Water exchange method for colonoscopy: learning curve of an experienced colonoscopist in a U.S. community practice setting

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Key words: water exchange, colonoscopy, learning curve

Abbreviations: ITT, intention-to-treat; CIR, cecal intubation rate; ITTCIR, intention-to-treat cecal intubation rate

Background: Water exchange colonoscopy has been reported to reduce examination discomfort and to provide salvage cleansing in unsedated or minimally sedated patients. The prolonged insertion time and perceived difficulty of insertion associated with water exchange have been cited as a barrier to its widespread use.

Aim: To assess the feasibility of learning and using the water exchange method of colonoscopy in a U.S. community practice setting.

Setting: Quality improvement program in nonacademic community endoscopy centers.

Subjects: Patients undergoing sedated diagnostic, surveillance, or screening colonoscopy.

Methods: After direct coaching by a knowledgeable trainer, an experienced colonoscopist initiated colonoscopy using the water method. Whenever >5 min elapsed without advancing the colonoscope, conversion to air insufflation was made to ensure timely completion of the examination.

Primary outcome: Water Method Intention-to-treat (ITT) cecal intubation rate (CIR).

Results: Female patients had a significantly higher rate of past abdominal surgery and a significantly lower ITTCIR. The ITTCIR showed a progressive increase over time in both males and females to 85-90%. Mean insertion time was maintained at 9 to 10 min. The overall CIR was 99%.

Conclusion: Use of water exchange did not preclude cecal intubation upon conversion to usual air insufflation in sedated patients examined by an experienced colonoscopist. With practice ITTCIR increased over time in both male and female patients. Larger volumes of water exchanged were associated with higher ITTCIR and better quality scores of bowel preparation. The data suggest that learning water exchange by a busy colonoscopist in a community practice setting is feasible and outcomes conform to accepted quality standards.

Introduction

The water exchange method with infusion of unrestricted water volume and removal of the water predominantly during insertion of the colonoscope¹ has been reported to be effective in minimizing discomfort and providing salvage cleansing of the sub-optimally prepared colon.^{2,3} For experienced colonoscopists who have not fully mastered the water exchange maneuvers,⁴ the “cumbersome” nature of water exchange has been explicitly described as a deterrent to its full adoption. Technical details including suction removal of the dirty water and replacement with clean water have been deemed time-consuming.⁵ The suspension of debris in luminal water related to the turbulence of water exchange has resulted in poor visualization.⁶ Other

experienced colonoscopists have reported that infusion of a limited volume of warm water which was then removed during withdrawal (water immersion) was adequate in deriving benefits of lowering discomfort.⁷⁻⁹ A systematic review of randomized controlled trials revealed that both water immersion and water exchange significantly reduced pain compared to usual air insufflation, and water exchange may be superior to water immersion in minimizing procedural discomfort in unsedated patients.¹⁰ Mastery of the method has resulted in cecal intubation rates meeting quality performance standards in sedated veteran patients.¹¹ The water exchange method was relatively easy to learn for an experienced colonoscopist but did require practice.¹¹ Despite potential benefits for patients, tight scheduling in the U.S. community practice setting is a distinct disincentive to learning the water exchange method, which requires a unique set of skills and time for practice. The aim of the current study was to assess the feasibility of learning and applying the water exchange method for sedated colonoscopy in a U.S. community practice setting. We tested the hypothesis that intention-to-treat

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Submitted: Apr/30/2012; Revised: Jun/15/2012; Accepted: Jun/05/2012
Previously published online: www.landesbioscience.com/journals/jig
DOI: 10.4161/jig.23734

(ITT) cecal intubation rate (CIR) improves over time when an experienced colonoscopist devotes a portion of the insertion time to practicing the use of water exchange, completing colonoscopy insertion with air insufflation if necessary to conform to the allotted examination time in the schedule.

Methods

All examinations were performed by a single operator on patients in three different endoscopy units over a period of 9 months, from March 2011 through November 2011. No modifications were made to staffing or equipment in any of the endoscopy units to accommodate water method colonoscopy, as these units were utilized by other operators on a regular basis. Examinations were performed with deep intravenous sedation using propofol, administered by anesthesiologists and registered nurse anesthetists. Endoscopy Unit #1 was an outpatient facility devoted to gastrointestinal endoscopy. Present for each case was an anesthesiologist, an assisting medical technician, and the operating gastroenterologist. Procedures were scheduled in one room every 30 min. Endoscopy Unit #2 was an ambulatory surgery center with one endoscopy room. Present for each case was an anesthesiologist or nurse anesthetist, two assisting registered nurses, and the operating gastroenterologist. Procedures were scheduled every 45 min. Endoscopy Unit #3 was a hospital facility devoted to gastrointestinal endoscopy. Present for each case was an anesthesiologist or nurse anesthetist, one assisting registered nurse, one assisting medical technician, and the operating gastroenterologist. Procedures were scheduled every 45 min or 30 min, depending on whether one or two rooms were available.

In order to maximize the quality of initial preparation, all patients were prepared with a split-dose PEG electrolyte solution (PEG/ELS) lavage preparation.^{12,13} Patients were restricted to a clear liquid diet on the day prior to examination, and instructed to consume at least 3 liters of clear liquids during the day. In the evening, they were instructed to drink one liter of the PEG/ELS followed by one liter of clear liquids. Patients were then instructed to drink a second liter of PEG/ELS six hours prior to their scheduled procedure time.

The water method was learned and utilized by Dr. Fischer (after direct coaching by Dr. F.W. Leung on two separate occasions) for routine colonoscopy examinations, with data collection as part of a continuous quality improvement program. Data were collected in writing by the technical assistant assigned to each case on a comprehensive data sheet. In all units, data collection was handled by multiple different assistants, so that brief training and retraining sessions were sometimes required. All examinations were initiated with the water method and the air pump turned off. If gas pockets were encountered in the colon, they were aspirated and replaced with infused water. Whenever insertion difficulty was encountered lasting >5 min, conversion to the more familiar air insufflation method was made, to ensure completion of the examination in a timely fashion to keep up with the schedule of total time for each procedure (interview and consent, insertion, withdrawal inspection, completion of report and data collection, review of results, and room turnover)

ranging from 30 to 45 min.

There were several departures from the “traditional” water exchange method described by Dr. F.W. Leung (1). The existing water infusion equipment present in each unit was not altered or replaced, that is, a warm water bath was not used, no special pumps or tubing were utilized, and room temperature tap water or bottled sterile water were used for infusion. In Unit #1, the water pump was the Olympus OFP Endoscopic Flushing Pump (Olympus Corporation), delivering 225 ml/min. In Unit #2, the water pump was the Endogator Pump (Pentax Corporation), delivering 350 ml/min, and in Unit #3, the water pump was the Olympus OFP Endoscopic Flushing Pump (Olympus Corporation), delivering 150 ml/min. 60 ml syringes of water mixed with simethicone were infused via the biopsy channel for rapid large volume water infusion and exchange when necessary. The primary outcome measured was the water exchange method intention-to-treat cecal intubation rate (ITTTCIR). Other procedure-related variables were recorded by the assistant. Data were tabulated as frequency counts, means and standard deviations (SD). Difference in proportions was assessed by Chi Square test. Difference in continuous variables was assessed by analysis of variance with contrasts and t tests.

Results

110 out of 348 procedures (32%) were performed in Unit #1; 220 out of 348 procedures (63%) were performed in Unit #2; 18 out of 348 procedures (5%) were performed in Unit #3; These outpatients were divided conveniently into 7 groups of 50 each based on the chronological order of colonoscopy. **Table 1** shows the overall demographic variables and procedure-related outcomes. The overall CIR was 99%. The female patients had a significantly higher proportion with a history of abdominal surgery and a significantly lower overall ITTCIR. The consecutive subgroup demographic variables and procedure-related outcomes are shown in **Table 2**. From Group 1 to Group 3, water immersion with limited volume of water infused was practiced after the first session of training. From Group 4 to Group 7, examined following the second session of water exchange training, the ITTCIR showed a progressive increase in both male and female patients from Group 4 to Group 7 (**Table 2**). It is important to note that following performance of 300 cases with the water method, data collection was discontinued at endoscopy unit #1 due to the combination of fixed 30 minute procedure times and the lack of adequate staffing in the room for data collection. Similar problems were encountered at unit #3 when the procedure time was limited to 30 min, often not enough time to allow for procedure completion and data collection. In addition, in unit #3, there were often unscheduled “add on” cases making it more difficult to schedule water method cases. For this reason, fewer cases were scheduled at unit #3. Cases performed with either water or air where data was not collected were not included in the study and excluded from this analysis.

Discussions

The motivation behind engaging in an exercise to learn the

Table 1. Details of the cases at the first and second training session

Cases	First Session	Second Session
Number	7	4
Gender (M:F)	4:3	1:3
Mean age (SD) years	45 (16)	70 (5)
Indication-screening	3	3
Indication-diagnostic	4	1
ITT cecal intubation success	5 (71%)	4 (100%)
Failure	At hepatic flexure, 2	Not applicable
Cecal intubation with air	2	Not applicable
Mean cecal intubation time (SD) min	15 (6)	22 (14)
Volume infused at cecum (SD) ml	Not recorded	1967 (1418)
Volume suctioned at cecum (SD) ml	Not recorded	1967 (1320)
Volume infused at end (SD) ml	857 (483)	2475 (1541)
Volume suctioned at end (SD) ml	843 (387)	2562 (1541)
Abdominal compression used	1 of 7	3 of 4
Position change used	1 of 7	2 of 4
Withdrawal bowel prep score		
Excellent	3	4
Good	3	1
Adenoma detection		
Proximal	1 of 7	3 of 4
Distal	2 of 7	0 of 4

Table 2. Overall demographic variables and procedure-related outcomes

	Overall (348)
Age (years)	57 (13)
Gender (Male)	212
Gender (Female)	136
Prior abd surgery (M/F)	27%/56%*
Overall ITTCIR (Male)	60%
Final CIR (Male)	99%
Overall ITTCIR (Female)	46%**
Final CIR (Female)	98%
Insertion (min)	11
Withdrawal (min)	9.5
Reposition	5%
Abdominal compression	55%

*p=0.0001, Chi Square test, vs. male; **p=0.024, Chi Square test, vs. male.

water exchange method by an experienced colonoscopist who can intubate the cecum in less than 10 min bears elaboration. The author (LS Fischer) provides colonoscopy to a cohort of adults with intellectual and developmental disabilities (IDD).¹⁴ These individuals frequently have comorbidities which interfere with colonoscopy preparation and examination, potentially compromising the quality of examinations. Oropharyngeal dysphagia, gastroesophageal reflux disorder (GERD), esophageal dysmotility, gastroparesis, and constipation are common comorbidities complicating preparation administration. There is little guidance in the literature regarding how to proceed with preparation in these difficult-to-prepare individuals, and there are no evidence-based guidelines regarding how to deal with preparation failure. The water method with water exchange has

been reported to provide salvage cleansing of the colon.^{2,3} In individuals with IDD, water exchange may improve the quality of preparations. Debris may be more effectively removed from the colon with the water exchange method because the lumen is collapsed and the debris is more easily accessible. Water infusion results in turbulence which loosens and suspends the debris for suctioning. Thus, proficiency in the water exchange method may offer an opportunity to test the hypothesis that individuals with IDD with difficult-to-prepare colons can be managed more successfully with this novel approach.¹⁵

Colonoscopy learning curves have been reported primarily for trainees.¹⁶⁻¹⁹ Procedure experience ranging from 100 to 200 cases has been cited as a minimal requirement to achieve competency. Very little information is available with regard to the details of training methods or the details of the maneuvers taught. The learning curve for the water exchange method was recently described by Ramirez et al.¹¹ To establish the learning curve of the water exchange method, an experienced colonoscopist examined 4 consecutive groups of 25 patients each. Outcomes were compared to a historical cohort (n=100) examined by the same colonoscopist using usual air insufflation. Intention-to-treat cecal intubation rate increased from 76% (first) to 96% (fourth quartile). Cecal intubation time in the first 2 quartiles was significantly longer (8.9±1.0 and 8.2±0.8 min, respectively) than that in the historical cohort (5.8±0.4 min) but decreased and became comparable to control values in the next 2 quartiles (7.2±0.9 and 6.6±0.6 min, respectively).

There were two training sessions in the current study. Details of these sessions are shown in **table 1**. The main issue encountered during the first session was the challenge for an endoscopist experienced in air insufflation to change practice habits and

Table 3. Consecutive subgroup demographic variables and procedure-related outcomes

Group (N)	Water Immersion			Water Exchange			
	1 (50)	2 (50)	3 (50)	4 (50)	5 (50)	6 (50)	7 (48)
Age (SD) (years)	61 (13)	57 (12)	57 (12)	55 (13)	55 (14)	56 (14)	61 (11)
Gender (Male)	32	30	30	26	29	34	31
Gender (Female)	18	20	20	24	21	16	17
ITTCIR (Male)	22%	30%	57%	85%	85%	85%	81%
Final CIR (Male)	100%	100%	96%	98%	98%	100%	100%
ITTCIR (Female)	0%**	30%	40%	79%	53%	69%	88%
Final CIR (Female)	98%	100%	92%	98%	100%	100%	100%
Insertion (min)	10 (3)	10 (3)	11 (4)	11 (4)	12 (5)	10 (3)	12 (5)
Withdrawal (min)	10 (4)	9 (4)	9 (4)	10 (4)	10 (4)	9 (4)	10 (4)
Volume infused (ml)	325 (137)	458 (192)	423 (253)	783 (318)	630 (265)	591 (235)	761 (631)
Withdrawal bowel preparation quality	2.9 (0.6)	3.0 (0.7)	3.3 (0.8)	3.7 (0.7)	3.5 (0.8)	3.5 (0.8)	3.8 (0.5)

Data are mean (SD), frequency count, percent of total; ITT, intent-to-treat; CIR, cecal intubation rate; N=50 per group; bowel prep quality scores (1=poor; 4=excellent) obtained during withdrawal; **p=0.024, Chi Square test, vs. male.

adapt to completely new techniques. This involved acceptance of the technical differences of water exchange colonoscopy which are not distending the colon, not "racing" to the cecum, removing all air to shorten and straighten the colon, performing water exchange to remove residual debris, inserting slowly, and having patience to perform water exchange. Leaving behind a familiar, rapid, and effective insertion technique with a near 100% success rate (air insufflation) was difficult. At the outset, there was no expectation of completing even one case with water alone, but in fact 5 out of 7 cases were completed without the use of air insufflation. A positive factor was that the trainer acted only as a coach and advisor, and did not touch the colonoscope. All of the actions were performed by the trainee. This enhanced the training and speeded learning of the technique. Challenges for the trainee included learning to recognize the direction of the lumen under water, recognizing the confluence of folds, learning circumferential examination of the mucosa to identify the direction of the lumen, learning water infusion to expand the lumen and water suction, and learning patience. The main issue at the second session was the challenge of practicing principles of water exchange rather than water immersion. A larger volume of water was infused for cleansing, and removal of all of this water on insertion was attempted. This resulted in high volume water exchange, increased insertion times, and delays in the schedule. Once again, learning to systematically examine the mucosa circumferentially was time consuming. In both training sessions the main limitation was time allowed per case.

The data in the current study confirm that use of the water method to initiate an examination does not preclude cecal intubation upon conversion to usual air insufflation in sedated patients examined by an experienced colonoscopist. With practice, ITTCIR increased over time in both male and female patients. Larger volumes of water exchanged were associated with higher ITTCIR and better bowel preparation quality scores. Mean insertion time was maintained at 9 to 10 min to keep up with the schedule. The overall cecal intubation rate was 99% for all examinations. There was progressive improvement in the ITTCIR, from 22% to 85% in males, and from 0 to 89% in females, over the course of the quality improvement study.

Salvage cleansing of the colon in cases with fair or poor preparation despite a split dose regimen was clearly demonstrated by the data in this report; water exchange (later stage of the study) was more effective than water immersion (early stage of the study). The ITTCIR for water exchange colonoscopy of 85% to 90% achieved after over 300 cases in this quality improvement study was less than the 95% reported by other operators.¹¹ Possible explanations for this lower rate of ITTCIR success in community practice include 30 minute procedure times with reduced time for water exchange, and infusion of room temperature water rather than warmed water with resulting colon spasm and longer insertion times. Factors believed to be associated with a successful outcome (and not reflected in **Tables 2** and **3**) include 45 min procedure times, and two assistants in the examination room to assist with the procedure and data collection.

In conclusion, these learning curve data suggest learning of the water exchange method by a busy colonoscopist in a community practice setting is feasible. Technical improvement occurs over time. Adherence to procedure times is possible with realistic scheduling. Our data are consistent with the findings in other community practice settings in the United States²⁰ and overseas.²¹

Acknowledgements

This study was supported in part by VA and ACG research funds (FWL).

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