Water exchange enhanced cecal intubation in potentially difficult colonoscopy. Unsedated patients with prior abdominal or pelvic surgery: a prospective, randomized, controlled trial

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Background: Colonoscopy is widely used for management of colorectal diseases. A history of abdominal or pelvic surgery is a well-recognized factor associated with difficult colonoscopy. Although water exchange colonoscopy (WEC) was effective in small groups of male U.S. veterans with such a history, its application in other cultural settings is uncertain.

Objective: To investigate the application of WEC in such patients.

Design: Prospective, randomized, controlled, patient-blinded study.

Setting: Tertiary-care referral center in China.

Patients: Outpatients with prior abdominal or pelvic surgery undergoing unsedated diagnostic, screening, or surveillance colonoscopy.

Intervention: Patients were randomized to examination by either WEC or conventional air colonoscopy (AC).

Main Outcome Measurements: Cecal intubation rate.

Results: A total of 110 patients were randomized to the WEC (n = 55) or AC (n = 55) group. WEC significantly increased the cecal intubation rate (92.7% vs 76.4%; P = .033). The maximum pain scores (± standard deviation) were 2.1 ± 1.8 (WEC) and 4.6 ± 1.7 (AC), respectively (P < .001). Multivariate analysis showed that the colonoscopy method was the only independent predictor of failed colonoscopy (odds ratio 11.44, 95% confidence interval, 1.35-97.09). A higher proportion of patients examined by WEC would be willing to have a repeat unsedated colonoscopy (90.9% vs 72.7%, P = .013).

Limitations: Single center; unblinded but experienced endoscopists.

Conclusion: This randomized, controlled trial confirms that the water exchange method significantly enhanced cecal intubation in potentially difficult colonoscopy in unsedated patients with prior abdominal or pelvic surgery. The lower pain scores and higher proportion accepting repeat of the unsedated option suggest that WEC is promising. It may enhances compliance with colonoscopy in specific populations. (Clinical trial registration number: NCT01485133.)

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Colonoscopy is widely used for management of colorectal diseases. Screening colonoscopy decreases the incidence and mortality of colorectal cancer by detection and treatment of precancerous lesions and early cancer.\(^1\)\(^-\)\(^3\) In patients with a history of abdominal or pelvic surgery, a failure rate of 14.2%\(^6\) has been reported, even with sedation. Postoperative adhesions may have changed the anatomy of the colon, contributing to the difficulty. Insufflated air may distend, lengthen, and angulate the colon, leading to increased discomfort in all, especially the unsedated patient, and greater difficulty of cecal intubation for the endoscopists.

The use of water infusion in lieu of air insufflation obviates excessive lengthening of the colon and facilitates completion of colonoscopy, even in unsedated patients. Several studies revealed that the water exchange method can significantly reduce the pain score and enhance the success of cecal intubation in unsedated or minimally sedated patients.\(^5\)\(^-\)\(^7\)

The water exchange method had been shown to increase the proportion of patients able to complete unsedated colonoscopy in small groups of male U.S. veterans with previous abdominal surgery. Veterans may represent a special population with better toleration of the discomfort of unsedated colonoscopy.\(^9\) It is not known whether in another cultural setting patients with a history of abdominal or pelvic surgery will benefit from water exchange colonoscopy (WEC). In addition, colonoscopies are technically more difficult to perform in women who have undergone gynecologic (pelvic) surgeries. Both previous gynecologic surgery and previous hysterectomy are independent predictors of difficulty of intubation in unsedated female patients.\(^9\) It is not known whether WEC would facilitate the performance of colonoscopy in unsedated female patients with a history of pelvic surgery.

We report a prospective, randomized, controlled trial (RCT) that was designed to investigate whether, compared with conventional air colonoscopy (AC), WEC could increase cecal intubation rates in Asian (Chinese) patients with prior abdominal or pelvic surgery.

### METHODS

This prospective, patient-blinded RCT, approved by the local institutional review board (ClinicalTrials.gov NCT01485133) was conducted at the Endoscopic Center of Xijing Hospital, China. Written informed consent was obtained from all the patients.

### Patients

The ratio of unsedated to sedated colonoscopy is about 3:1, and both sedated and unsedated colonoscopy are routine at our center. From November 2011 to July 2012, outpatients who underwent unsedated colonoscopy were invited to participate. Patients with a history of abdominal or pelvic surgery were enrolled. Exclusion criteria included any of the following: aged <18 years or >80 years; current pregnancy; history of colon resection; severe colon stricture or obstructing tumor; hemodynamic instability; and inability to provide informed consent. Patients who met the inclusion criteria were randomly assigned to the WEC or AC group by using computer-generated random numbers immediately before the examination. The randomization list was not accessible to the endoscopists or assistants.

The preparation method was reported with an acceptable cleansing rate and tolerance.\(^10\) All patients consumed a regular meal for lunch and clear liquids for dinner the day before the colonoscopy. They drank two sachets of polyethylene glycol 4000 electrolytes powder (WanHe Pharmaceutical Co, Shenzhen, China) dissolved in 2 L of water between 4:00 AM and 5:00 AM within 2 hours of the colonoscopy on the same day of colonoscopy. Patients were encouraged to drink more clear liquids after purgatives for adequate hydration before colonoscopy.

Patient blinding involved colonoscopists not informing the patients of the methods, the set-up (colonoscope, water pump, and other equipment) was the same for both WEC and AC, and the display screen was placed over the head of the patients so they could not see the endoscopic images.

### Endoscopic procedure

All colonoscopies were performed from 9:00 AM to 1:00 PM by two experienced colonoscopists (Y.L.P. or L.H.Z.). Before the start of the study, both had performed >2000 AGs and 50 WECs (with 100% cecal intubation rate in the last 30). The variable-stiffness colonoscope (CF-Q260; Olympus, Beijing) was used.

An assistant explained to the patients the pain scores (degree of abdominal pain) to be used. At regular intervals during the insertion phase, patients were asked by an unblinded assistant to report the pain score by using an 11-point visual analog scale (0 = no pain and 10 = most severe pain imaginable).\(^11\)\(^-\)\(^12\)

Colonoscopy began with the patient in the left lateral position. For WEC,\(^13\) the air pump was turned off before colonoscopy. During insertion, residual air in the lumen

### Take-home Message

- Water exchange colonoscopy can significantly reduce the pain score and increase cecal intubation rates in unsedated patients with prior abdominal or pelvic surgery. This method also was associated with a higher proportion of patients who reported willingness to repeat unsedated colonoscopy.
- The lower pain scores and higher proportion of patients accepting a repeat of the unsedated option suggest that water exchange colonoscopy is a promising addition to colorectal cancer prevention.
was suctioned, and 37°C (maintained with a water bath) water was infused with a peristaltic pump (OFP; Olympus) through the biopsy channel to obtain lumen visualization. Turbid luminal water due to residual feces was suctioned and replaced by clean water until the colon lumen was clearly visualized again. Thus, infused water was removed predominantly during the insertion phase. The total volume of water was not restricted. For the AC method, air was insufflated during insertion (water was not made available). Successful cecal intubation was defined as insertion of the colonoscope tip into the cecal caput. During withdrawal in both groups, residual water and feces were suctioned and air was insufflated sufficiently to facilitate inspection. The quality of the bowel preparation was assessed during withdrawal by using the Boston Bowel Preparation Scale (BBPS, a 10-point scale).14 At the end of the examination, patients were asked by an unblinded assistant to indicate whether they would be willing to undergo a repeat unsedated colonoscopy.

Maneuvers such as abdominal compression, position change, or colonoscope stiffness variation were implemented as needed. If patients reported a pain score of ≥6,12 unsedated intubation would be terminated (intention-to-treat failure of unsedated colonoscopy). Rescue was attempted with a conventional sedated colonoscopy by using air insufflation (usual practice at our institution) in the same session by the same endoscopist.

Outcomes

Baseline characteristics including age, sex, body mass index (BMI), main indication for the colonoscopy, and previous abdominal or pelvic surgery were collected before the examination.

The primary outcome was the cecal intubation rate. The secondary outcomes included the maximum and mean pain scores during insertion in the right-side, transverse, and left-side colon; polyp detection rate; patient willingness to undergo a repeat unsedated colonoscopy; insertion time (from rectum to cecum), withdrawal time (from cecum to rectum excluding time for biopsy and polypectomy); volume of water infused; number of abdominal compressions, position change, and stiffness variation during the insertion phase was used; and BBPS scores.

Statistical analysis

A pilot study was conducted to determine the cecal intubation rate of WEC (100% in 20 patients) and AC (85% in 20 patients), respectively. Sample size calculation was carried out in the program Win Episcope version 2.0 (The University of Edinburgh, Edinburgh, Scotland). We estimated that 102 patients (51/study group) would provide a power of 80% to detect a 15% increase in the cecal intubation rate, from 85% in the AC group to 100% in the WEC group, with a 2-sided significance level of .05.

Descriptive statistics were computed for all variables. Analyses were performed by using an intention-to-treat approach. Continuous variables were represented by using mean and standard deviation (SD). Chi-square and t tests were used to compare proportions and means for normally distributed data, as appropriate. The Fisher exact test was used to evaluate for differences in cecal intubation rate. A multivariate logistic regression analysis was performed by adjusting the variables with a value < .10 by univariate analysis. Statistical analyses were performed by using SPSS version 19.0 for Windows (IBM Corporation, Armonk, NY). A 2-tailed P value < .05 was considered significant.

RESULTS

In an 8-month period, 785 outpatients were scheduled. A total of 151 patients (19.2%) had prior abdominal or pelvic surgery. A total of 137 patients provided informed consent, and 110 patients were enrolled and randomized to the WEC group (n = 55) and the AC group (n = 55). The other 27 patients were excluded, 24 met exclusion criteria, and 3 subsequently decided not to undergo colonoscopy. The patient flow is detailed in Figure 1. A total of 70.9% of patients in the WEC group and 67.2% in the AC group were female (P = .68). Other baseline
characteristics (age, BMI, indication for the colonoscopy, and previous abdominal or pelvic surgery) between the two groups were well balanced (Table 1). In the present study, more than two-thirds of patients underwent a diagnostic colonoscopy. Four patients in the WEC group and 10 in the AC group each reported two symptoms, such as abdominal pain, rectal bleeding or melena, or change in bowel habits.

The study outcomes are summarized in Table 2. The cecal intubation rate was significantly higher in the WEC group (92.7% vs 76.4%; \( P = 0.033 \)). Among the 17 failed cases, 3 needed to repeat bowel preparation (2 in the WEC group and 1 in the AC group) and 2 had obstructing tumors (1 in each group). The remainder were rescued with a conventional sedated colonoscopy by using air insufflation, which was the usual practice in our endoscopic center. Ten in the AC group were successful (mean operation time, 13.8 ± 6.4 minutes). Two (1 in each group) failed despite sedation (mean operation time, 54.4 ± 2.1 minutes) (Table 3). The air method with sedation remained unsuccessful in 1 patient in the water group.
because of a severe colon stricture. Multivariate analysis showed that the colonoscopy method was the only independent predictor of failed colonoscopy (odds ratio 11.44; 95% confidence interval, 1.35-97.09; \( P < .025 \)) (Table 4). For those with successful cecal intubation, the total colonoscopy, cecal intubation, and withdrawal times were not significantly different between the two groups (Table 2).

Among patients who successfully completed colonoscopy, the maximum pain scores were 2.1 ± 1.8 (WEC) and 4.6 ± 1.7 (AC) (\( P < .001 \)). The mean pain scores were also lower in the WEC group (1.3 ± 1.3 vs 3.6 ± 1.2; \( P < .001 \)). The mean pain scores in the left side of the colon, transverse colon, and right side of the colon were all lower in the WEC group compared with the AC group.

Among patients who successfully completed colonoscopy, BBPS was higher in the WEC group compared with the AC group (8.1 ± 1.2 vs 7.2 ± 1.6; \( P = .002 \)). No significant difference was observed between the two groups regarding polyp detection rate (\( P = .153 \)), although that in the WEC group was higher. Cecal intubation time and withdrawal time were found to be comparable between the two groups (both \( P > .05 \)). WEC required significantly less-frequent use of position change (29.1% vs 65.5%; \( P < .001 \)), abdominal compression (7.3% vs 38.2%; \( P < .001 \)), and stiffness variation (9.1% vs 25.5%; \( P = .023 \)) during the insertion phase. A significantly higher proportion of patients would be willing to have a repeat unsedated colonoscopy in the WEC group than in the AC group (90.9% vs 72.7%; \( P = .013 \)).

The mean (± SD) volume of water used during insertion in the WEC group was 472 ± 164 mL. No complications were noted in either group.

**DISCUSSION**

Modified from water immersion as an adjunct to air insufflation, the novel method of WEC in lieu of air insufflation as the sole modality to aid colonoscope insertion was first described in 2007.15 Unlike a recent RCT of water immersion that showed a decreased cecal intubation rate,17 the current study confirmed the superior performance by WEC in increasing the cecal intubation rate.16 The current study also confirmed the results of several others demonstrating WEC to be associated with less pain and greater willingness to repeat unsedated colonoscopy in sedated, unsedated, or sedation on-demand conditions.5-7 Although it was suggested that WEC would be useful in difficult colonoscopy by a hypothesis-generating review,18 its advantage was proven only in small groups of male veterans with previous abdominal surgery.8 Here we further demonstrated in a patient-blinded RCT in a different cultural setting that unsedated patients with a history of abdominal or pelvic surgery also benefitted from WEC with an increased completion rate (92.7% vs 76.4%). Although the intubation time was comparable between the two groups, patients required fewer assistance measures in the WEC group.
The prolonged insertion time with WEC\textsuperscript{8,19} was deemed a potential barrier to its widespread adoption.\textsuperscript{10} In the current study, mean intubation times were considerably shorter than those in the earlier reports.\textsuperscript{8,19} The reason may be due to the differences in the patients (non veterans vs veterans) and the endoscopists (more and less experience with unsedated colonoscopy), respectively.

A history of abdominal (eg, cholecystectomy, appendectomy, gastrectomy) or pelvic (eg, hysterectomy, oophorectomy) surgery is unequivocally associated with difficult colonoscopy.\textsuperscript{4} Adhesions may lead to an angulated or fixed colon, causing discomfort during intubation. Colon elongation and exaggeration of angulations at flexures or fixed colon, causing discomfort during intubation. Double-balloon endoscopy has been used to complete examination in patients with prior unsuccessful or technically difficult colonoscopy (87.2% had a history of previous abdominal surgery).\textsuperscript{20} The comparisons regarding cecal intubation rate and pain score between WEC and double-balloon endoscopy in patients with difficult colonoscopy deserves further investigation.

Unsedated patients can participate more easily in changing position and abdominal compression, both of which are well-accepted maneuvers for facilitating intubation, especially in difficult colonoscopy. As shown in our study, 65.5% and 38.2% of patients undergoing traditional colonoscopy with air insufflation, respectively, needed to change position or receive abdominal compression. The need for position change and abdominal compression was reduced by WEC, respectively, 2.3-fold and 5.2-fold. The data provided confirmation that these difficult colonoscopies were made easier. These superior attributes also were recognized by Vemulpalli and Rex\textsuperscript{21} in their retrospective study of patients with redundant colons and previous incomplete colonoscopies.

Double-balloon, single-balloon, transparent hood-attached,\textsuperscript{22} small-caliber,\textsuperscript{23} variable-stiffness or overtube-assisted\textsuperscript{24} endoscopes had been shown to be useful in difficult colonoscopy. Carbon dioxide insufflation,\textsuperscript{25} the patient listening to music,\textsuperscript{26} magnetic endoscope imaging,\textsuperscript{27} and oil lubrication\textsuperscript{28} also were reported to be useful for difficult colonoscopy. Unlike these methods, WEC is characterized by prevention of lengthening and distention of the colon. Only minimal discomfort (maximum pain score of 2.1 ± 1.8) was reported, confirming that the examination was well-tolerated by most unsedated Asian patients.\textsuperscript{12} Thus, it is an appropriate method for the patients who are not suitable for sedation or where sedation is less available. A comparison of WEC with each of the above methods in patients with documented, or in those with factors associated with difficult colonoscopy will be instructive.

The strengths of the present study are in the design (prospective RCT with patient blinding) and in the analysis (intention-to-treat method). The limitations include performance at a single, tertiary-care referral center by only two experienced endoscopists. The lack of blinding of the assistant who gathered the data on pain scores and willingness to repeat unsedated colonoscopy exposed these outcomes to uncertain bias. The absence of statistical significance in the higher polyp detection rate is likely a type II error due to the small sample size.

In conclusion, the current study provides confirmation of the proof-of-principle observations that WEC is applicable in unsedated patients.\textsuperscript{6} Furthermore, WEC significantly enhances cecal intubation in potentially difficult colonoscopy, that is, in unsedated patients with histories of abdominal or pelvic surgery.\textsuperscript{8} The lower pain scores and higher proportion of patients accepting repeat of the unsedated option suggest that WEC is a promising addition to colorectal cancer prevention. It may enhance compliance with colonoscopy in specific populations, for example, in the setting of colorectal cancer screening and surveillance. Whether the current results are applicable to trainee education needs to be further evaluated. The impact of WEC on other factors (eg, female patients with low BMI, older age, previous incomplete colonoscopy due to redundancy and tortuosity, irritable bowel syndrome, inflammatory bowel disease) associated with difficult colonoscopy\textsuperscript{18} also deserves to be assessed in RCTs.

REFERENCES


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