdrawal is done with gas insufflation to distend the lumen for exploration, as usual in AI or CO2 insufflation colonoscopy. Initially, different labels were used to identify the techniques, namely water infusion or water immersion grouped as WI. Although evidence was not adequate to prove that WE method was better for increasing cecal intubation rate, the use of WE seemed to have a higher ADR/PDR and patients' acceptance of colonoscopy. Moreover, pooled data showed that WE relieved patients' pain and minimized the need for on‐demand sedation and adjunct maneuvers. However, WE was demonstrated to be more time‐consuming during the insertion phase. ADR was considered to be the leading parameter of our study as the quality of endoscopist's performance of colonoscopy is mainly defined by the capacity of detecting precancerous lesions.

Keywords: Water-Aided Colonoscopy, Air Insufflation Colonoscopy

Introduction

Colonoscopy is a diagnostic as well as a therapeutic procedure performed to evaluate the large intestine (i.e., colon, rectum, and anus) as well as the distal portion of the small intestine (terminal ileum). The visual data that the camera feeds to the screen helps to detect abnormalities as well as overgrowth of the colonic wall and, in turn, allows us to evaluate, biopsy, and remove mucosal lesions using different types of biopsy instruments through these accessory channels. **(1)**.

Colonoscopy continues to be the primary means of investigating lower gastrointestinal symptoms. Colonoscopy has been shown to reduce the risk of subsequent colorectal cancer (CRC) both in screening and in the symptomatic population. However, despite its popularity, colonoscopy is not perfect, and post colonoscopy cancer is a recognized feature. Colonoscopy is the most commonly performed endoscopic procedure in the United States and is the preferred method to screening for CRC. Polypectomy during colonoscopy has been shown to decrease the incidence of colorectal cancer and associated mortality. However, colonoscopy is not a perfect tool and several aspects of this procedure continue to be the focus of active research to improve the quality as well as patient outcomes **(2)**.

Fig. 1. Technique of colonoscopy **(1)**.

Colonoscopy is widely viewed in the USA as a comfortable procedure, which in addition to its capacity to examine the entire colon, has contributed to the progressive decline in flexible sigmoidoscopy screening. Patients within the same practice who were screened with unsedated flexible sigmoidoscopy were more than twice as likely to say they would not be screened again compared with patients screened with sedated colonoscopy. The use of propofol for sedation in combination with carbon dioxide insufflation has allowed many patients to have a painless procedure and post-procedure experience and function normally (except driving is usually not allowed) on the same day of the procedure **(3)**.

The major advantage of colonoscopy remains its unmatched potential for detection of precancerous lesions, and its ability to detect cancer is matched only by CT colonography. CT colonography has not been well received because it still requires bowel preparation to approach colonoscopy for polyp detection, its high cost as a strategy, and the risks associated or believed to be associated with radiation. Colonoscopy appears to hold a substantial advantage for detection of serrated lesions. These lesions are not well seen at CT colonography, and CT colonography trials never report serrated lesions as a separate outcome. Absence of blood vessels on the surface of serrated lesions has long led to suspicion that guaiac-based fecal occult biood test (FOBT) and fecal immunochemical test (FIT) could not detect them, which proved completely true when finally tested. Only fecal DNA has shown some sensitivity for serrated lesions among noninvasive tests **(4)**.

A major advantage of colonoscopy is the potential for long-lasting protection from cancer. Of available tests, only colonoscopy is recommended at 10-year intervals. Case-control studies of screening sigmoidoscopy identified protection against left-sided cancer following sigmoidoscopy of 10 and 16 years, which were the longest periods for which protection was assessed. A previous case-control study of colonoscopy in Germany found that protection against colorectal cancer remained substantial for more than 20 years. If intervals between screening can be linked to the adenoma detection rates of examiners, this evidence suggests the possibility that patients could have lifelong protection from a single negative colonoscopy by a high detecting colonoscopist at about age 60, or perhaps two examinations at ages 50 and 70 years. Colonoscopy is started with the patient in left lateral position. In a randomized controlled trial, Vergis et al, challenged this conventional starting position by compared it with right lateral starting position. Cecal intubation was quicker by 3 minutes 33 seconds and patient comfort higher when colonoscopy began with patients in the right lateral position. The greatest benefit was seen in women and those with previous history of surgery. These results need further validation in larger multicenter trials and could lead to a simple and inexpensive change in colonoscopy practice for improving efficiency and patient satisfaction **(5)**.

Looping of colonoscope is the bane of insertion phase of colonoscopy, causing pain, increasing procedure time as well as the risk of adverse events like perforation and splenic injury. Abdominal pressure is routinely used to prevent looping and an abdominal compression device (ColoWrap) has been developed for this purpose. In a randomized, sham controlled trial, Crockett et al found no benefit of the ColoWrap in cecal intubation time, frequency of manual pressure or position changes **(5)**.

However, in a subset analysis of patients with body mass index (BMI) between 30 and 40, the cecal intubation time was significantly lower in the ColoWrap group - 4.69 minutes vs 6.10 minutes in synthetic group; P = 0.03. Magnetic endoscopic imaging (MEI) is another device that can help avoid looping by showing the 3-dimensional real time configuration of the colonoscope. A meta-analysis showed that the adjunctive use of MEI improved cecal intubation rates, lowered cecal intubation times as well as pain scores compared with standard colonoscopy. However, this equipment requires capital investment and its utility in routine clinical practice may be limited. It could however have a role be as a teaching tool for trainees to understand the dynamics of colonoscope insertion and optimizing the learning curves **(6)**.

Water-aided technique

The term "water-assisted colonoscopy" or "water-aided colonoscopy" (WAC) encompasses different techniques that entail infusion of water as an adjunct to or in inplace of gas insufflation to allow insertion of the colonoscope to the cecum. Withdrawal is done with gas insufflation to distend the lumen for exploration, as usual in AI or CO_2 insufflation colonoscopy. Initially, different labels were used to identify the techniques, namely water infusion or water immersion grouped as WI **(7)**.

Water immersion and WE, albeit similar in the use of water infusion to aid insertion to the cecum, markedly differ in the timing of water removal. Removal of infused water during insertion, as in WE, may maximize cleanliness and adenoma detection during withdrawal. Avoidance of gas insufflation is important with WE. Once gas is insufflated, the average colonoscopist will have lowered the likelihood of the optimal benefits offered by WE in minimizing gas-induced colon elongation and smoothing sharp bends at flexures **(8)**.

There are several proposed mechanisms through which water may facilitate the passageof a colonoscope through the colon. When filled with water, the sigmoid colon may be weighted down into the left lower quadrant if the patient is in the left lateral decubitus position. This can straighten the sigmoid and make tight angles less acute. Another mechanism may be related to the shortening of the colon through the use of water as opposed to air, which may elongate the colon.8 In addition, the use of water may help to lubricate the scope, allowing for easier passage. Other proposed mechanisms include decreased colonic spasm **(9)**

During water immersion, water is infused during insertion and the air pump is turned off. Infused water is then aspirated during scope withdrawal. Water exchange involves the infusion of clean water with suction and removal of the fecal suspension during insertion. Water exchange also involves turning-off of the air pump. A hybrid of these methods is often used in practice and in trials. In this technique, water is used as an adjunct to air insufflation during the passage through tight strictures or angles often observed in the sigmoid colon **(10)**

With regards to water exchange, one expert has offered helpful maneuvers in a recent editorial. These maneuvers include the infusion of a minimal amount of water that is sufficient to open the lumen or spasm. The investigator suggests that to minimize inadvertent mucosal suction, the endoscopist should decrease the level of suction and point the suction port toward the center of the lumen. In addition, if bowel preparation is not optimal, the endoscopist should infuse clean water and suction the debris simultaneously. In the author's opinion, cleaning of the bowel is easier in a water-filled colon than in an air-filled lumen because the simultaneous infusion and suctioning of water creates a turbulent environment that suspends the fecal debris, allowing for efficient suctioning of fecal debris. Finally, although maneuvers such as abdominal compression and change of patient position may be required less often in water techniques, these adjunctive techniques should still be considered an integral part of the examination **(10)**

Water-aided colonoscopy versus air insufflation colonoscopy:

Regarding pain

The data from RCTs comparing traditional air insufflations (AI) with water immersion(WI)or water exchange(WE) from 2008 to 2011 were summarized in a recent systematic qualitative review. The data from 3 additional RCTs published in 2012 are added. The reductions in mean or median pain scores of the water-aided method groups are presented as percentages of the air insufflation groups. The overall reduction of pain scores was qualitatively greater with water exchange compared with water immersion in patients not given full sedation. Water immersion is difficult to perform if the colon is not prepared well. Suctioning dirty water and replacing it with clean water during insertion is time consuming **(8)**.

Water exchange evolved from water immersion to manage residual feces in the colonic lumen, which requires time but is also effective in providing salvage cleansing in patients prepared with non–split-dose and split-dose bowel regimens. The prolonged insertion time of the water exchange method in scheduled, unsedated patients was deemed a major limitation to its widespread application; in addition, the time needed to learn the necessary maneuvers makes it impractical when only 30 minutes or less are allotted for each colonoscopy in a typical clinical practice. However, the feasibility of water exchange in situations other than scheduled, unsedated patients is suggested by mean insertion times ranging from 5 to 13 minutes in these alternative settings, as summarized in a recent systematic qualitative review **(10)**

Overall, the data of water-aided compared with traditional air insufflations, pain during colonoscopy is reduced by both water immersion and exchange. The reduction in pain scores was qualitatively smaller with water immersion compared with water exchange. In settings in which full sedation is practiced, the pain reduction provided by water-aided methods is likely to be of less importance than in settings in which unsedated, on-demand sedation, or minimally sedated colonoscopy, is practiced **(10)**

A total of nine studies investigating the difference in the maximum pain score during colonoscopy procedure were carried out using the visual analog scale from 0 to 10 to grade patients' pain (0 = no pain, 10 = most severe pain). Pooled estimates showed that the maximum pain score was significantly lower in WE group (WMD = −1.99, 95% CI = −2.68 to −1.30, $P < 0.00001$, $I2 = 94\%$) **(11)**.

Impact on adenoma detection:

A recent systematic qualitative review assessed the impact of water-aided methods on ADR. With water immersion, the effect on ADR is inconsistent. With water exchange, there is a trend toward higher ADR. Compared with air insufflations, no increase in ADR was shown for water immersion, but an increase was observed with water exchange, especially for diminutive adenomas in the proximal colon **(10)**

As for ADR, eight studies involving a total of 6067 colonoscopies were included, and in 1586 of them at least one adenoma was detected. ADR was significantly higher in WE group (RR = 1.28, 95% CI = 1.18–1.38, $P < 0.00001$, $I2 = 0\%$). As for PDR, five studies involving a total of 3907 colonoscopies were included, and in 1768 of them at least one polyp was detected. Similarly, PDR was also higher in WE group (RR = 1.30, 95% CI = 1.21–1.39, $P < 0.00001$, $I2 = 0\%$) **(11)**.

Studies regarding differences between water aided and air insufflation:

Although evidence was not adequate to prove that WE method was better for increasing cecal intubation rate, the use of WE seemed to have a higher ADR/PDR and patients' acceptance of colonoscopy. Moreover, pooled data showed that WE relieved patients' pain and minimized the need for on‐demand sedation and adjunct maneuvers. However, WE was demonstrated to be more time‐consuming during the insertion phase. ADR was considered to be the leading parameter of our study as the quality of endoscopist's performance of colonoscopy is mainly defined by the capacity of detecting precancerous lesions **(12)**.

Currently, the recommended ADR target for a mixed male–female population is at least 25%. However, previous studies have reported an approximately 22% adenoma missing rate undergoing tandem colonoscopy. Interval cancers from these missed lesions would occur in 0.3% of the screened persons. Thus, the recognition of interval cancers in patients with low ADR calls for meticulous examination. In our study, pooled data suggested that WE was superior to AI with respect to ADR (29.4% vs. 22.9%). The

increase was significant (6.5%). Similar trend was observed for PDR (50.2% vs. 39.3%), with an increase of 10.9%. There are several possible mechanisms. The most important factor is the improved bowel preparation, which allows the colonoscopists focusing on searching for lesions. Besides, with water infusion, colon topography may not be changed and small polyps floating underwater can be more easily visible **(13)**.

Moreover, the magnifying effect of water can make the change in vasculature of neoplasm more obvious. Minimizing pain and discomfort are of greatest importance for patients to accept colonoscopy. For this purpose, routine sedation, as one of the assistive techniques, has been commonly implemented into colonoscopy. However, with WE method, there was a major reduction in pain score (by more than 1 unit compared with AI), thus the proportion of patients asking for sedation was significantly lower. Besides, our study also showed less need for abdominal compression or position change in WE group, since water reduces angulations during intubation and facilitates instrument passage with less looping, especially in the left colon. All these contributed to a significantly higher proportion of patients willing to repeat the procedure with WE than AI (91% vs. 85%) **(11)**.

The time efficiency of performance is another important factor in adoption of a new method for colonoscopy. With regard to WE, more time has been spent for water infusion and suction during cecal intubation. In RCTs, the mean cecal insertion time for water method ranged from 6.9 to 17.4 min, suggesting a small but significant increase when compared with air method (4.9–12.0 min). However, the longer time (about 2 min) required by WE may play an important role in revealing more lesions during insertion, as confirmed. This disadvantage might be overcome by more standardized technique training **(11)**.

In 1984, Falchuk first described a water infusion technique that facilitated colonoscopy in patients who could not undergo successful colonoscopy with air insufflation because of severe diverticular disease. In these patients, infusion of 100 ml of water in the sigmoid colon allowed the identification of the colonic lumen and assisted the advancement of the colonoscope through the segment with severe diverticulosis. This maneuver was repeated in 5 other patients with equal success **(14)**. Since then, some modifications have been adopted to improve the effectiveness of this technique, such as using warm water infusion and imposing no restriction on the water volume infused into the colon in most circumstances **(15)**.

The detailed techniques of water infusion varied among investigations in different studies. In some studies, certain fixed volumes of water (from 200 to 400 ml) were instilled into the rectum and sigmoid colon through the biopsy channel of colonoscope with a syringe or by enema at the beginning of the examination In others, during colonoscope insertion, water was intermittently infused with a foot-switch-controlled water pump at the endoscopist's discretion to identify the colonic lumen. So there was no restriction of the overall volume of water. During insertion, water infusion was used exclusively to distend the colon and the air supply was turned off until the cecum was reached. When air pockets were encountered at flexures and redundant segments, suction removal of residual air minimized angulations and reduced the risk of loop formation **(16)**.

In a collapsed airless colon, the infusion of water was used to confirm the location of the lumen to facilitate advancement of the colonoscope. As lumen identification proceeded, the infused water was removed by suction to minimize avoidable distention. If turbid water (caused by residual stool) obscured the vision, the water was suctioned and clean water was infused to improve the endoscopic view. When the cecum was thought to be reached, the air pump was turned on to confirm the location. In withdrawal phase, air was insufflated, and in the meantime, residual water and feces were suctioned for full evaluation of the colon. The heat from the warm water could relax colonic smooth muscle and reduce spasms **(10)**

Therefore, in some studies, warm water near body temperature (36 or 37 ^{0} C), instead of water at room temperature, was used. In one study, although warm water at 42 ^{0} C was used in order to reinforce the antispasmodic effect, there were no reported cases of burns, abdominal pain, or rectal urgency. Over the last 30 years, the procedure for colonoscopy has been gradually developed with rapid advances in accessories

and instruments. However, experienced endoscopists may still perform unsuccessful colonoscopy, where they fail to reach the cecum in up to 18 % of procedures **(17)**.

In (WIC), due to gravity, the water infused into the sigmoid colon flows to the lower lying descending colon in the left lateral position, thereby opening a passage through the loops and bends. Meanwhile, abdominal compression is applied, and patient's position is changed if needed, which consequently facilitates the passage of colonoscope and enhances cecal intubation. Additionally, some studies reported that the reduction of colonic spasm may contribute to the higher cecal intubation rate in warm water immersion colonoscopy WIC. In our meta-analysis, the pooled OR for all studies (1.90; CI 1.21, 2.99) and the trainee subgroup (1.83; CI 1.15, 2.93) further confirmed that WIC had a significantly higher cecal intubation rate than AIC ($p = 0.02$) **(10)**

Some studies reported shorter insertion time in WIC than in AIC. A plausible explanation is that water infusion may have decreased colonic loops and spasm **(10)** In the meantime, the cleaning effect of water obviates the necessity for the time-consuming lavage of dirty areas of the mucosa. However, opposite results were reported in several studies, where more time was required to suck larger amount of water in WIC. Our meta-analysis did not show a significant difference in the time taken for cecal intubation between the two types of colonoscopy (0.04 min; CI -1.45, 1.52; $p = 0.96$). However, the subgroup analysis demonstrated that the water technique proved even more beneficial for trainees, with shorter insertion time in WIC group (-1.72; CI -3.34, -0.11; $p = 0.04$). This finding indicates that the water method is simple and relatively easy for the trainee to learn **(18)**.

Whether the water technique affects polyp detection rates becomes another important question because the possibility of missing colorectal lesions remains unavoidable even for experienced endoscopists. Radaelli et al. found lower polyp and adenoma detection rates in the study arm **(18)**., whereas other studies reported that WIC was similar to or even exceeded the conventional colonoscopy in this respect. Advocates of the water technique hold that the cleansing effect may have contributed to the higher adenoma yield, whereas some argue that too much residue makes it difficult to see through the colon clearly when attempting to insert the colonoscope properly, although the residue can be removed by suction while infusing more water to clean the colon **(16)**.

The meta-analysis result from 9 studies showed no difference in the polyp detection rates between the water infusion and the standard group (OR = 1.17; CI 0.78, 1.77; $p = 0.44$). In view of these conflicting data, water infusion most likely did not have a clinically significant effect on the polyp detection rate. However, this conclusion needs further confirmation. In conventional colonoscopy, air is usually infused into the colonic lumen to distend the collapsed colon and assist the advancement of the colonoscope. However, excessive air insufflation results in elongation of the colon, which can make cecal intubation difficult and cause the patient discomfort in the form of abdominal pain and distension **(15)**.

In WIC, the warm water infused into the colonic lumen assists in straightening the colon and opening the colonic junction. At the same time, the heat from water helps relax colonic spasms and relieve the patient's pain. The result showed that WIC had a significantly lower VAS for pain than AIC. However, no significant difference in patient's pain was found between WIC and AIC in the subgroup analysis for the trainees. The sedation mode in the studies included in this meta-analysis was divided into unsedated, minimal sedation, on demand, and sedated. With the on-demand mode, sedation and analgesia were administered on patient request if significant pain or discomfort occurred **(10)**

Several studies using on-demand mode have already consistently demonstrated that the water infusion method not only permitted a significantly higher proportion of patients to complete colonoscopy without sedation, but also reduced the dose of analgesia/sedation needed to achieve intubation of the cecum. In studies using a minimal sedation protocol, each patient received low doses of analgesia/sedation just before the examination, and during the procedure, additional medication was to be administered by the nurse if the patient reported significant pain. Similar to the result of on-demand mode, studies with minimal sedation also found that less analgesia/sedation was used in WIC than in AIC **(17)**.

Several studies revealed that WIC markedly enhanced the proportion of patients who were willing to undergo another colonoscopy because of less pain during the procedure. Our statistical analysis also

demonstrated that the rate of willingness to repeat the procedure was significantly higher in WIC than in AIC **(18)**.

Smooth insertion of the colonoscope without causing discomfort or pain is not always possible, particularly for endoscopists with limited experience. In the subgroup analysis of colonoscopy performed by trainees, a higher cecal intubation rate and shorter intubation time were remarkably achieved in the WIC group compared with the conventional one, although no significant difference was found between the two methods in terms of the patient's pain during the procedure. This result suggests that the warm water method may be a simple, safe, and feasible method that aids the colonoscopy trainee in inserting the colonoscope with ease **(17)**.

It is noteworthy that there was no report of procedurerelated complications (perforation or bleeding) in patients who underwent WIC. It is generally accepted that the use of water instead of the conventional room air reduces angulations in the colon and facilitates passage of the colonoscope with less looping of the instrument. Thus, procedure-related complications (perforation or bleeding) are not likely to increase in patients undergoing WIC. The amount of infused water ranged from 200 to 3,000 ml in the studies included in our meta-analysis. However, none of these studies estimated and reported a potential electrolyte imbalance associated with water infusion. One possible reason is that most of the infused water was aspirated into the suction bottle instead of remaining in the colon during examination. Further well-designed studies are needed to evaluate the risk of electrolyte imbalance associated with WIC **(17)**.

Jun and Bing in meta-analysis showed that water infusion was associated with less pain than air insufflation during colonoscopy ($P < 0.00001$) and the maximum pain score was also lower during water infusion ($P < 0.00001$). The tolerability score of patients after colonoscopy was higher in the water infusion group. Some patients with difficult intubation require abdominal compression or position change during colonoscopy. Six RCTs compared these between the two groups, and showed that patients with water infusion needed less abdominal compression or position change **(19)**.

The effect of water infusion on caecal intubation time was variable with three RCTs indicating that it was less and four finding no difference. This result meant at least that water infusion did not increase the duration of colonoscopy. There has been some indication that water infusion can improve the adenoma detection rate **(10)** but this was not found in all the studies included in the meta-analysis **(19)**.

Most patients prefer sedation during colonoscopy and sedation-related complications are low, being around 1%. Six of the studies reported that by providing less discomfort medication requirements are decreased. This is a simple and inexpensive method for minimizing the cost of drugs and sedation-related complications **(19)**.

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