**Name of Journal: *World Journal of Gastrointestinal Endoscopy***

**ESPS Manuscript NO: 21040**

**Manuscript Type: Original Article**

***Retrospective Study***

**Use of automated irrigation pumps improves quality of bowel preparation for colonoscopy**

Ravi S *et al*. Irrigation pumps improve quality of colonoscopy prep

**Sujan Ravi, Rana Sabbagh, Fadi Antaki**

**Sujan Ravi,** Department of Internal Medicine, University of Alabama at Birmingham, Birmingham, AL 35233, United States

**Sujan Ravi, Rana Sabbagh, Fadi Antaki,** Division of Gastroenterology, Department of Internal Medicine, John D. Dingell Veterans Affairs Medical Center and Wayne State University School of Medicine, Detroit, MI 48201, United States

**Sujan Ravi, Rana Sabbagh,** Detroit Medical Center, Detroit, MI 48201, United States

**Author contributions:** Ravi S, Sabbagh R and Antaki F designed the study; Ravi S and Sabbagh R collected data; Ravi S and Antaki F performed data analysis and interpretation, drafting of manuscript and draft revision; Ravi S, Sabbagh R and Antaki F approved the final manuscript.

**Supported by** Resources and the use of facilities at the John D. Dingell VA Medical Center, Detroit, MI, United States.

**Institutional review board statement:** The study was approved by the Wayne State University Institutional Review Board (IRB# 025911M1E(V)) and the John D. Dingell Veterans Affairs Medical Center Research Committee.

**Informed consent statement:** A waiver of informed consent was granted by the Wayne State University Institutional Review Board (IRB) as the study satisfied the following criteria: (1) risk is no more than minimal, (2) the waiver does not adversely affect the rights and welfare of research participants and (3) the research could not be practicably carried out without the waiver. All research participants had signed informed consent for the colonoscopy procedure.

**Conflict-of-interest statement:** None of the authors have any financial conflict of interest in relationship to the submitted manuscript.

**Data sharing statement:** No other data is available.

**Open-Access:** This is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

**Correspondence to: Fadi Antaki, MD, AGAF,** **Associate Professor** of Medicine, Division of Gastroenterology, John D. Dingell VA Medical Center and Wayne State University, 4646 John R Road, C-3825, Detroit, MI 48201, United States. fadi.antaki@va.gov

**Telephone:** +1-313-5763389

**Fax:** +1-313-5761237

**Received:** June 28, 2015

**Peer-review started:** July 6, 2015

**First decision:** August 16, 2015

**Revised:** October 23, 2015

**Accepted:** January 16, 2016

**Article in press:**

**Published online:**

**Abstract**

**AIM**: To evaluate the effectiveness of automated irrigation pumps (AIPs) in improving the quality of the bowel preparation and the yield of colonoscopy.

**METHODS:** A retrospective observational study was conducted at a single medical center. Outpatient colonoscopies performed during a 4-mo time period when AIPs were not in use, were compared to colonoscopies performed during control period. The main outcomes measured were quality of bowel preparation, procedures aborted due to poor preparation, recommendations to repeat at short interval due to sub-optimal bowel preparation and adenoma detection rates.

**RESULTS:** One thousand and thirty-seven colonoscopies were included. A higher proportion of cases did not achieve a satisfactory bowel preparation when AIPs were not used (24.4% *vs* 10.3%, *P* < 0.01). The number of procedures aborted due to inadequate preparation was not significantly different, however a repeat procedure at a short interval was recommended in a higher proportion of cases when AIPs were not used (21.3% *vs* 6.9%, *P* < 0.01). Good or excellent preparation was 2.91 (95%CI: 2.04–4.15) times more likely when AIPs were used. Detection of polyps and adenomas was not significantly different.

**CONCLUSION**: AIP use during colonoscopy results in a higher proportion of colonic preparation rated as satisfactory, although polyp detection rate is not significantly affected. Recommendations for repeat colonoscopy at shorter interval significantly decrease with the use of AIPs. This study supports the use of the irrigation pumps in endoscopy units to improve the quality of colonoscopy.

**Key words:** Automated irrigation pumps; Quality; Colonoscopy; Adenoma; Polyps; Bowel preparation; Surveillance interval

**© The Author(s) 2016.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** The use of automated irrigation pumps during colonoscopy results in higher quality of preparation and decreases recommendations for repeating colonoscopy at short interval.

Ravi S, Sabbagh R, Antaki F. Use of automated irrigation pumps improves quality of bowel preparation for colonoscopy. *World J Gastrointest Endosc* 2016; In press

**INTRODUCTION**

Colorectal cancer (CRC) is the third most common cancer and the second leading cause of cancer deaths in the United States[1,2].Colonoscopy is used for screening to detect early cancer, and may also prevent CRC by detection and removal of the CRC neoplastic precursor, the adenomatous polyp[3-5].Improving the yield of colonoscopy has attracted much attention in recent years[6].In the past, manual irrigation using water-filled syringes, was used to clean any retained fecal matter or colonic contents, in order to allow for a detailed examination of the colonic mucosa and therefore to improve the yield of colonoscopy[7,8].Automated irrigation pumps (AIPs), which are operated by a foot pedal and connect to the auxiliary channel of newer generation endoscopes have largely replaced the manual irrigation method, as they are much more efficient and convenient. It is, however, not known whether the AIPs increase the detection of polyps during colonoscopy when compared to the manual method. Moreover, the efficacy of these AIPs in decreasing the rate of procedures prematurely repeated due to inadequate bowel preparation has also never been studied. The aim of this study is to evaluate the effectiveness of AIPs in improving the quality of the bowel preparation, improving the yield of colonoscopy and decreasing the rate of repeat colonoscopy for inadequate bowel preparation.

**MATERIALS AND METHODS**

***Study design***

The study was conducted at the John D. Dingell Veterans Affairs Medical Center (JDDVAMC) in Detroit, Michigan. It was approved by the Wayne State University Institutional Review Board and the JDD VAMC Research Committee.

A retrospective chart review was performed for colonoscopies completed during the study periods. The use of AIPs was suspended at the endoscopy unit of the JDDVAMC for a period of 4 mo in 2009 for administrative reasons; therefore patients who underwent colonoscopy during this period constituted the main study group. For these procedures, manual irrigation was performed at the request of endoscopist, when retained fecal or bilious material was encountered. It was done by a technician using syringes filled with 60 mL of sterile water through the suction channel of the endoscope. Patients who underwent colonoscopy in an eight-month period in 2008 and 2009 constituted the control groups. They were selected to match the level of training of the gastroenterology fellows involved and the calendar year of the study group. Standard bowel preparation for both groups consisted of conventional dosing of a 4-L polyethylene glycol solution and 15 mg of Bisacodyl the evening prior to endoscopy. Colonoscopies that were aborted due to reasons other than poor colonic preparations, procedures repeated at a short interval (such as for follow-up after piecemeal polypectomy), colonoscopies performed on hospitalized patients, and those performed by non-gastroenterologists were excluded from the study.

Information was collected by review of the medical records about each patient’s demographics, indication for the procedure, history of prior adenomatous polyps or cancer, involvement of a gastroenterology fellow, use of the AIPs, quality of the colonic preparation, detection of polyps and adenomas, with all associated details, and if the procedure was aborted due to sub-optimal preparation or if it was advised to repeat the procedure sooner than recommended by guidelines due to the quality of the preparation.

Colonoscopy was performed using Olympus Q160 and Q180 endoscopes (Olympus America Inc., Center Valley, PA). Some procedures were performed by an attending physician alone (board-certified in Gastroenterology), while, in other cases, the attending physician directly supervised a gastroenterology fellow. Attending physicians involved in the procedures were the same during the different study periods. AIPs (OFP, Olympus America Inc., Center Valley, PA) were available in every procedure room and routinely connected to the endoscope during the control period. Indications for colonoscopy were classified into either screening or diagnosis. The bowel preparation was determined by the attending physician for every case and reported in the endoscopy report using the Aronchick scale[9],as excellent, good, fair or poor. For our study, we considered the bowel preparation to be satisfactory if the procedure report described it as either good or excellent, no retained fecal material was mentioned in the findings and no recommendation for repeat at short interval for sub-optimal bowel preparation was made.

The primary outcomes were quality of the bowel preparation and the number of procedures aborted or repeated early due to sub-optimal preparation. The secondary outcomes evaluated were detection rates for polyps and adenomas.

***Statistical analysis***

SAS version 9.3 (SAS Institute, Cary, NC) was used for statistical analyses. For the preliminary descriptive analyses, *χ*2 test was used for the description of categorical variables and a two-sided *t*-test was used for continuous variables for the comparison of means. Multivariable logistic regression model was used to compare the outcomes between the groups. Odds ratio was considered to be statistically significant if the *P* value was less than 0.05.

**RESULTS**

Information was collected for a total of 1037 colonoscopies. AIPs were used for 709 procedures. Mean age of the group was 60.23 years. Majority was male (93.5%). The study group included 535 (51.6%) African-Americans and 487 (47%) Caucasians. Five hundred and sixty-four colonoscopies were performed for screening or surveillance (54.4%), while 473 (45.6%) were performed for diagnostic purposes. Two hundred and seventy-two (26.2%) of the patients had a prior history of polyps/CRC. The two groups were not significantly different in the demographic factors, endoscopist, indication for the procedure or history of polyps or CRC (Table 1).

A significantly higher proportion of cases did not achieve a satisfactory bowel preparation when manual flushes were used as compared to when AIPs were used (24.4% *vs* 10.3%, *P* < 0.01) (Table 2). Although the number of procedures aborted due to poor preparation was slightly higher in the group with manual flushes, this was not statistically different (*P* = 0.10). However a repeat procedure at a short interval was recommended in a significantly higher proportion of cases when manual flushes were used (21.3% *vs*. 6.9%, *P* < 0.01). On multivariate logistic regression analysis, after adjusting for indication, history of polyps or CRC, sex, age, and race, odds of calling bowel preparation satisfactory was 2.91 (95%CI: 2.04-4.15) times more likely when AIPs were used in comparison to manual flushes. When adjusted for the same variables, the detection of polyps and adenomas was not significantly different between the two groups.

**DISCUSSION**

Colonoscopy is a cost-effective (USD 11900 per year of life gained)[10] tool for screening and prevention of CRC through the detection and removal of pre-cancerous, adenomatous polyps. However sub-optimal bowel preparation limits the effectiveness of colonoscopy as it can result in a higher than usual rate of missed polyps, which can lead to interval cancers[11].Studies have shown than endoscopists do not always follow guidelines and frequently recommend repeat colonoscopy at a shorter interval than suggested by those guidelines[12,13]. This makes colonoscopy less cost-effective as a CRC screening modality. The reasons for such recommendations are not well known[12],however the fear of missed lesions when bowel preparation is sub-optimal is probably a major factor[14].

For all these reasons, a lot of attention has been paid in recent years towards improving the quality of bowel preparation, such as multiple studies comparing different types and brands of laxatives used for bowel preparation, as well as the recommended changes in the timing of those laxatives to “split dose” [15].

However, there has not been much research to evaluate the effectiveness of AIPs in enhancing the adenoma detection rate, improving the quality of bowel preparation or decreasing the rate of procedures prematurely aborted and repeated due to inadequate bowel preparation. Our study supports the hypothesis that the use of AIPs during colonoscopy results in a significantly higher proportion of colonic preparation being rated as satisfactory with a corresponding decline in the odds of recommending a repeat procedure at a shorter than usual interval.

Our study results are in concurrence with other studies evaluating the relationship between quality of the bowel prep and the recommendation from the endoscopist about the timing of the repeat procedure[16-18.] As colonoscopy is usually aborted when the bowel preparation is very poor and unlikely to be improved with any type of irrigation, manual or automated, there was no difference in the rate of procedures aborted for poor preparation in our study.

Although studies have shown an increase in adenoma and polyp detection rate with improvement in the quality of bowel prep[16,19-21],we did not find an increased rate of adenoma or polyp detection with the use of AIPs, despite the improvement in the quality of the bowel preparation. We believe this could possibly be from the heightened vigilance of the endoscopist when the use of AIPs was suspended for a limited period of time in our unit, and the results might have been different if the AIPs were introduced for the first time during the study.

The study has a few limitations. The retrospective design has some inherent limitations. The determination of the quality of preparation was based on each individual endoscopist’s interpretation on the Aronchick scale. Withdrawal time was not routinely recorded in our endoscopy unit at the time of the study. The influence of cleaning using manual flushes or AIPs on total procedure as well as on withdrawal times, which might be different depending on the quality of the bowel preparation, could not be determined. The total volume of water used in either group was not recorded. Although the devices were routinely connected to the endoscope for every single case in the AIPs group, while they were not available in the other group, we could not determine if irrigation by either method was indeed used in every case. Some of the information that could influence adenoma detection rate such as lifestyle and dietary habits could not be evaluated. The sample in itself included both diagnostic and screening colonoscopies. We attempted to alleviate the bias by adjusting for indication of colonoscopy. In addition, our study population was from a Veterans Affairs medical center with a majority of African-American males. This might limit the generalizability of the results of the study. The suspension of the use of AIPs for a period of time might by itself have led to results that could be different if AIPs were being introduced to an endoscopy unit for the first time. As we used the conventional bowel preparation regimen in our endoscopy unit at the time of the study, we could not evaluate the usefulness of AIPs with split dose bowel regimen.

In conclusion, our study provides evidence that AIPs improve the endoscopist assessment of the quality of the bowel preparation and reduce the number of repeat procedures due to sub-optimal preparation. This supports the widespread use of these devices in endoscopy units to improve the quality of colonoscopy.

**COMMENTS**

***Background***

Colonoscopy is used for screening to detect early cancer, and may also prevent colorectal cancer (CRC) by detection and removal of the CRC neoplastic precursor, the adenomatous polyp.Automated irrigation pumps (AIPs), which are operated by a foot pedal and connect to the auxiliary channel of newer generation endoscopes have largely replaced the manual irrigation method, as they are much more efficient and convenient. It is, however, not known whether the AIPs increase the detection of polyps during colonoscopy when compared to the manual method. Moreover, the efficacy of these AIPs in decreasing the rate of procedures prematurely repeated due to inadequate bowel preparation has also never been studied.

***Research frontiers***

AIPs, which are operated by a foot pedal and connect to the auxiliary channel of newer generation endoscopes have largely replaced the manual irrigation method, as they are much more efficient and convenient.

***Innovations and breakthroughs***

The aim of this study is to evaluate the effectiveness of AIPs in improving the quality of the bowel preparation, improving the yield of colonoscopy and decreasing the rate of repeat colonoscopy for inadequate bowel preparation.

***Applications***

This study provides evidence that AIPs improve the endoscopist assessment of the quality of the bowel preparation and reduce the number of repeat procedures due to sub-optimal preparation. This supports the widespread use of these devices in endoscopy units to improve the quality of colonoscopy.

***Peer-review***

This manuscript by Ravi *et al* describes a retrospective evaluation of patients receiving colonoscopy performed with manual irrigation or an automatic irrigation device. The manuscript is certainly relevant to modern endoscopic practices.

**REFERENCES**

1 **Jemal A**, Siegel R, Ward E, Hao Y, Xu J, Murray T, Thun MJ. Cancer statistics, 2008. *CA Cancer J Clin* 2008; **58**: 71-96 [PMID: 18287387 DOI: 10.3322/CA.2007.0010]

2 **American Cancer Society.** Cancer Facts & Figures 2014.Atlanta: American Cancer Society. 2014

3 **Zauber AG**, Winawer SJ, O'Brien MJ, Lansdorp-Vogelaar I, van Ballegooijen M, Hankey BF, Shi W, Bond JH, Schapiro M, Panish JF, Stewart ET, Waye JD. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *N Engl J Med* 2012; **366**: 687-696 [PMID: 22356322 DOI: 10.1056/NEJMoa1100370]

4 **Bokemeyer B,** Bock H, Huppe D, Düffelmeyer M, Rambow A, Tacke W, Koop H. Screening colonoscopy for colorectal cancer prevention: results from a German online registry on 269000 cases. *Eur J Gastroenterol Hepatol* 2009; **21:** 650-655 [DOI: 10.1097/MEG.0b013e32830b8acf]

5 **Lieberman DA**, Weiss DG, Bond JH, Ahnen DJ, Garewal H, Chejfec G. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. Veterans Affairs Cooperative Study Group 380. *N Engl J Med* 2000; **343**: 162-168 [PMID: 10900274]

6 **Imperiale TF**, Glowinski EA, Juliar BE, Azzouz F, Ransohoff DF. Variation in polyp detection rates at screening colonoscopy. *Gastrointest Endosc* 2009; **69**: 1288-1295 [PMID: 19481649 DOI: 10.1016/j.gie.2007.11.043]

7 **Froehlich F**, Wietlisbach V, Gonvers JJ, Burnand B, Vader JP. Impact of colonic cleansing on quality and diagnostic yield of colonoscopy: the European Panel of Appropriateness of Gastrointestinal Endoscopy European multicenter study. *Gastrointest Endosc* 2005; **61**: 378-384 [PMID: 15758907]

8 **Harewood GC**, Sharma VK, de Garmo P. Impact of colonoscopy preparation quality on detection of suspected colonic neoplasia. *Gastrointest Endosc* 2003; **58**: 76-79 [PMID: 12838225]

9 **Aronchick CLW,** Wright S, DuFrayne F, Bergman G. Validation of an instrument to assess colon cleansing. *AM J Gastroenterol* 1999; **94:** 2667

10 **Maciosek MV**, Solberg LI, Coffield AB, Edwards NM, Goodman MJ. Colorectal cancer screening: health impact and cost effectiveness. *Am J Prev Med* 2006; **31**: 80-89 [PMID: 16777546]

11 **Baxter NN**, Goldwasser MA, Paszat LF, Saskin R, Urbach DR, Rabeneck L. Association of colonoscopy and death from colorectal cancer. *Ann Intern Med* 2009; **150**: 1-8 [PMID: 19075198]

12 **Saini SD**, Nayak RS, Kuhn L, Schoenfeld P. Why don't gastroenterologists follow colon polyp surveillance guidelines?: results of a national survey. *J Clin Gastroenterol* 2009; **43**: 554-558 [PMID: 19542818 DOI: 10.1097/MCG.0b013e31818242ad]

13 **Mysliwiec PA**, Brown ML, Klabunde CN, Ransohoff DF. Are physicians doing too much colonoscopy? A national survey of colorectal surveillance after polypectomy. *Ann Intern Med* 2004; **141**: 264-271 [PMID: 15313742]

14 **Menees SB**, Kim HM, Elliott EE, Mickevicius JL, Graustein BB, Schoenfeld PS. The impact of fair colonoscopy preparation on colonoscopy use and adenoma miss rates in patients undergoing outpatient colonoscopy. *Gastrointest Endosc* 2013; **78**: 510-516 [PMID: 23642491 DOI: 10.1016/j.gie.2013.03.1334]

15 **Cohen B,** Tang RS, Groessl E, Herrin A, Ho SB. Effectiveness of a simplified "patient friendly" split dose polyethylene glycol colonoscopy prep in Veterans Health Administration patients. *J Interv Gastroenterol* 2012; **2**: 177-182 [PMID: 23687605]

16 **Lebwohl B**, Kastrinos F, Glick M, Rosenbaum AJ, Wang T, Neugut AI. The impact of suboptimal bowel preparation on adenoma miss rates and the factors associated with early repeat colonoscopy. *Gastrointest Endosc* 2011; **73**: 1207-1214 [PMID: 21481857 DOI: 10.1016/j.gie.2011.01.051]

17 **Ben-Horin S**, Bar-Meir S, Avidan B. The impact of colon cleanliness assessment on endoscopists' recommendations for follow-up colonoscopy. *Am J Gastroenterol* 2007; **102**: 2680-2685 [PMID: 17714555]

18 **Menees SB**, Elliott E, Govani S, Anastassiades C, Judd S, Urganus A, Boyce S, Schoenfeld P. The impact of bowel cleansing on follow-up recommendations in average-risk patients with a normal colonoscopy. *Am J Gastroenterol* 2014; **109**: 148-154 [PMID: 24496417 DOI: 10.1038/ajg.2013.243]

19 **Adler A**, Wegscheider K, Lieberman D, Aminalai A, Aschenbeck J, Drossel R, Mayr M, Mroß M, Scheel M, Schröder A, Gerber K, Stange G, Roll S, Gauger U, Wiedenmann B, Altenhofen L, Rosch T. Factors determining the quality of screening colonoscopy: a prospective study on adenoma detection rates, from 12,134 examinations (Berlin colonoscopy project 3, BECOP-3). *Gut* 2013; **62**: 236-241 [PMID: 22442161 DOI: 10.1136/gutjnl-2011-300167]

20 **Chokshi RV**, Hovis CE, Hollander T, Early DS, Wang JS. Prevalence of missed adenomas in patients with inadequate bowel preparation on screening colonoscopy. *Gastrointest Endosc* 2012; **75**: 1197-1203 [PMID: 22381531 DOI: 10.1016/j.gie.2012.01.005]

21 **Sherer EA**, Imler TD, Imperiale TF. The effect of colonoscopy preparation quality on adenoma detection rates. *Gastrointest Endosc* 2012; **75**: 545-553 [PMID: 22138085 DOI: 10.1016/j.gie.2011.09.022]

**P-Reviewer:** Alberti LR, Chow WK, Kim BW, Pauli E

**S-Editor:** Song XX **L-Editor:** **E-Editor:**

**Table 1 Baseline characters of the study population**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Manual flushes | Automated irrigation pumps | *P* value |
| *n* | 328 | 709 |  |
| Age, yr (mean, 95%CI) | 60.0 (59.0-61.1) | 60.3 (59.6-61.1) | 0.70 |
| Gender, *n* (%) | 0.34 |
| Female | 18 (5.5) | 49 (6.9) |  |
| Male | 310 (94.5) | 660 (93.1) |  |
| Race, *n* (%) | 0.47 |
| African-American | 176 (53.7) | 359 (50.6) |  |
| Caucasian | 146 (44.5) | 341 (48.1) |  |
| Others | 6 (1.8) | 9 (1.3) |  |
| Performed by: *n* (%) | 0.42 |
| Attending physician alone | 65 (19.8) | 156 (22.0) |  |
| GI fellow with attending physician | 263 (80.2) | 553 (78.0) |  |
| Indications, *n* (%) | 0.09 |
| Screening | 191 (58.2) | 373 (52.6) |  |
| Diagnostic | 137 (41.8) | 336 (47.4) |  |
| History of CRC /polyps, *n* (%) | 0.55 |
| No | 238 (72.6) | 527 (74.3) |  |
| Yes | 90 (27.4) | 182 (25.7) |  |

GI: Gastroenterology; CRC: Colorectal cancer.

**Table 2 Colonoscopy results stratified by the use of the automated irrigation pumps**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Manual flushes | Automated irrigation pumps | Odds ratio (95%CI)*P* value |
| *n* | 328 | 709 |  |
| Prep quality, *n* (%) |  |  | 2.91 (2.04 to 4.15)*P* < 0.01 |
| Sub-optimal prep | 80 (24.4) | 73 (10.3) |  |
| Satisfactory prep | 248 (75.6) | 636 (89.7) |  |
| Procedure aborted due to poor prep, *n* (%)  | 2.45 (0.92 to 6.50)*P* = 0.10 |
| No | 323 (98.5) | 684 (96.5) |  |
| Yes | 5 (1.5) | 25 (3.5) |  |
| Recommendation to repeat early due to prep quality, *n* (%) | 0.27 (0.18 to 0.40)*P* < 0.01 |
| No | 258 (78.7) | 660 (93.1) |  |
| Yes | 70 (21.3) | 49 (6.9) |  |
| Polyp detection, *n* (%) | 0.85(0.64 to 1.12)*P* = 0.60 |
| Yes | 194 (59.2) | 407 (57.4) |  |
| No | 134 (40.8) | 302 (42.6) |  |
| Adenoma detection, *n* (%) | 0.99(0.75 to 1.31)*P* = 0.65 |
| Yes | 133 (40.6) | 298 (42.0) |  |
| No | 195 (59.4) | 411 (58.0) |  |