A new method for screening and surveillance colonoscopy: Combined water-exchange and cap-assisted colonoscopy

Andrew W. Yen^{1,2}, Joseph W. Leung^{1,2}, Felix W. Leung^{3,4}

¹Division of Gastroenterology, Sacramento Veterans Affairs Medical Center, VANCHCS; ²Division of Gastroenterology and Hepatology, University of California Davis Medical Center; ³Division of Gastroenterology, Sepulveda Ambulatory Care Center, VAGLAHS; ⁴David Geffen School of Medicine at UCLA

Key words: colonoscopy, colon cancer, adenoma, screening, water colonoscopy, cap-assisted colonoscopy

Abbreviations: CRC: colorectal cancer; WCC: water-exchange and cap-assisted colonoscopy; PDR: polyp detection rate; ADR: adenoma detection rate; APC: adenomas per colonoscopy; CAC: cap-assisted colonoscopy; SSP: sessile serrated polyp

Background & Aims: Colonoscopy plays an important and central role in current colorectal cancer screening and prevention programs, but it is an imperfect tool. Adjunct techniques may help improve the performance of colonoscopy to increase the detection of polyps with neoplastic potential. This study investigates the novel approach of combined water-exchange and cap-assisted colonoscopy (WCC) and its impact on adenoma detection.

Methods: A single-center single-colonoscopist consecutive group observational study to compare WCC with conventional air insufflation colonoscopy was performed. Data were collected from 50 consecutive patients undergoing outpatient colorectal cancer screening or polyp surveillance with WCC. Adenoma detection rates (ADR) and adenomas detected per colonoscopy (APC) were compared to a control group of 101 consecutive patients examined with conventional air colonoscopy during the immediate prior period.

Results: Cecal intubation was achieved in all patients. As an emerging and alternative quality metric for colonoscopy, APC was significantly higher in the WCC group (3.08 vs. 1.50, $p=0.0021$). The conventional quality metric, overall ADR, was higher in the WCC group compared to the air colonoscopy group (70.0% vs. 59.4%, $p=0.22$). This difference was not statistically significant, likely due to a type II error.

Conclusion: The observational data suggest APC is a more sensitive indicator of quality colonoscopy than ADR. WCC shows promise as a novel technique that merges two simple adjunct methods to help improve the performance of colonoscopy. The data suggest larger, prospective studies are necessary to determine the true impact of water-exchange combined with cap-assisted maneuvers.

Introduction

Colorectal cancer (CRC) is an important cause of cancer related morbidity and mortality in the United States. It accounts for approximately 10% of all cancer related deaths,¹ which is the basis for recommendations supporting widespread screening and surveillance programs. It is generally agreed that effective CRC screening and prevention relies on the early detection and subsequent removal of polyps with neoplastic potential.² Because of this, colonoscopy plays a central and important role in current screening and prevention programs. Despite recent encouraging reports citing declining CRC incidence and mortality after colonoscopy and polypectomy,³ we must recognize as a screening tool, colonoscopy is still imperfect. Even North American epidemiologic data suggest colonoscopy may not protect against right sided colon cancers⁴⁻⁶ and the reasons for this are likely

multifactorial. Some factors, such as tumor and polyp biology, are out of the control of the endoscopist, while others are more operator dependent, including achieving an adequate bowel preparation at the time of examination, the complete removal of identified polyps, and perhaps most importantly, the quality of mucosal inspection performed during colonoscopy. The latter includes ensuring high cecal intubation rates and spending sufficient time and employing appropriate maneuvers to examine the entire mucosal surface on scope withdrawal. Additionally, recognition of subtle or flat lesions, which can be easily missed, particularly in the proximal colon,⁷ is an essential step in identifying and subsequently removing these lesions.

Because of the current limitations with colonoscopy and wide variability in measured quality indicators among endoscopists, methods that enhance polyp and adenoma detection are desirable and adjunct techniques to improve the performance of colonoscopy have been investigated. In this pilot study, we performed a consecutive group observational study to compare conventional air insufflation colonoscopy with a novel technique of combined water-exchange and cap-assisted colonoscopy (WCC). We test the hypothesis that WCC increases adenoma

*Correspondence to: Andrew W. Yen; Email: andrew.yen3@va.gov
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detection compared to conventional air colonoscopy.

Methods

Data on polyp and adenoma detection were collected from 50 consecutive patients undergoing outpatient CRC screening or surveillance with WCC at our institution. Polyp detection rate (PDR), adenoma detection rate (ADR), and adenomas per colonoscopy (APC) were compared to a control group of 101 consecutive patients who underwent CRC screening or surveillance with conventional air colonoscopy during the immediate prior period. A single endoscopist (AWY) performed all procedures using high definition colonoscopes (Olympus PCF-H180AL, Olympus Medical Systems Corp., Tokyo, Japan). Insertion and withdrawal techniques were performed by the methods defined as follows:

Control method: Air insufflation colonoscopy

Conventional colonoscopy using air insufflation to distend the colon during scope insertion was used in the control group. For this technique, judicious use of air is employed during scope advancement until the cecum is reached. Water is used only for irrigation if poor bowel preparation is encountered. Upon scope withdrawal, air is used to adequately distend the colon to facilitate inspection of the mucosa and biopsy or remove lesions.

Study method: Combined water-exchange and cap-assisted colonoscopy

WCC utilizes the combined approach of water-exchange colonoscopy and cap-assisted colonoscopy (CAC). A transparent cap (Disposable Distal Attachment D-201-12704, Olympus Medical Systems Corp., Tokyo, Japan) (**Fig. 1**) is fitted to the tip of the colonoscope and with the air pump turned off, the scope is inserted into the rectum. Residual air and fluid are immediately suctioned out of the colon and warm water (37 °C) is infused with a paddle pump using the side arm adaptor connected to the scope channel to help minimally distend the lumen for visualization. The scope is advanced and in each colonic segment, this exchange-removal of residual air and stool and infusion of sterile water-is performed. Suction and infusion of fluid can be simultaneously performed with this method. There is no limit to the amount of water used. This facilitates scope passage with minimal distention and lengthening of the colon. Upon identification of the appendiceal orifice under water (**Fig. 2**), water is suctioned and air insufflated to facilitate inspection and removal of lesions (**Fig. 3**). Upon scope withdrawal, the transparent cap is used to assist with mucosal inspection, flattening haustral folds to improve mucosal exposure.

Statistics

Data on polyp and adenoma detection were collected for each group. PDR, the proportion of procedures with at least one polyp, and ADR, the proportion of procedures with at least one adenomatous polyp, were assessed. APC, the mean number of adenomas per colonoscopy (total number of adenomas/total number of procedures) and standard deviations were calculated for each group. Additional data including proximal colon sessile

serrated polyp (SSP) detection rates and total adenomas and SSP in aggregate detected per colonoscopy were recorded and analyzed. Statistical analysis was performed using the Student's t-test for normally distributed continuous variables and the Fisher's exact test for non-continuous variables. Two-tailed p-values were used, with a significant p-value less than 0.05.

Results

Observations in 50 patients undergoing WCC were compared to those of 101 patients undergoing conventional air colonoscopy. There were no significant differences in baseline patient characteristics between groups in this predominantly male population of U.S. veterans (**Table 1**). Comparison of polyp and adenoma detection between the two techniques are reported in table 2. Cecal intubation rates in both groups were 100% ($p=1.0$). PDR (90% vs. 84.2%, $p=0.45$) and ADR (70.0% vs. 59.4%, $p=0.22$) were higher in the WCC group, although neither reached statistical significance with this sample size. Similarly, proximal colon ADR (56.0% vs. 47.5%, $p=0.39$) was higher for WCC, but this difference was not statistically significant. However, the APC was significantly higher in the WCC group compared to historical controls (3.08 vs. 1.50, $p=0.0021$). The proximal colon SSP detection rate (24.0% vs. 9.9%, $p=0.03$) was also significantly higher with the combined approach, with the mean number of proximal colon SSP per colonoscopy approaching statistical significance (0.28 vs. 0.12, $p=0.062$).

Evaluation of polyp and adenoma detection between the first and last ten WCC procedures was also performed to assess the impact of the learning curve for this novel technique (**Table 3**). PDR remained high throughout the study and there was a trend toward increasing ADR (40.0% vs. 90.0%, $p=0.06$) and APC (1.10 vs. 5.00, $p=0.054$) between the first and last ten procedures, but these did not reach statistical significance.

There were no immediate procedural complications noted in the air colonoscopy or WCC groups.

Discussion

The use of water in lieu of air during the insertion phase of colonoscopy, or water-exchange, has received recent attention. Aside from improving patient comfort and decreasing sedation requirements, water-exchange colonoscopy provides the added advantage of salvage cleansing and may assist with optimizing mucosal examination of the colon. This is accomplished by the removal of residual stool and debris and possibly through other plausible but unconfirmed factors such as increasing the proportion of time for uninterrupted examination of the colon (without the need for additional cleaning) or decreasing the number or severity of colonic contractions during the withdrawal phase of examination.⁸ Prior studies have suggested this method has the serendipitous advantage of improving ADR, independent of the quality of bowel preparation,⁹ but variations of this technique (e.g. water immersion, adopted by some colonoscopists) are not without limitations. Studies from proponents of water immersion have suggested decreased cecal intubation rates with this method, primarily related to poor visualization of the colon

Figure 1. Disposable Distal Attachment (D-201-12704, Olympus Medical Systems Corp., Tokyo, Japan)

Figure 3. Cecal polyp seen with cap mounted colonoscope

Figure 2. Underwater endoscopic view of the appendiceal orifice (A) and terminal ileum (B) with the cap mounted scope. Note, the distal attachment is nearly transparent underwater.

in patients with suboptimal bowel preparation.¹⁰ Other perceived drawbacks include increased procedure time,¹¹ concerns regarding large volume water infusion,¹² and anecdotally, induction of mucosal trauma with the amount of suctioning required to remove infused water.

CAC is another simple adjunct technique, utilizing a transparent hood fitted to the tip of the colonoscope to improve mucosal exposure. It allows more thorough evaluation of the colonic mucosa, particularly behind the proximal aspect of haustral folds.¹³ Additional advantages of this method from randomized controlled trials include improved cecal intubation rates,¹³ decreased cecal intubation time,¹⁴ and assistance with endoscopic interventions and polypectomy.¹⁵ Although the data have been conflicting, some studies also suggest improved adenoma detection with this method.¹⁶ Unfortunately, CAC has potential drawbacks as well. Prior studies report impaired endoscopic visualization in individuals with suboptimal bowel preparation when stool or debris becomes lodged in the tip of the

cap.¹⁴ It has also been suggested that passage of the colonoscope with this distal attachment may be challenging through segments of severe diverticulosis.¹⁷

Mizukami and colleagues reported an early variation of water immersion colonoscopy, called the collapse-submergence method, that utilized an opaque rubber attachment fitted to the tip of the colonoscope to help maintain visualization of the lumen.¹⁸ Using water immersion, the scope could be navigated through the distal colon and sigmoid-descending junction. Procedure success relied on a well cleaned colon and air insufflation once the transverse colon was reached. Average cecal intubation success by novice colonoscopists with this technique was 58.6%. Since that report, the water method has evolved with the emergence of water-exchange.⁸ The technique of WCC has not been previously reported, but the concurrent use of these two simple methods has theoretical and practical advantages. In addition to acquiring the benefits of each individual technique, the combined approach can help the endoscopist optimize water-exchange, a more efficient

Table 1. Baseline patient characteristics

	Air	WCC	p
Total number of procedures	101	50	
Mean age of subjects (years)	61.8 (SD 8.3)	62.1 (SD 6.1)	0.8*
Male/female	96/5 (95%/5%)	48/2 (96%/4%)	1.0**

*based on t-test; **Fisher's exact test.

WCC, water-exchange and cap-assisted colonoscopy; SD, standard deviation.

Table 2. Comparison of polyp and adenoma detection between conventional air colonoscopy and combined water-exchange and cap-assisted colonoscopy

	Air	WCC	p
Cecal intubation rate	101 (100%)	50 (100%)	1.0*
Polyp detection rate (PDR)	85 (84.2%)	45 (90.0%)	0.45*
Adenoma detection rate (ADR)	60 (59.4%)	35 (70.0%)	0.22*
Proximal colon ADR	48 (47.5%)	28 (56.0%)	0.39*
Proximal colon SSP detection rate	10 (9.9%)	12 (24.0%)	0.03*
Overall adenoma + proximal colon SSP detection rate	64 (63.4%)	38 (76.0%)	0.14*
Adenomas per colonoscopy (APC)	1.50 (SD 2.0)	3.08 (SD 4.2)	0.0021**
Proximal colon SSP per colonoscopy	0.12 (SD 0.41)	0.28 (SD 0.64)	0.062**
Total number of adenomas + proximal colon SSP per colonoscopy	1.62 (SD 2.04)	3.38 (SD 4.21)	0.0007**

Based on *Fisher's exact test; **t-test.

WCC, water-exchange and cap-assisted colonoscopy; PDR, polyp detection rate; ADR, adenoma detection rate; SSP, sessile serrated polyp; APC, adenomas per colonoscopy; SD, standard deviation.

Table 3. Learning curve for combined water-exchange and cap-assisted colonoscopy: Comparison of polyp and adenoma detection between the first and last ten procedures

	First Ten	Last Ten	p
Cecal intubation rate	10 (100%)	10 (100%)	1.0*
Polyp detection rate (PDR)	10 (100%)	10 (100%)	1.0*
Adenoma detection rate (ADR)	4 (40.0%)	9 (90.0%)	0.06*
Proximal colon ADR	4 (40.0%)	3 (30.0%)	1.0*
Proximal colon SSP detection rate	3 (30.0%)	3 (30.0%)	1.0*
Overall adenoma + proximal colon SSP detection rate	5 (50%)	9 (90.0%)	0.14*
Adenomas per colonoscopy (APC)	1.10 (SD 1.9)	5.00 (SD 5.68)	0.054**
Proximal colon SSP per colonoscopy	0.30 (SD 0.48)	0.50 (SD 0.97)	0.57**
Total number of adenomas + proximal colon SSP per colonoscopy	1.40 (SD 1.9)	5.50 (SD 5.72)	0.045**

Based on *Fisher's exact test; **t-test.

PDR, polyp detection rate; ADR, adenoma detection rate; SSP, sessile serrated polyp; APC, adenomas per colonoscopy; SD, standard deviation.

and effective use of the water method.¹⁹ During the procedure, the simultaneous infusion and removal of water generates turbulence within the lumen of the colon near the tip of the colonoscope. The turbulence dislodges and removes even adherent debris. The exchange of water leaves a net neutral balance of fluid within each segment of bowel to minimize colon distention and maintain patient comfort. With WCC, this exchange can be performed efficiently and almost continuously, as concerns for interruption of exchange are limited. With the conventional water method, normal mucosa often occludes the channel of the scope with frequent suctioning, but with the hood mounted at the tip in WCC, separation between the mucosa and suction port is always maintained, resulting in efficient, uninterrupted exchange.

The biggest theoretical advantage of this combined approach is the observation that the strengths of each individual technique address the limitations of the other. Disadvantages of the water

method discussed above such as decreased cecal intubation and increased cecal intubation time are addressed with the use of the cap itself, which increases the rigidity of the distal scope, and through more effective water-exchange, which quickly clears the lumen of turbid fluid and debris. Even poor bowel preparations can be salvaged with WCC. Additionally, concerns surrounding large volumes of retained fluid are addressed as the water infused during the examination is sequentially removed as the scope is advanced through each bowel segment. Furthermore, mucosal trauma is limited, even with frequent or continuous suctioning, because the cap holds the mucosa away from the suction channel.

Visual impairment from retained debris trapped in the hood during CAC is addressed with WCC as well. The turbulent flow generated at the tip of the scope by continuous water-exchange does not allow debris to settle into the cap attachment. Furthermore, passage of the cap-mounted scope through

segments of severe diverticulosis is aided by the use of water, which straightens bowel segments and helps open the lumen.

In this pilot evaluation, WCC appears to be a feasible approach of combining two simple, complementary techniques that enhance the performance of optical colonoscopy, with potential to improve polyp and adenoma detection. Although PDR and ADR are not significantly improved in this small study, in the hands of an endoscopist with high baseline polyp and adenoma detection, a much larger sample size would be necessary to demonstrate potentially small incremental differences. However, the APC was significantly higher in the WCC group compared to conventional air colonoscopy. APC is an alternative and emerging quality metric for colonoscopy and may be a more accurate indicator of quality examination,²⁰ creating better separation between endoscopists and endoscopic techniques. Baseline APC with conventional air colonoscopy in this population was similar to those previously reported in larger, prospective trials,^{16,21} suggesting the significant difference between techniques found in this pilot study may be noteworthy. Proximal colon SSP detection was also significantly improved with WCC, although the impact of increased detection of these lesions and use of this measure as a quality metric for colonoscopy has not been established.

In this retrospective pilot assessment, procedure times (insertion and withdrawal time), sedation, and detailed assessment of patient characteristics were not comprehensively tracked. All of the withdrawal times, however, were >6 min as recommended by guidelines. The authors are sensitive to the issues regarding withdrawal time and adenoma detection. An adequate withdrawal time (e.g. >6 min) ensures adequate adenoma detection,²² although mandated prolonged withdrawal times do not necessarily increase adenoma detection.²³ In a recent systematic review of randomized controlled trials comparing traditional air insufflation and water-aided methods for colonoscopy,²⁴ all of the studies reviewed met the minimum standard of a 6 minute withdrawal time. Correlation analysis was performed on the reviewed data. There was no significant correlation between withdrawal time and ADR ($r=0.182$; $n=18$, $p=0.472$). The differences between water-exchange and air insufflation in terms of withdrawal time and ADR were also evaluated. Regression analysis shows there is no significant correlation between these two parameters ($r=0.527$; $n=9$, $p=0.145$). The absence of significant correlation between these paired parameters suggests statistical evaluation/transformation to control for the effect of withdrawal time on ADR in studies involving water-aided methods, and by inference in our current report, may not be meaningful. The impact of study and control methods on ADR controlling for "inspection time" will be assessed by our group in future studies. When adenomas are found, the time to perform biopsy and polypectomy lengthens overall withdrawal time. Thus, increased overall withdrawal time may be both the cause of, and result of, increased adenoma detection, which confounds the inference that increased withdrawal time may lead to increased adenoma detection. We hypothesize that the important parameter is inspection time (total withdrawal time minus polypectomy/intervention time minus time spent washing and suctioning residual fecal matter), which is currently

not available in any of the reviewed articles or our pilot study. We feel that regardless of what relationship we obtain with ADR, controlling for withdrawal time, the information may introduce unnecessary confusion in the absence of real data on "inspection time."

An additional notable limitation to the current report is that this was not a blinded study and the observations are subject to operator bias since the procedures were performed by a single endoscopist. Detection rates of the first ten WCC cases (**Table 3**) appeared numerically lower than those of the baseline rates (**Table 2**) with air insufflation colonoscopy. Further comparison of detection rates between the first and last ten WCC procedures showed a trend toward increases in all categories (**Table 3**). Taken together the learning curve indicates some experience with the WCC technique may be required to optimize lesion detection.

Conclusion

WCC shows promise as a novel, simple technique that can assist endoscopists in each phase of colonoscopy: insertion, inspection, and intervention. Larger, prospective studies are necessary to determine its true impact, the most significant being improving adenoma detection. With the significant increase in APC noted in this pilot study, additional investigation with this combined approach deserves consideration.

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Disclosure

The authors have no conflict of interest pertinent to this report to declare.

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