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***Retrospective Study***

**Split-dose bowel preparation improves adequacy of bowel preparation and gastroenterologists’ adherence to National Colorectal Cancer Screening and Surveillance Guidelines**

Menees SB *et al*. Impact of split-dose bowel regimen on GI follow-up recommendations

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**Abstract**

***aim***

to quantify the impact of split-dose regimen on endoscopists’ compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

***METHODS***

A retrospective chart review of all endoscopy reports in average-risk individuals > 50 years old with a normal screening colonoscopy and 1-2 small polyps was undertaken. Data was abstracted from two time periods, pre and post-split-dose bowel preparation institution. Main outcome measurements were recommendation for timing of repeat colonoscopy and bowel preparation quality. Bivariate analysis with chi-square tests and student *t*-tests were performed to assess differences between the two cohorts. Multivariable logistic regression was used with guideline consistent recommendations as the dependent variables and an indicator for 2011 cohort as the primary predictor.

***Results***

Four thousand two hundred and twenty-five patients were included in the study; 47.0% (1987) prior to the institution of split dose bowel preparation, and 53.0% (2238) after the institution of split dose bowel preparation. Overall, 82.2% (*n* = 3472) of the colonoscopies were compliant with guideline recommendations, with a small but significant, increased compliance rate in year 2011 (83.7%) compared to year 2009 (80.4%, *P* = 0.005), corresponding to an unadjusted odds ratio of 1.25 (95%CI: 1.07-1.47; *P* = 0.005). Colonoscopies with either “Adequate” or “Excellent” had increased from 30.6% in year 2009 to 39.6% in year 2011 (*P* < 0.001). However, there was no significant difference in poor/inadequate category of bowel preparation as there was a mild increase from 4.6% in year 2009 to 5.1% in year 2011 (*P* = 0.50).

***Conclusion***

Split-dose bowel regimen increases endoscopists’ compliance to guidelines in average risk patients with normal colonoscopy or 1-2 small polyps.

**Key words:** Colorectal cancer screening; Bowel preparation; Colonoscopy; Average-risk

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**C****ore tip:** We evaluated the impact of split-dose regimen on endoscopists’ compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm). We retrospectively evaluated 4255 patients who underwent colonoscopy during two time periods, pre and post the institution of split-dose bowel preparation. We found that split-dose bowel regimen increased endoscopists’ compliance to guidelines in average risk patients with normal colonoscopy or 1-2 small polyps. Additionally, bowel preparation quality with either “Adequate” or “Excellent” had increased between the two time periods.

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**INTRODUCTION**

National guidelines state that average-risk 50+ year old individuals who have normal screening colonoscopy should get a repeat colonoscopy in 10 years. However, physician recommendations do not always comply with guidelines. Krist *et al*[[1](#_ENREF_1)] reviewed whether endoscopists’ recommendations for patients undergoing colonoscopy for all indications adhered to published guidelines for follow-up recommendations. In only 64.9% of all reports, the endoscopist specified when retesting should occur. Recommendations were consistent with current guidelines in 36.7% of cases. However, Krist *et al*[[1](#_ENREF_1)] did not account for patient bowel preparation at the time of the procedure in determining guideline consistent recommendation. Based on our previous research, bowel prep was the single most important factor determining compliance by endoscopists for follow-up colonoscopies[[2](#_ENREF_1)]. Patients with fair bowel prep were 18.0 times (95%CI: 12.0-28.0) more likely to have recommendations inconsistent with guidelines compared to patients with excellent/good preps.

In addition to association with guideline inconsistent recommendations, suboptimal colonoscopy preparation reduces adenoma detection rate (ADRs) and is a risk factor for incomplete colonoscopy[[3-5](#_ENREF_3)]. To reduce the incidence of suboptimal bowel preparation, research has focused on the timing of the bowel preparation dosing in relation to the colonoscopy. The split-dosing regimen, where patients take a portion of the laxative the evening prior to colonoscopy and the other half on the day of colonoscopy, improves the bowel preparation quality. Studies have consistently shown that split-dose regimen is superior to administration of preparation on the day or night before the colonoscopy[6]. As early as 2009, the ACG CRC Screening Guidelines recommended institution of split-dose bowel preparation[7]. However, adoption of the split-dose bowel preparation has lagged due to providers’ concern of patient compliance[8,9].

New quality measures assessing physician adherence to guidelines have been instituted by the Centers for Medicare and Medicaid Services (CMS) through the Physician Quality Reporting System (PQRS). For the Physician Quality Reporting System (PQRS), participating endoscopists’ will report the frequency of recommending repeat colonoscopy in 10 years after a normal colonoscopy in an average-risk patient. For participation, endoscopists will receive a small bonus in Medicare payments. In 2014, failure to report this resulted in a reduction in Medicare payments. Beside this economic factor, it’s essential to guide CMS on what is an acceptable compliance rate for this quality measure (the frequency of recommending repeat colonoscopy in 10 years after a normal colonoscopy in an average-risk patient) and continue to assess the impact of bowel preparation on physician recommendation, particularly with split-dose bowel preparation. We hypothesize that the institution of split dosing bowel preparation will reduce recommendations inconsistent with guidelines for follow-up colonoscopies in patients with normal colonoscopy or 1-2 small polyps (< 10 mm). Therefore, the objective of this research is to quantify the impact of split-dose regimen on endoscopists’ compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

**Materials and Methods**

***Study design***

With Institutional Review Board approval, a retrospective comparative review of medical records of from two time periods; pre and post institution of split-dose bowel regimen was performed. Medical records of 50 year and older consecutive average-risk patients undergoing colonoscopy for CRC screening in the outpatient setting between January 1, 2009 thru December 31, 2009 (pre-implementation of split-dose bowel regimen) and January 1, 2011 thru December 31, 2011 (post-implementation of split-dose bowel regimen) were reviewed. Inclusion criteria were average risk patients referred for colorectal cancer screening colonoscopy with none, 1 or 2 identified polyps. Subjects were excluded for the following reasons:concurrent gastrointestinal symptoms (*e.g.*, anemia, overt or obscure GI blood loss, abdominal pain, diarrhea, unexplained weight loss); family history of CRC; personal history of CRC, colon polyps, hereditary CRC syndrome, inflammatory bowel disease; detection of any colonic polyps, or incomplete colonoscopies (*i.e.*, failure to visualize the appendiceal orifice and cecum). Only colonoscopies performed by gastroenterologists that were present in both calendar years were included. Patients with follow-up recommendations for “Barium Enema” or “Discontinue due to age” were also excluded.

***Protocol for bowel preparation and definition of bowel preparation quality***

Bowel preparation details are included in Table 1 for same day bowel preparation utilized in 2009 and split-dose bowel preparation utilized in 2011. Bowel preparation quality and other endoscopic data were reported via the ProVation® Medical Systems v.42 and University of Michigan endoscopy sites, respectively. Endoscopists rated bowel preparation quality according to the percentage of colonic mucosa visualized during the colonoscopy based on the Aronchick score which has been previously validated: “Excellent”: greater than 95% of mucosa visualized; “Good”: 90%-95% of mucosa visualized; “Fair”: 80%-90% of mucosa visualized; and “Poor”: less than 80% mucosal visualization. An endoscopist could also report bowel preparation quality as “Adequate” or “Inadequate” if they felt the preparation did or did not, respectively, allow for the detection of polyps 5 mm or larger[10].

***Endoscopists’ recommendation intervals***

Data were abstracted from patient colonoscopy report forms, pathology report and follow-up pathology letter for the endoscopists’ recommendation for follow-up screening colonoscopy. Follow-up recommendations were determined by adherence to the American College of Gastroenterology 2009 guidelines[7]. Recommendations consistent with guidelines included follow-up in 10 years, follow-up in 5 to 10 years for 1-2 small adenomas (as determined by pathologists), or ≤ 1 year if bowel preparation quality was rated poor or inadequate regardless of the number of polyps. Any deviations from these recommendations were considered inconsistent with guidelines. If no recommendation was given by the endoscopist, it was classified as inconsistent with guidelines.

***Subject and procedure data***

Data were collected from medical notes on subject demographic, clinical, and procedural factors. Demographics included age, gender, and race/ethnicity; clinical factors comprised body mass index (BMI), concurrent narcotics and tricyclic antidepressant (TCA) usage, and diabetic status. Colonoscopy procedure data were collected on type of bowel preparation agent used, whether a GI fellow participated, and procedure completion status. Specific endoscopist characteristics were not collected due to IRB concerns of the ability to identify specific gastroenterologists with the collected information.

***Statistical analysis***

Recommendation appropriateness was determined as either consistent or inconsistent with guidelines as described above under Endoscopist Recommendation Intervals. Primary exposure variable of interest was the institution of split-dose bowel preparation, and thus was the year 2011 *vs* 2009. Chi-square tests and student *t*-tests were used to assess differences in various demographic and procedure characteristics between 2009 *vs* 2011 cohort. To test if the institution of split-dosing bowel preparation reduced the percent of follow-up recommendations consistent with guidelines in patients with normal colonoscopy, logistic regression was used with guideline consistent recommendations as the dependent variables and an indicator for 2011 cohort as the primary predictor. Other independent predictors of guideline consistent recommendations included age, sex, race, BMI, narcotics use, TCA use, diabetes, and procedure characteristics. Odds ratios and 95% confidence intervals were obtained from the logistic regression model parameter estimates. Statistical analysis was performed using Stata 13.1 (StataCorp LP, College Station, TX, United States)

**RESULTS**

A total of 4225 patients were included in the study with 47.0% (1987) from year 2009 prior to the institution of split dose bowel preparation, and 53.0% (2238) from year 2011 after the institution of split dose bowel preparation. Overall, 82.2% (*n* = 3472) of the colonoscopies were compliant with guideline recommendations, with a significantly higher compliance in year 2011 (83.7%) than in year 2009 (80.4%, *P* = 0.005), corresponding to an unadjusted odds ratio of 1.25 (95%CI: 1.07-1.47; *P* = 0.005).

Patient and procedure characteristics are summarized by study year in Table 2. Patients from year 2011 tended to be younger than those from year 2009 (means of 55.5 *vs* 56.1, respectively), but the difference was because 0% of year 2011 patients were 75 year or older, while 2.6% (52 of 1987) of year 2009 patients were 75 years or older. Patients from the two years were also different with respect to other characteristics including race and tricyclic antidepressant use. Although the distribution of bowel preparation quality was significantly different between the two years, the difference was not in “Poor” or “Inadequate” bowl quality. Specifically, in colonoscopies with bowel preparation quality ratings noted using four-level quality ratings only, colonoscopies rated as “Excellent” increased from 26.5% in year 2009 to 37.8% in year 2011, while those rated as “Poor” increased only slightly from 2.8% in 2009 to 3.1% in 2011. Similarly, when the binary rating of “Adequate” was combined with “Excellent” and “Inadequate” combined with “Poor” for colonoscopies without the four-level bowel preparation quality noted, the percentage of colonoscopies with “Excellent” or “Adequate” bowel preparation increased from 30.6% in year 2009 to 39.6% in year 2011 (*P* < 0.001, from comparing “Excellent” or “Adequate” *vs* other quality ratings), while the percentage of “Poor” or “Inadequate” quality increased from 4.6% in year 2009 to 5.1% in year 2011 (*P* = 0.50). Thus the split-dose preparation appears to have resulted in higher percentage of excellent/adequate preparation quality by reductions in mid-quality colonoscopies, but made no significant difference in poor/inadequate category of bowel preparation. Another important shift between the two years was the higher rate of MiraLAX®/Gatorade® use as the bowel preparation type in 2011 compared with 2009 (57.1% *vs* 28.3%).

Year 2011 cohort remained more likely to give guideline consistent recommendations (OR = 1.25, Table 3) even after adjusting for age, gender, race, BMI, current narcotics use, TCA use, type II diabetes, site and presence of polyp. Increasing age was associated with significantly lower odds of guideline consistent recommendations, and patients with type II diabetes was associated with 0.68 times lower (*P* = 0.005) odds of guideline consistent recommendations. On the other hand, the participation of gastrointestinal (GI) fellows (*P* = 0.02) or having a colonoscopy with one or two polyps (as determined by pathology) were associated with a significant higher likelihood (*P* < 0.001) of guideline consistent recommendations.

Between the two years, in addition the implementation of split-dosing, the primary exposure of interest, we found both bowel quality and bowel preparation distributions to have changed significantly. To assess if the increased compliance between the two years can be explained by changes in preparation quality (which we expected to be associated with split dosing), changes in preparation type, or both, we further adjusted the model with the bowel preparation quality and bowel preparation type. After further adjusting for bowel preparation quality, we no longer found compliance difference between the two years [OR = 1.12 (95%CI = 0.93-1.34, *P* = 0.25)]. In addition, compared with “Excellent” or “Adequate” quality, all other preparation quality ratings were associated with lower odds of compliant recommendations: the adjusted OR of compliance for “Good” preparation was 0.48 (*P* < 0.001), “Fair” was 0.05 (*P* < 0.001), and “Poor” or “Inadequate” was 0.11 (*P* < 0.001). Similarly, when bowel preparation type categories were added to the model, the difference between the two years in compliance was no longer significant (OR = 1.16, *P* = 0.10), although bowel preparation type was not statistically significant, either. Lastly, compliance difference between the two years was not significant (OR = 1.03, *P* = 0.76) when both preparation quality and preparation type were included.

In summary, from year 2009 to year 2011, a significant increase in guideline consistent recommendations was seen, a significant increase in “Excellent” or “Adequate” colonoscopies were seen, a significant increase in the use of MiraLAX®/Gatorade® was seen, and the significant increase in guideline consistent recommendations from year 2009 to 2011 were no longer significant after controlling for either bowel preparation quality or bowel preparation type. To explore further whether the changes in preparation quality or changes in preparation type that led to increased compliance, we also fit logistic regression models separately by year (Table 4). In both 2009 and 2011 colonoscopies, we found preparation quality to be independent predictors of compliance whether adjusted for preparation type or not; however, preparation type was a significant predictor of compliance only in 2009 colonoscopies, prior to split-dosing. These results suggested that split dosing likely reduced any differences in preparation quality associated with preparation type and hence resulted in less difference in compliance.

**DISCUSSION**

In our analysis of average risk CRC screening patients, implementation of split-dose bowel preparation led to an increase in guideline consistent recommendation, as indicated by increased percentage of guideline consistent recommendations from year 2009 to year 2011. Both the unadjusted and covariate adjusted odds ratios indicate a significant increase in guideline consistent recommendation from the year before to after the implementation of split-dose preparation. Additionally, we also found an increase percentage of bowel preparations rated as “Excellent” in quality between years 2009 to 2011, and it appears split-dose preparation led to decreases the percentage of “Good” and “Fair” preparation, but not in “Poor” preparation. Further analyses showed that an increase in guideline compliant recommendations from year 2009 to 2011 was explained by increased “Excellent” bowel preparation or decreased “Good” or “Fair” preparation. We reached this conclusion from the findings that (1) a significant increase in guideline consistent recommendations was seen from year 2009 colonoscopies to year 2011 colonoscopies; (2) a significant increase in “Excellent” or “Adequate” colonoscopies were seen from year 2009 to year 2011; and (3) the significant increase in guideline consistent recommendations from year 2009 to 2011 were no longer significant after controlling for bowel preparation quality. Our study adds further support for the use of split-dose bowel regimen as it is now uniformly recommended to optimize bowel preparation for colonoscopy[7,11-13].

This study is unique as it is the first to look at endoscopists’ recommendations as an outcome pre- and post-introduction of split-dose bowel preparation. Studies of physician post-colonoscopy recommendations have shown varying compliance to guidelines. A retrospective review of screening and surveillance colonoscopies demonstrated endoscopists’ compliance in 81% of subjects based on pathology[14]. However, recommendations were only provided in 74% of their cohort. This study removed bowel preparation as a factor as poor or fair bowel preparation or lack of bowel preparation data were exclusion criteria. These findings are markedly better than Krist *et al*[1]. where recommendations were only provided in 64.9% of reports. In studies including bowel preparation in their investigation, uniformly bowel preparation quality impacts the likelihood of endoscopists’ guideline compliance. Ransohoff *et al*[15] found that follow-up recommendations in bowel preparations less than excellent were associated with shorter surveillance intervals for those with no polyps, small or medium adenomas. Additionally, Rex *et al*[16] demonstrated that imperfect bowel preparation lead to a higher likelihood of patients to be brought back earlier than suggested or required by current practice standards (20% *vs* 12.5%, *P* = 0.04). Our study contributes data for future benchmarks for endoscopist compliance of guidelines in the real world, split-bowel preparation setting, as the Centers for Medicare and Medicaid Services (CMS) requires reporting of quality indicators through the Physician Quality Reporting System.

Significant patient and procedural characteristics were associated with both a higher and lower likelihood of guideline-inconsistent follow-up recommendations. Two patient characteristics associated with a higher likelihood of guideline-inconsistent recommendations included increasing age and the co-morbidity of diabetes mellitus. Both characteristics are associated with CRC. Increasing age is the strongest non-modifiable risk factor for the development of colorectal cancer[17]. The likelihood of CRC begins to increase after age 40 with a peak incidence between the ages of 65-79. For diabetes mellitus, Larsson *et al*[18]. performed a meta-analysis of more than 2.5 million patients that demonstrated a 30% increased risk of CRC relative to non-diabetic individuals. This finding was constant even when controlling for BMI and physical activity. This literature may explain the association for early repeat colonoscopy recommendations in patients with these characteristics. However, two procedural characteristics, finding 1-2 polyps regardless of pathology and having a GI fellow participate in the colonoscopy were less likely to have guideline-inconsistent follow-up recommendations. Surveys of gastroenterologists have shown an improvement in guideline knowledge and agreement for follow-up recommendations for colonoscopies[19,20]. Saini *et al*[19] assessed gastroenterologists’ knowledge of the 2003 guidelines for management of various polyps. At that time, only 63.6% knew the correct interval for 2 small adenomas, but also 28.8% of gastroenterologists disagreed with the guideline. In 2010, Shah *et al*[20] surveyed Veterans Affairs gastroenterologists’ similar questions about the 2006 polyp surveillance guidelines. Ninety-five percent of gastroenterologists identified the correct 5-10 years interval for one 8 mm adenoma. In this cohort of GI doctors, only 7% of those who knew guidelines correctly would deviate from clinical guidelines in their clinical practice. With the finding of any type of polyp, our endoscopists are compliant and know the guidelines. Additionally, gastroenterology fellows participating in the colonoscopy reduced the likelihood of inconsistent guidelines. The influence would have to be on the procedure itself as the attending physician is responsible for the follow-up pathology letter. In the literature, GI trainees have been noted to have positive impact on adenoma detection rate with the hypothesis that longer withdrawal times increase the likelihood of polyp detection or having an additional person involved in the colonoscopy allows optimal visualization[21-23]. For our cohort, the fellows’ presence may have allowed better visualization (possible more patience with stool clearance) or as a reminder for guideline compliance.

Our study has several potential limitations. As this study was retrospective in nature, the preparation type, preparation quality documentation and endoscopist recommendations are limited to the medical records. Furthermore, patients who were prescribed spilt-dose bowel regimen during the second time period may not have actually taken it as recommended. Another limitation is the lack of use of quality assessment tool training of such as the Boston Bowel Preparation Scale; however the grading scale in Provation® is based on the Aronchick scale[10,24]. Additionally, there may be variability amongst physician reporting of bowel preparation quality that is not able to be captured by the retrospective nature of this study. The generalizability of the study may be limited since it involved only procedures performed by academic physicians, although the study was conducted at outpatient ambulatory surgery centers, and in-hospital academic medical centers.

In conclusion, our study demonstrates that besides increasing bowel preparation quality, split-dose bowel preparation also increases guideline consistent recommendations in average risk patients with normal colonoscopy or 1-2 small polyps. Our data adds further justification for the routine use of split-dose bowel in daily practice. Education about recent guideline recommendations and the need for split-dose bowel preparation should be continued.

**Article Highlights**

***Research background***

Split-dose bowel regimen is considered standard of care for bowel preparation in national guidelines. Since it improves bowel preparation quality, we should see an increase endoscopists’ compliance to guidelines.

***Research motivation***

Split-dose bowel regimen is recommended in national guidelines for colonoscopy bowel preparation. There is no data on how institution of split-dose bowel preparation can maximize the proportion of patients with an “excellent” bowel prep and quantify the impact of “excellent” bowel prep on increasing the likelihood of recommending an appropriate interval for repeat screening/surveillance colonoscopies.

***Research objectives***

Examine the impact of split-dose regimen on endoscopists’ compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

***Research methods***

We conducted this retrospective study of colonoscopies performed in average-risk individuals 50 or greater from two time periods, pre and post-split bowel preparation institution. Only patients with normal or 1-2 small polyps were included. Primary and secondary outcome measurements included: recommendation for timing of repeat colonoscopy and bowel preparation quality, respectively. Bivariate analysis and multivariable logistic regression were utilized to assess the impact of split-dosing bowel preparation on both physician follow-up recommendation and bowel preparation quality.

***Research results***

After the institution of split-dose bowel regimen, there was a small, but significant increase in physician compliance to guideline recommendations in patients with normal colonoscopy and 1-2 small polyps. This correlated to the increase in both excellent and adequate bowel preparation. There was no measurable change in the amount of patients who had poor/inadequate bowel preparation.

***Research conclusions***

In this current study, our research supports the use of split-dose bowel regimen to help optimize bowel preparation. Improvement of bowel preparation quality increases the likelihood of physician compliance for follow-up colonoscopy in patients with normal colonoscopy and 1-2 small polyps.

***Research perspectives***

This study supports the use of split-dose bowel regimen for colonoscopy bowel preparation. Our study also acquired information on endoscopist compliance to CRC screening guidelines after the implementation of split-dose preparation in order to provide a new baseline for comparison. Improvement in endoscopist compliance can help make colonoscopy more cost-effective. It is crucial for endoscopist to abide by current guidelines, as recommending earlier colonoscopies not only exposes patients to excess procedural risk, but also drains limited resources that could be used for unscreened patients. This study provides pilot data for future endoscopist-based interventions.

**References**

1 **Krist AH**, Jones RM, Woolf SH, Woessner SE, Merenstein D, Kerns JW, Foliaco W, Jackson P. Timing of repeat colonoscopy: disparity between guidelines and endoscopists' recommendation. *Am J Prev Med* 2007; **33**: 471-478 [PMID: 18022063 DOI: 10.1016/j.amepre.2007.07.039]

2 **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]

3 **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]

4 **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 DOI: 10.1067/mge.2003.294]

5 **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]

6 **Bucci C**, Rotondano G, Hassan C, Rea M, Bianco MA, Cipolletta L, Ciacci C, Marmo R. Optimal bowel cleansing for colonoscopy: split the dose! A series of meta-analyses of controlled studies. *Gastrointest Endosc* 2014; **80**: 566-576.e2 [PMID: 25053529 DOI: 10.1016/j.gie.2014.05.320]

7 **Rex DK**, Johnson DA, Anderson JC, Schoenfeld PS, Burke CA, Inadomi JM; American College of Gastroenterology. American College of Gastroenterology guidelines for colorectal cancer screening 2009 [corrected]. *Am J Gastroenterol* 2009; **104**: 739-750 [PMID: 19240699 DOI: 10.1038/ajg.2009.104]

8 **Altawil J**, Miller LA, Antaki F. Acceptance of split-dose bowel preparation regimen for colonoscopy by patients and providers. *J Clin Gastroenterol* 2014; **48**: e47-e49 [PMID: 24296425 DOI: 10.1097/MCG.0b013e3182a9f78d]

9 **Lin OS**, Schembre DB. Are split bowel preparation regimens practical for morning colonoscopies? Implications of the new american college of gastroenterology colon cancer screening guidelines for real-world clinical practice. *Am J Gastroenterol* 2009; **104**: 2627-8; author reply 2628-9 [PMID: 19806092 DOI: 10.1038/ajg.2009.415]

10 **Aronchick CA**, Lipshutz WH, Wright SH, Dufrayne F, Bergman G. Validation of an instrument to assess colon cleansing [abstract]. *Am J Gastroenterol* 1999; **94**: 2667

11 **American Society of Colon and Rectal Surgeons (ASCRS)**; American Society for Gastrointestinal Endoscopy (ASGE); Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), Wexner SD, Beck DE, Baron TH, Fanelli RD, Hyman N, Shen B, Wasco KE. A consensus document on bowel preparation before colonoscopy: prepared by a Task Force from the American Society of Colon and Rectal Surgeons (ASCRS), the American Society for Gastrointestinal Endoscopy (ASGE), and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). *Surg Endosc* 2006; **20**: 1161 [PMID: 16799744 DOI: 10.1007/s00464-006-3037-1]

12 **Lieberman DA**, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology* 2012; **143**: 844-857 [PMID: 22763141 DOI: 10.1053/j.gastro.2012.06.001]

13 **Johnson DA**, Barkun AN, Cohen LB, Dominitz JA, Kaltenbach T, Martel M, Robertson DJ, Boland CR, Giardello FM, Lieberman DA, Levin TR, Rex DK; US Multi-Society Task Force on Colorectal Cancer. Optimizing adequacy of bowel cleansing for colonoscopy: recommendations from the US multi-society task force on colorectal cancer. *Gastroenterology* 2014; **147**: 903-924 [PMID: 25239068 DOI: 10.1053/j.gastro.2014.07.002]

14 **Ratuapli SK**, Gurudu SR, Atia MA, Crowell MD, Umar SB, Harrison ME, Leighton JA, Ramirez FC. Postcolonoscopy Followup Recommendations: Comparison with and without Use of Polyp Pathology. *Diagn Ther Endosc* 2014; **2014**: 683491 [PMID: 25242879 DOI: 10.1155/2014/683491]

15 **Ransohoff DF**, Yankaskas B, Gizlice Z, Gangarosa L. Recommendations for post-polypectomy surveillance in community practice. *Dig Dis Sci* 2011; **56**: 2623-2630 [PMID: 21698368 DOI: 10.1007/s10620-011-1791-y]

16 **Rex DK**, Imperiale TF, Latinovich DR, Bratcher LL. Impact of bowel preparation on efficiency and cost of colonoscopy. *Am J Gastroenterol* 2002; **97**: 1696-1700 [PMID: 12135020 DOI: 10.1111/j.1572-0241.2002.05827.x]

17 **Siegel RL**, Miller KD, Fedewa SA, Ahnen DJ, Meester RGS, Barzi A, Jemal A. Colorectal cancer statistics, 2017. CA Cancer J Clin 2017; 67: 177-193 [PMID: 28248415]

18 **Larsson SC**, Orsini N, Wolk A. Diabetes mellitus and risk of colorectal cancer: a meta-analysis. *J Natl Cancer Inst* 2005; **97**: 1679-1687 [PMID: 16288121 DOI: 10.1093/jnci/dji375]

19 **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]

20 **Shah TU**, Voils CI, McNeil R, Wu R, Fisher DA. Understanding gastroenterologist adherence to polyp surveillance guidelines. *Am J Gastroenterol* 2012; **107**: 1283-1287 [PMID: 22951869 DOI: 10.1038/ajg.2012.59]

21 **Buchner AM**, Shahid MW, Heckman MG, Diehl NN, McNeil RB, Cleveland P, Gill KR, Schore A, Ghabril M, Raimondo M, Gross SA, Wallace MB. Trainee participation is associated with increased small adenoma detection. *Gastrointest Endosc* 2011; **73**: 1223-1231 [PMID: 21481861 DOI: 10.1016/j.gie.2011.01.060]

22 **Rogart JN**, Siddiqui UD, Jamidar PA, Aslanian HR. Fellow involvement may increase adenoma detection rates during colonoscopy. *Am J Gastroenterol* 2008; **103**: 2841-2846 [PMID: 18759826 DOI: 10.1111/j.1572-0241.2008.02085.x]

23 **Peters SL**, Hasan AG, Jacobson NB, Austin GL. Level of fellowship training increases adenoma detection rates. *Clin Gastroenterol Hepatol* 2010; **8**: 439-442 [PMID: 20117245 DOI: 10.1016/j.cgh.2010.01.013]

24 **Lai EJ**, Calderwood AH, Doros G, Fix OK, Jacobson BC. The Boston bowel preparation scale: a valid and reliable instrument for colonoscopy-oriented research. *Gastrointest Endosc* 2009; **69**: 620-625 [PMID: 19136102 DOI: 10.1016/j.gie.2008.05.057]

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**Table 1 Utilized colonoscopy preparations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Bowel preparation** | **Diet and fluid instructions** | **Traditional dosing (night before)** | **Split dose-bowel preparation** |
| PEG, HalfLytely, NuLYTELY®, or TriLyte, | Clear liquid diet for lunch and dinner;Ingest other clear liquids between doses of laxative. | Take 8 oz. every 15 min until it was gone between 12 pm. and 6 pm. | Between 5 pm and 6 pm the night before colonoscopy, drink one (8 oz.) glass of laxative and continue drinking one (8 oz). glass every 15 min until 2 l (64 oz.) of the prep solution is gone;Drink the final 2 l (64 oz.) of prep solution 5 h before you need to leave for your procedure. |
| MoviPrep®, | Clear liquid diet for lunch and dinner;Ingest other clear liquids between doses of laxative. | Take 8 oz. every 15 min until it was gone between 12 pm. and 6 pm. | Between 5 pm. and 6 pm., begin drinking the prep;The MoviPrep container is divided by 4 marks;Every 15 min drink the solution down to the next mark (about 8 oz.), until the full liter has been consumed;Over the course of the evening, drink an additional 0.5 L of clear liquids;The next day, drink the final liter (32 oz.) of prep solution 5 h before you need to leave for your procedure. |
| MiraLAX®(PEG 3350) /Gatorade® | Clear liquid diet for lunch and dinner;Ingest other clear liquids between doses of laxative. | Take 2 tablets of bisacodyl between 12 pm. and 6 pm., 4 h later take 8 oz. of the MiraLAX®/Gatrade® mixed in 2 liters of Gatorade® every 15 min until gone. | At 12 noon, take 2 Dulcolax tablets;Between 5 and 6 pm, drink one (8 oz.) glass of the Miralax/Gatorade solution and continue drinking one (8 oz.) glass every 15 min thereafter until half the mixture (32 oz.) is gone.The next day, drink the final liter (32 oz.) of prep solution 5 h before you need to leave for your procedure. |
| OsmoPrep | Clear liquid diet for lunch and dinner;Ingest other clear liquids between doses of laxative. | Take first set of 20 tablets between 12 noon and 6 pm;Take a dose of 4 tablets every 15 min with at least 8 ounces of clear liquid;The second set of 12 tablets was to be taken 10-16 h after in the same manner as described above. | Between 5 and 6 pm take 4 tablets with 8 oz. of any clear liquid every 15 min;You will take a total of 20 tablets and drink 40 oz. of clear liquids over a 1 h period.The next day, 5 h before you need to leave for your procedure, take 4 tablets with 8 oz. of any clear liquid every 15 min;You will take a total of 12 tablets and drink 24 oz. of clear liquid over a 30-min period. |

**Table 2 Patient and procedure characteristics by study year: 2009 is prior to split dosing, and 2011 is after split dosing**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristic** | **2009 (*n* = 1987)** | **2011 (*n* = 2238)** | **Total (*n* = 4225)** | ***P* value**1 |
| Age, yr |  |  |  |  |
| ≤ 55 | 1096 (55.2) | 1311 (58.6) | 2407 | < 0.001 |
| 55-65 | 606 (30.5) | 674 (30.1) | 1,280 |  |
| 65-75 | 233 (11.7) | 253 (11.3) | 486 |  |
| ≥ 75 | 52 (2.6) | 0 (0) | 52 |  |
| Female | 1099 (55.3) | 1182 (52.8) | 2281 | 0.10 |
| Race/ethnicity |  |  |  |  |
| White or Hispanic | 1652 (83.1) | 1846 (82.5) | 3498 | < 0.001 |
| Black | 131 (6.6) | 160 (7.1) | 291 |  |
| Asian  | 128 (6.4) | 129 (5.8) | 257 |  |
| Other | 20 (1.0) | 100 (4.5) | 120 |  |
| BMI (kg/m2), mean (SD) | 1871 (94.2) | 2213 (98.9) | 4084 | 0.61 |
| Current narcotics2 use |  |  |  |  |
| Yes | 131 (6.6) | 163 (7.3) | 294 | 0.36 |
| No | 1856 (93.4) | 2066 (92.3) | 3922 |  |
| Current TCA use |  |  |  |  |
| Yes | 47 (2.4) | 31 (1.4) | 78 | 0.02 |
| No | 1940 (97.6) | 2198 (98.2) | 4138 |  |
| Type II diabetes |  |  |  |  |
| Yes | 164 (8.3) | 201 (9.0) | 365 | 0.40 |
| No | 1823 (91.7) | 2037 (91.0) | 3860 |  |
| Bowel prep quality  |  |  |  |  |
| Adequate or excellent | 592 (30.6) | 886 (39.6) | 1478 | < 0.001 |
| Good | 1044 (54.0) | 1048 (46.9) | 2092 |  |
| Fair  | 209 (10.8) | 189 (8.5) | 398 |  |
| Inadequate or poor | 89 (4.6) | 113 (5.1) | 202 |  |
| Polyp present |  |  |  |  |
| Yes | 745 (37.5) | 807 (36.1) | 1552 | 0.33 |
| No | 1242 (62.5) | 1431 (63.9) | 2673 |  |
| Prep type |  |  |  |  |
| 8L PEG | 5 (0.3) | 17 (0.8) | 22 | < 0.001 |
| MiraLAX®/Gatorade® | 541 (28.3) | 1228 (57.1) | 1769 |  |
| 4L PEG, GoLYTELY, NuLYTELY, Colyte, TriLyte | 1015 (53.1) | 771 (35.9) | 1786 |  |
| Half-Lytely,Osmoprep, Moviprep, other | 352 (18.4) | 133 (6.2) | 485 |  |
| Prep type |  |  |  |  |
| MiraLAX®/Gatorade® | 541 (28.3) | 1228 (57.1) | 1769 | < 0.001 |
| 4L PEG, GoLYTELY, NuLYTELY, Colyte,TriLyte | 1015 (53.1) | 771 (35.9) | 1786 |  |
| Half-Lytely, Osmoprep, Moviprep, other | 357 (18.7) | 150 (7.0) | 507 |  |
| GI fellow present |  |  |  |  |
| Yes | 187 (9.4) | 303 (13.5) | 490 | < 0.001 |
| No | 1800 (90.6) | 1935 (86.5) | 3735 |  |

All values are *n* (%), unless otherwise specified. The total number of patients for each characteristic may not add to total (*n* = 4225) due to missing data. 1From testing differences in the distribution of characteristics between years; based on *t*-test for continuous variables and *χ*2 test for categorical variables; 2Narcotics are Opiods and their derivatives. Common narcotics include morphine, heroin, hydrocodone, Oxycodone, Methadone, Clonitazene. BMI: Body mass index; TCA: Tricyclic antidepressant.

**Table 3 Adjusted odds ratios of guideline consistent recommendations in average risk patients (*n* = 4023)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic**  | **OR** | ***P* value** | **95%CI** |
| Year 2011 | 1.25 | 0.01 | (1.05, 1.47) |
| Age, yr |  |  |  |
| ≤ 55 | 1.00 |  |  |
| 55-65 | 0.80 | 0.02 | (0.67, 0.97) |
| 65-75 | 0.64 | < 0.001 | (0.50, 0.82) |
| ≥ 75 | 0.40 | 0.004 | (0.21, 0.74) |
| Male | 0.94 | 0.44 | (0.79, 1.11) |
| Race/ethnicity |  |  |  |
| White or Hispanic | 1.00 |  |  |
| Black | 0.90 | 0.52 | (0.66, 1.24) |
| Asian | 1.09 | 0.63 | (0.76, 1.56) |
| Other | 1.00 | 0.99 | (0.61, 1.64) |
| BMI (kg/m2) | 0.99 | 0.10 | (0.97, 1.00) |
| Current Narcotics1 use | 0.79 | 0.14 | (0.59, 1.08) |
| Current TCA use | 0.89 | 0.71 | (0.50, 1.60) |
| Type II Diabetes | 0.68 | 0.006 | (0.52, 0.89) |
| Polyp present | 2.29 | < 0.001 | (1.89, 2.77) |
| GI fellow present | 1.48 | 0.02 | (1.06, 2.08) |

1Narcotics are Opiods and their derivatives; Common narcotics include morphine, heroin, hydrocodone, Oxycodone, Methadone and Clonitazene. BMI: Body mass index; TCA: Tricyclic antidepressant.

**Table 4 Adjusted1 odds ratios of guideline consistent recommendations in average risk patients obtained from logistic regression models fit separately by each year**

|  |  |  |
| --- | --- | --- |
|  | **2009****Before split-dosing** | **2011****After split-dosing** |
| **OR** | ***p* value** | **95%CI** | **OR** | ***p* value** | **95%CI** |
| Prep Quality |  |  |  |  |  |  |
| Adequate or excellent | 1.0 |  |  |  |  |  |
| Good | 0.55 | 0.001 | (0.38, 0.78) | 0.44 | < 0.001 | (0.32, 0.61) |
| Fair  | 0.04 | < 0.001 | (0.03, 0.06) | 0.06 | < 0.001 | (0.04, 0.09) |
| Inadequate or Poor | 0.17 | < 0.001 | (0.09, 0.30) | 0.08 | < 0.001 | (0.05, 0.13) |
| Bowel prep type |  |  |  |  |  |  |
| MiraLAX®/Gatorade® | 1.0 |  |  | 1.0 |  |  |
| 4L PEG, GoLYTELY, NuLYTELY, Colyte, TriLyte | 0.65 | 0.013 | (0.46, 0.91) | 1.10 | 0.485 | (0.84, 1.45) |
| Half-Lytely, Osmoprep, Moviprep, other | 0.62 | 0.032 | (0.41, 0.96) | 0.70 | 0.134 | (0.44, 1.12) |

1Adjusted also for all variables listed under Table 3.