Published in final edited form as:

Clin Gastroenterol Hepatol. 2016 August ; 14(8): 1155–1162. doi:10.1016/j.cgh.2016.03.044.

HIGH-QUALITY BOWEL PREPARATION IS REQUIRED FOR DETECTION OF SESSILE SERRATED POLYPS

Brian T. Clark, M.D.¹ and Loren Laine, M.D.^{1,2}

¹Yale School of Medicine, New Haven, CT

²VA Connecticut Healthcare System, West Haven, CT

Abstract

Background & Aims—The effect of bowel preparation quality has been well-characterized for detection of adenomas but not for detection of sessile serrated adenomas/polyps (SSPs). We performed a prospective study to determine proportions of patients in whom SSPs were detected at different levels of bowel preparation quality, using common validated scoring systems.

Methods—Our study enrolled 749 male veterans 50–75 years old undergoing screening or surveillance colonoscopy. Proportions of patients in whom SSP were detected were calculated for each level of preparation quality based on the Aronchick scale (poor=low quality, fair=intermediate quality, and good or excellent=high quality) and the Boston bowel preparation scale (BBPS, scores of 0–3 for right, transverse, and left colon segments). We compared SSP detection among different levels of preparation quality using multivariate logistic regression, adjusting for age, indication, and endoscopist. Our primary hypothesis was that SSP detection would not be significantly lower with intermediate-quality than with high-quality preparations.

Results—SSPs were detected in a significantly smaller proportion of patients with intermediate-quality preparation than high-quality preparation, for the entire colon (4.6% vs 12.0%; odds ratio [OR]=0.37; 95% confidence interval [CI], 0.15–0.87) and right colon (1.5% vs 7.9%; OR= 0.19; 95% CI, 0.05–0.81). SSPs were detected in smaller proportions of patients with total colon BBPS scores <7 than in patients with BBPS scores of 7–9 (4.7% vs 12.6%; OR=0.36; 95% CI, 0.19–0.67). SSPs were detected in right colons of a smaller percentage of patients with BBPS scores of 2 than scores of 3 (4.7% vs 9.5%; OR=0.50; 95% CI, 0.26–0.94).

Conclusions—Any bowel preparation quality below high quality is associated with a significant decrease in the detection of SSPs. Although intermediate-quality preparation and BBPS

Correspondence: Loren Laine, MD, Section of Digestive Diseases P.O. Box 208019, New Haven, CT 06520-8019, loren.laine@yale.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Disclosures: None.

Writing Assistance: None.

Author Contributions: Both authors were fully involved in study concept and design, acquisition, analysis and interpretation of data, and drafting and critical revision of manuscript. Both authors approved the final draft submitted.

segment scores of 2 appear to be adequate for detection of adenomas, these levels of preparation quality may not be adequate for detection of SSPs.

Keywords

colonoscopy; colorectal neoplasm; quality; colon cancer; early detection

INTRODUCTION

The use of screening and surveillance colonoscopy significantly reduces both the incidence and mortality from colorectal cancer.^{1–4} However, colonoscopy remains imperfect. Approximately 2 to 10% of colorectal cancers are interval cancers, found within 6 to 60 months after colonoscopy and before the next recommended surveillance.^{5–9} Polyps associated with the serrated pathway, including sessile serrated adenomas/polyps and traditional serrated adenomas have become increasingly recognized as an important potential cause of interval cancers. Sessile serrated adenomas/polyps (SSPs) may be more difficult to detect endoscopically than traditional adenomas because they are subtle lesions, typically flat or sessile with indistinct margins.^{10, 11} Recent data suggest an association between SSPs and both missed lesions and interval colorectal cancer development in the right colon.^{8, 12–15} Inadequate detection and removal of these SSPs is suspected to be one cause of the inferior protection of colonoscopy for proximal compared to distal colorectal cancer.^{6, 15, 16}

The effectiveness of screening and surveillance colonoscopy hinges upon adequate visualization and removal of neoplastic polyps, and the adenoma detection rate (ADR) is now accepted as the primary quality indicator for screening colonoscopy, given its documented correlation with interval cancers.^{17, 18} The quality of bowel preparation is a key factor for adenoma detection. In a prior systematic review we found that intermediate-quality prep does not decrease ADRs as compared to high-quality prep¹⁹, while low-quality bowel prep has consistently been shown to be associated with inferior ADRs and advanced ADRs.^{19–23} Given the subtle nature of SSPs, one would hypothesize that the quality of bowel prep would impact the ability of an endoscopist to identify SSPs—with potentially even greater impact than on detection of traditional adenomas. However, the impact of prep quality on detection of SSPs is not well characterized. While an expert panel suggested that prep quality should affect detection of SSPs²⁴, no studies have actually evaluated this. Two previous studies reported no association of bowel prep quality with serrated polyp detection rate or proximal serrated polyp detection rate,^{25, 26} even for poor prep as compared to optimal prep. However these studies included proximal hyperplastic polyps in their analyses and were not limited solely to SSPs.^{25, 26}

Our study therefore aimed to prospectively evaluate the detection rates of SSPs (both overall and specific to the right colon) related to the quality of bowel preparation. Based on the findings from our previous meta-analysis evaluating traditional adenomas¹⁹ our primary hypothesis was that intermediate-quality (fair) prep was associated with no significant difference in SSPDR or right-colon SSPDR compared to high-quality (excellent or good) prep, using the most commonly employed ordinal scoring method, the Aronchick scale²⁷. To allow for improved generalizability, we also evaluated these outcomes using two prep

scoring methods recommended by current guidelines^{28, 29}; the Boston Bowel Preparation Scale (BBPS)^{30, 31}, which is a valid and reliable quantitative scoring system, and a dichotomous system of adequate or inadequate, which is recommended for determining whether patients may return at guideline-recommended screening/surveillance intervals or need early repeat colonoscopy.^{17, 29}

METHODS

Study Population

All men, age 50–75 years, undergoing colonoscopy for an indication of screening or surveillance at the West Haven Veterans Affairs Medical Center were invited to participate prospectively. Exclusion criteria included the following: prior resection of any portion of the colon or rectum, active anti-thrombotic therapy preventing polypectomy, American Society of Anesthesiologists Class 3 or higher, familial polyposis syndrome, inflammatory bowel disease, inability to achieve cecal intubation, a total BBPS of 0 (solid stool covering all segments of colon), or inability to completely remove a polyp (e.g., polyp too large). Eligible patients were recruited before their scheduled procedure and informed consent was obtained.

This study was approved by the institutional review board of the Veterans Affairs West Haven Medical Center in November 2013 with continuing review approval in November 2014.

Study Design

Eligible patients who consented to participation underwent their planned colonoscopy by one of the four study endoscopists (attending gastroenterologists on the faculty at an academic institution) assigned to perform procedures that day per normal standard of care. The colonoscope was passed to the cecum, the colonoscope was withdrawn with washing and aspirating of colonic contents as needed to optimize visualization of colonic mucosa and the mucosa was carefully examined. As part of the study protocol, all endoscopists agreed before initiation of the study to remove all polyps that were identified, as would be done for any other screening or surveillance examination. Tiny polyps (< 3 mm) in the rectum and distal sigmoid colon determined to have characteristics of hyperplastic polyps could be left at the discretion of the endoscopist.³² All procedures were performed using Olympus (Tokyo, Japan) EVIS Exera II high-definition colonoscopes. Narrow band imaging could be used at the discretion of the endoscopist. Each polyp was submitted for histological assessment per usual standard of care.

Data Collection

Characteristics of all polyps detected were prospectively recorded and included location (right, transverse, or left colon), size (using visual comparison with forceps of known dimension and/or visualization after retrieval), morphology (sessile/flat vs. pedunculated), and histological characteristics. Other data prospectively collected included age, indication (screening, surveillance), participating study endoscopist, and withdrawal time. Withdrawal

time was the total time for withdrawal from cecum to anus and included all interventions and other delays including irrigation, aspiration, biopsies, and polypectomies.

Outcome Definitions

Overall SSPDR was defined for each level of prep quality as the number of those colonoscopies in which at least one SSP was detected divided by the total number of colonoscopies with that level of prep quality. Right colon SSPDR was calculated similarly, using only data from the right colon (cecum and ascending colon, per BBPS definition²⁰). Only sessile-serrated adenomas/polyps and traditional serrated adenomas were included in our definition of SSP as defined histologically by histopathologists using standard definitions.²⁴ All pathologists providing histologic diagnoses were trained in GI pathology and had previously reviewed and agreed upon the features that classify a serrated polyp as an SSP rather than a hyperplastic polyp as outlined in current consensus guidelines: dilated and/or branched crypts, particularly basally; excessive serration and mature goblet cells and mucinous cells in basal half of crypts; and often excessive extracellular mucin.²⁴ Polyps that were classified as hyperplastic polyps were not included in our definition of SSP.²⁴ Pathologists were blinded to the prep quality.

Bowel Prep Quality Definition

After completing the colonoscopy the endoscopist rated the adequacy of bowel preparation using three different scoring systems. To mirror the structure of our previous meta-analysis evaluating ADR and prep quality¹⁹, the scale used for the primary assessment of bowel prep quality in this study was the modified Aronchick scale: a 4-point ordinal scale rated after washing as “excellent” (a small volume of clear liquid with >95% of mucosal surface seen), “good” (a large volume of clear liquid but >90% of mucosal surface seen), “fair” (some semi-solid stool that could be suctioned or washed away but > 90% of mucosal surface seen) and “poor” (semi-solid stool that could not be suctioned or washed away with <90% of mucosal surface seen).²⁷ We included the Aronchick scale as one of our scoring systems because it is a validated method that is the most commonly used prep scoring system.^{19, 28} The Aronchick scale is commonly said to assess the amount of retained stool upon initial inspection.²⁸ However, the original publication of this scoring system states “after procedure completion, adequacy of colonic cleansing was evaluated” by the Aronchick scale²⁷, and this is how our study endoscopists also scored the prep--after washing and examining the entire colon. We used the Aronchick scale to define a three-tiered ordinal scoring system, as has been done previously¹⁹: *high-quality* prep was defined as either “excellent” or “good” prep, *intermediate-quality* prep was defined as “fair” prep, and *low-quality* prep was defined as “poor” prep.

Endoscopists also rated the adequacy of bowel preparation using the BBPS^{30, 31}, scoring left colon, transverse colon, and right colon segments as 0 (mucosa not seen due to solid stool or thick liquid stool that cannot be cleared), 1 (areas of the colon segment not well seen due to staining, residual stool and/or opaque liquid), 2 (minor amount of residual staining, small fragments of stool and/or opaque liquid but mucosa seen well), or 3 (entire mucosa of the colon segment seen well). Total BBPS score was defined as the sum of the three individual colon segments scores (range 0–9). We felt it was important to evaluate this scoring method

because it is the most well-validated and reproducible scoring method in current clinical practice, and endorsed by recent guidelines.²⁸ Finally the endoscopists rated the prep quality on a dichotomous scale of “adequate” or “inadequate” by answering the question: “Are you confident that after cleaning, the endoscopic view allowed visualization of lesions >5mm?” All four study endoscopists underwent formal training in assessment of bowel preparation adequacy using these scoring systems prior to participating in the trial.

Statistical Analyses

Detection rates and 95% confidence intervals (CIs) were calculated using the exact method for binomial proportions. Adjusted odds ratios (ORs) and 95% CIs were calculated using multivariate logistic regression adjusting for subject’s age, indication (screening or surveillance) and endoscopist. Adjusted OR and 95% CI were used to compare exposure categories. The primary analysis compared intermediate-quality versus high-quality prep in the entire colon. Secondary analyses compared intermediate-quality versus high-quality prep in the right colon and low-quality versus high-quality prep in the entire colon and right colon. Right-colon SSPDRs and adjusted ORs were also calculated for BBPS right-colon segment scores (BBPS=1 or BBPS=2 versus BBPS=3). In addition, SSPDRs and adjusted ORs for the entire colon were calculated for the following dichotomous comparisons of bowel prep quality: total BBPS<7 versus BBPS=7–9, any segment BBPS=1 versus all segments BBPS=2–3, and “inadequate” versus “adequate”. To address concerns over misclassification of SSPs as hyperplastic polyps, we performed sensitivity analyses of SSPDR for the entire colon and right colon, including proximal (right colon and/or transverse colon), large (>1cm) hyperplastic polyps in our definition of SSP as has been done in previous studies.³³ We also performed post-hoc analyses of hyperplastic polyp detection rate and ADR stratified by the three tiers of bowel prep quality, calculated similarly to SSPDR. Hypothesis testing of differences in proportions was performed using two-sample proportion testing.

Finally, because the definition of “adequate” bowel prep quality per current guidelines is the ability to identify polyps >5mm,^{28, 29} we also assessed the proportion of patients with SSPs who had SSPs >5mm for the low, intermediate, and high-quality bowel prep categories. Analyses were performed using Stata 13.1 (StataCorp, College Station, TX). This study was a pre-specified part of a larger prospective study and the sample size accrued was based on the primary study.

RESULTS

From January 2014 to February 2015, 778 patients were recruited to participate in this study. 749 patients ultimately completed their colonoscopic examination and met criteria for inclusion. Selected descriptive characteristics are shown in Table 1. The mean age was 67 years, with 51.7% of the cases performed for screening and 48.3% for surveillance. The 4 participating endoscopists each performed between 15.2% and 31.5% of the procedures. The mean withdrawal time ($\pm$ S.E.) was 23.8 ± 0.4 minutes. Mean withdrawal times were similar for high-quality (24.5 ± 0.51 minutes) and intermediate-quality (24.7 ± 0.98 minutes) preps, while the withdrawal time for low-quality prep (18.5 ± 1.07 minutes) was shorter than both

high-quality and intermediate quality preps ($p<0.01$). The mean ADR was $68.2 \pm 1.7\%$ (screening ADR= $63.0 \pm 2.5\%$, surveillance ADR= $73.8 \pm 2.3\%$). The mean SSPDR was $9.9\% \pm 1.1\%$. One-hundred and thirty-eight (97.9%) of 141 SSPs were sessile/flat, 581 (99.5%) of 584 hyperplastic polyps were sessile/flat, and 1691 (96.1%) of 1759 adenomas were sessile/flat; none were traditional serrated adenomas.

Outcomes Based on Three-Tiered Ordinal Scale

Table 2a shows the raw SSPDRs and adjusted ORs for the different comparisons of prep quality. Our primary analysis demonstrated that the SSPDR for intermediate-quality prep (4.6%, 95% CI 1.7% to 9.8%) was significantly lower than the SSPDR for high-quality prep (12.0%, 9.3% to 15.1%) with OR=0.37 (0.15 to 0.87). The SSPDR was also lower with low-quality prep (4.9%, 1.6% to 11.1%) as compared to high-quality prep: OR= 0.38 (0.15 to 0.99). The higher SSPDR with high-quality prep was not due to a disproportionately greater detection of diminutive polyps; rather among patients with SSPs, most had SSPs >5mm with low-quality (4/5 (80%)), intermediate-quality (5/6 (83.3%)), and high-quality bowel prep (45/62 (72.6%)). Sensitivity analysis, including large, proximal hyperplastic polyps in the definition of SSP, demonstrated similar results (Table 2b), with a significantly lower SSPDR for both intermediate-quality (adjusted OR=0.36, 0.15–0.85) and low-quality (adjusted OR=0.37, 0.14–0.96) prep compared to high-quality prep.

The individual endoscopists did not differ significantly in their overall SSPDR (range 9.1% to 11.0%), and endoscopist was not a significant covariate in the regression model. Limiting the analysis solely to the right colon (Table 2a), SSPDR for intermediate-quality prep was significantly lower than SSPDR for high-quality prep (OR= 0.19, 0.05 to 0.81).

Hyperplastic polyp detection rates were not decreased for intermediate-quality vs. high-quality prep (38.5% vs. 33.8%), while hyperplastic polyp detection rates were less with low-quality prep (23.5%) than with high-quality ($p=0.041$) or intermediate-quality prep ($p=0.015$). ADRs for high-quality and intermediate-quality prep were not significantly different (72.3% vs. 65.4%), while both high-quality and intermediate-quality prep resulted in higher ADR compared to low-quality prep (51.0%, $p<0.01$ and $p=0.03$, respectively).

Outcomes Based on BBPS Score and Dichotomous Comparisons

Using the BBPS, rates of detecting at least one SSP in the right colon increased with increasing BBPS segment scores from 1.9% (BBPS=1) to 4.7% (BBPS=2) to 9.5% (BBPS=3) (Table 3). Right-colon SSPDRs were inferior for both BBPS=2 (OR= 0.50, 0.26 to 0.94) and BBPS=1 (OR=0.21, 0.05 to 0.92) when compared to the very best prep quality of BBPS=3. When using the BBPS for the entire colon, patients with any colon segment BBPS score=1 had lower SSPDR than those with all colon segment BBPS scores=2–3 (OR= 0.31, 0.12 to 0.79), and patients with BBPS <7 had a decrement in SSPDR as compared to those with BBPS=7–9 (OR=0.36, 0.19 to 0.67) (Table 4). Patients deemed to have “inadequate” prep were significantly less likely to have SSPs detected in the entire colon (OR= 0.27, 0.12 to 0.60) (Table 4) and in the right colon (OR=0.20, 0.06 to 0.66) compared to patients with “adequate prep.”

DISCUSSION

In this prospective analysis of 749 male veterans undergoing colonoscopy for screening or surveillance colonoscopy, we found that detection rates of SSPs were significantly lower in the entire colon and in the right colon with intermediate-quality (fair) prep compared to high-quality (excellent or good) prep using the most commonly employed ordinal scale-the Aronchick²⁷ scoring system. This finding was consistent using the BBPS, the most well-validated and reproducible quantitative scoring system endorsed for current clinical practice.^{28, 30, 31} A decrease in prep quality of the right-colon segment score from BBPS=3 to BBPS=2 and a decrease in prep quality of the entire colon from BBPS=7–9 to BBPS<7 were associated with decreased SSPDR. Using any of the three prep scoring methods described in this study, prep quality appeared to be a significant predictor of the ability of the endoscopist to detect SSPs, even when adjusting for patient age, procedure indication, and endoscopist performing the procedure. Thus, our findings are consistent in demonstrating that even modest decrements in bowel prep quality will markedly diminish the ability of endoscopists to detect SSPs.

Two previous studies have specifically evaluated the impact of prep quality on detection of serrated polyps and neither reported a significant influence of bowel prep quality. In a prospective study of 1354 screening colonoscopies performed by 5 endoscopists, prep quality as assessed by the Ottawa scale (0–14) was not associated with proximal serrated polyp detection.²⁶ A separate cross-sectional registry-based study of 13,002 colonoscopies performed by 54 endoscopists showed no significant difference in serrated polyp detection rate or proximal serrated polyp detection rate for both fair and poor prep when compared to high-quality (excellent or good) prep; this study used their own prep scoring system that has not been validated nor used outside of their practices.²⁵ Different from the current study, both of these previous studies included hyperplastic polyps as well as SSPs. The prior studies' inclusion of proximal hyperplastic polyps may be one potential explanation for the difference in results in our study compared to prior studies. The incidence of hyperplastic polyps is much higher than the incidence of SSPs¹⁰, and the ability to detect hyperplastic polyps may differ from the ability to detect SSPs due to differences in morphology. If this is the case, the detection rate for all serrated polyps would differ from the SSPDR due to the inclusion of hyperplastic polyps. Therefore, inclusion of hyperplastic polyps may dilute the observed effect of bowel prep quality on detection rates of SSPs. We found that the detection rate of hyperplastic polyps was similar with intermediate and high-quality bowel prep, markedly different from the significant decrease in SSPDR with intermediate vs. high-quality prep. This provides further support for the hypothesis that previous studies may have missed the true impact of bowel prep quality on SSPDR due to their inclusion of hyperplastic polyps.

Additionally, the endoscopists participating in both prior studies demonstrated significant variability in their baseline SSPDR: SSPDR ranged from 6% to 22% in one study²⁶, while the other study demonstrated a median proximal SSPDR of 4.5% with interquartile range from 2.4% to 7.5%.²⁵ Other previous studies have also demonstrated that detection of SSPs is operator-dependent and may be highly variable. In an evaluation of 6681 screening colonoscopies performed by 15 academic endoscopists, proximal serrated polyp detection

rate ranged from 1% to 18% and number of proximal serrated polyps per colonoscopy ranged from 0.01 to 0.26 among endoscopists.¹¹ A separate study of 7192 colonoscopies performed by 13 academic endoscopists showed variation in rates of detection of hyperplastic polyps (7.7% to 31%, $p<0.001$) as well as SSPs (0% to 2.2%, $p=0.02$).¹⁰ In contrast, the endoscopists participating in our study had relatively minor variation in their SSPDR (range 9.1%–11.0%). The marked variability among the multiple endoscopists' SSPDRs in prior studies potentially may have outweighed and masked the effect of bowel prep quality on SSPDR.

While ours is the first study to demonstrate a significant influence of prep quality on the ability to detect SSPs, more importantly our study suggests a major difference in the impact of bowel prep quality on detection of SSPs as compared to traditional adenomas. Intermediate-quality bowel prep is reported to provide ADRs comparable to those with high-quality bowel prep (good-excellent Aronchick scores).¹⁹ Furthermore, BBPS colon segment scores of 2 (on a scale of 0–3) are comparable to the highest-quality segment scores of 3 in identifying adenomas >5mm, the guideline definition of adequate bowel preparation.³⁴ Thus, intermediate-quality prep and BBPS scores of 2 may be considered “adequate” for adenoma detection on screening and surveillance colonoscopy. In contrast, our results indicate that intermediate-quality prep or BBPS segment scores of 2 are inferior to high-quality prep for detection of SSPs. This divergence is not startling: the more subtle appearance of SSPs as compared to traditional adenomas may necessitate better bowel prep quality for SSP visualization.

Given the ongoing concern with the relationship between SSPs and right-sided interval colorectal cancer, this dichotomy will be an important consideration as guidelines for colonoscopic screening and surveillance are modified in the future. Will intermediate-quality prep and BBPS colon-segment scores of 2 be considered sufficient to instruct patients to return at guideline-recommended intervals because they provide acceptable detection of adenomas, or will high-quality prep scores be required to ensure acceptable rates of SSP detection? Adenomas still remain far and away the most common neoplastic polyp and the most common precursor to colorectal cancer³⁵; SSPs account for less than 10% of all colorectal polyps.^{13, 36} So when considering implications for guideline development for population-level screening and surveillance, it is likely that considering all BBPS segment scores of at least 2 or intermediate-quality bowel preparation as adequate will remain a reasonable recommendation. Nevertheless, the yield of detecting SSPs does appear to be improved by achieving a high-quality bowel prep, and, if confirmed in larger studies, this finding may lead to the suggestion that colonoscopy be repeated early rather than at guideline-recommended screening/surveillance intervals if bowel prep is not high-quality. This may be especially important in the right colon where SSPs are more prevalent, and where protection from colorectal cancer has been least impacted by colonoscopy.

Our study has several inherent limitations. The study population, consisting of male veterans with high adenoma prevalence, may limit generalizability. Additionally, the endoscopists participating in this study included 4 university faculty attending gastroenterologists with similar and relatively high SSPDRs. While this allowed us to minimize the impact of differences in endoscopic abilities among endoscopists, it also may limit generalizability. In

addition, the withdrawal times of these endoscopists were longer and the ADRs higher than typical in standard clinical practice, presumably at least in part due to the greater time spent in washing and examining patients in a study setting as well as the larger than average number of polypectomies required in male veterans. The mean withdrawal times for colonoscopies with intermediate and high-quality preps were nearly identical, indicating withdrawal time cannot account for the difference in our primary analysis of SSPDR between intermediate and high-quality prep. The withdrawal time of 18.5 minutes in low-quality prep procedures was lower than the withdrawal time in high-quality prep procedures, due to fewer polypectomies and possibly less time irrigating/aspirating to achieve a higher-quality prep and less mucosal inspection. Some portion of the decreased SSPDR in the secondary analysis of low-quality vs. high-quality preps potentially could be due to shorter withdrawal time.

Our study was also limited by the small number of SSPs in the intermediate-quality (6/142) and low-quality (5/102) prep groups. Given the low prevalence of SSP, future studies with larger populations are required to confirm our findings. Finally, while our adjusted analyses controlled for potential confounders of polyp detection including endoscopist, patient age and the indication for the procedure (screening or surveillance), some factors associated with increased risk of polyp development such as family history or smoking were not evaluated.

In conclusion, our study demonstrates that in male veterans undergoing screening or surveillance colonoscopy, any decrease in bowel prep quality below high-quality is associated with a significant decrease in the detection of SSPs. While intermediate-quality prep and BBPS segment scores of 2 appear to be adequate for detection of adenomas, these levels of prep quality are associated with lower rates of detecting SSPs in these patients. Future studies should be aimed at elucidating whether this is true for the general population. In the meantime, endoscopists and patients should strive to attain optimal prep quality (Aronchick scale of excellent or good or BBPS segment score of 3), especially in the right colon, in order to maximize the potential benefit of colonoscopy in reducing the development of colorectal cancer.

Acknowledgments

Financial Support: Supported by NIH T32 DK007017 (B.C.)

Abbreviations

SSP	Sessile serrated adenoma/polyp
ADR	adenoma detection rate
SSPDR	sessile-serrated polyp detection rate
BBPS	Boston bowel preparation scale
CI	confidence interval
OR	odds ratio

REFERENCES

1. Citarda F, Tomaselli G, Capocaccia R, et al. Efficacy in standard clinical practice of colonoscopic polypectomy in reducing colorectal cancer incidence. *Gut*. 2001; 48(6):812–815. Epub 2001/05/19. [PubMed: 11358901]
2. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. *The New England journal of medicine*. 1993; 329(27):1977–1981. Epub 1993/12/30. [PubMed: 8247072]
3. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *The New England journal of medicine*. 2012; 366(8):687–696. Epub 2012/02/24. [PubMed: 22356322]
4. Thiis-Evensen E, Hoff GS, Sauar J, et al. Population-based surveillance by colonoscopy: effect on the incidence of colorectal cancer. *Telemark Polyp Study I. Scand J Gastroenterol*. 1999; 34(4):414–420. Epub 1999/06/12. [PubMed: 10365903]
5. Singh H, Turner D, Xue L, et al. Risk of developing colorectal cancer following a negative colonoscopy examination: evidence for a 10-year interval between colonoscopies. *JAMA : the journal of the American Medical Association*. 2006; 295(20):2366–2373. Epub 2006/05/25. [PubMed: 16720822]
6. Baxter NN, Goldwasser MA, Paszat LF, et al. Association of colonoscopy and death from colorectal cancer. *Annals of internal medicine*. 2009; 150(1):1–8. Epub 2008/12/17. [PubMed: 19075198]
7. Brenner H, Chang-Claude J, Jansen L, et al. Role of colonoscopy and polyp characteristics in colorectal cancer after colonoscopic polyp detection: a population-based case-control study. *Annals of internal medicine*. 2012; 157(4):225–232. Epub 2012/08/23. [PubMed: 22910933]
8. Samadder NJ, Curtin K, Tuohy TM, et al. Characteristics of missed or interval colorectal cancer and patient survival: a population-based study. *Gastroenterology*. 2014; 146(4):950–960. [PubMed: 24417818]
9. Shergill AK, Connors EE, McQuaid KR, et al. Protective association of colonoscopy against proximal and distal colon cancer and patterns in interval cancer. *Gastrointest Endosc*. 2015; 82(3): 529.e1–537.e1. Epub 2015/05/06. [PubMed: 25936449]
10. Hetzel JT, Huang CS, Coukos JA, et al. Variation in the detection of serrated polyps in an average risk colorectal cancer screening cohort. *The American journal of gastroenterology*. 2010; 105(12): 2656–2664. [PubMed: 20717107]
11. Kahi CJ, Hewett DG, Norton DL, et al. Prevalence and variable detection of proximal colon serrated polyps during screening colonoscopy. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*. 2011; 9(1):42–46. Epub 2010/10/05. [PubMed: 20888435]
12. Sawhney MS, Farrar WD, Gudiseva S, et al. Microsatellite instability in interval colon cancers. *Gastroenterology*. 2006; 131(6):1700–1705. Epub 2006/11/08. [PubMed: 17087932]
13. Huang CS, Farrar FA, Yang S, et al. The clinical significance of serrated polyps. *The American journal of gastroenterology*. 2011; 106(2):229–240. quiz 41. [PubMed: 21045813]
14. Arain MA, Sawhney M, Sheikh S, et al. CIMP status of interval colon cancers: another piece to the puzzle. *The American journal of gastroenterology*. 2010; 105(5):1189–1195. Epub 2009/12/17. [PubMed: 20010923]
15. Nishihara R, Wu K, Lochhead P, et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. *The New England journal of medicine*. 2013; 369(12):1095–1105. [PubMed: 24047059]
16. Brenner H, Chang-Claude J, Rickert A, et al. Risk of colorectal cancer after detection and removal of adenomas at colonoscopy: population-based case-control study. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology*. 2012; 30(24):2969–2976. Epub 2012/07/25. [PubMed: 22826281]
17. Rex DK, Schoenfeld PS, Cohen J, et al. Quality indicators for colonoscopy. *Gastrointestinal endoscopy*. 2015; 81(1):31–53. [PubMed: 25480100]
18. Corley DA, Jensen CD, Marks AR, et al. Adenoma detection rate and risk of colorectal cancer and death. *The New England journal of medicine*. 2014; 370(14):1298–1306. [PubMed: 24693890]

19. Clark BT, Rustagi T, Laine L. What level of bowel prep quality requires early repeat colonoscopy: systematic review and meta-analysis of the impact of preparation quality on adenoma detection rate. *The American journal of gastroenterology*. 2014; 109(11):1714–1723. quiz 24. Epub 2014/08/20. [PubMed: 25135006]
20. Adler A, Wegscheider K, Lieberman D, et al. 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(2):236–241. [PubMed: 22442161]
21. Froehlich F, Wietlisbach V, Gonvers JJ, et al. 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(3):378–384. Epub 2005/03/11. [PubMed: 15758907]
22. de Jonge V, Sint Nicolaas J, Cahen DL, et al. Quality evaluation of colonoscopy reporting and colonoscopy performance in daily clinical practice. *Gastrointest Endosc*. 2012; 75(1):98–106. Epub 2011/09/13. [PubMed: 21907986]
23. Sherer EA, Imler TD, Imperiale TF. The effect of colonoscopy preparation quality on adenoma detection rates. *Gastrointest Endosc*. 2012; 75(3):545–553. Epub 2011/12/06. [PubMed: 22138085]
24. Rex DK, Ahnen DJ, Baron JA, et al. Serrated lesions of the colorectum: review and recommendations from an expert panel. *The American journal of gastroenterology*. 2012; 107(9):1315–1329. quiz 4, 30. [PubMed: 22710576]
25. Anderson JC, Butterly LF, Robinson CM, et al. Impact of fair bowel preparation quality on adenoma and serrated polyp detection: data from the New Hampshire colonoscopy registry by using a standardized preparation-quality rating. *Gastrointest Endosc*. 2014; 80(3):463–470. Epub 2014/05/14. [PubMed: 24818550]
26. de Wijkerslooth TR, Stoop EM, Bossuyt PM, et al. Differences in proximal serrated polyp detection among endoscopists are associated with variability in withdrawal time. *Gastrointestinal Endoscopy*. 2013; 77(4):617–623. [PubMed: 23321338]
27. Aronchick CA, Lipshutz WH, Wright SH, et al. A novel tableted purgative for colonoscopic preparation: efficacy and safety comparisons with Colyte and Fleet Phospho-Soda. *Gastrointest Endosc*. 2000; 52(3):346–352. Epub 2000/09/01. [PubMed: 10968848]
28. Johnson DA, Barkun AN, Cohen LB, et al. Optimizing adequacy of bowel cleansing for colonoscopy: recommendations from the US multi-society task force on colorectal cancer. *Gastroenterology*. 2014; 147(4):903–924. [PubMed: 25239068]
29. Lieberman DA, Rex DK, Winawer SJ, et al. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology*. 2012; 143(3):844–857. [PubMed: 22763141]
30. Lai EJ, Calderwood AH, Doros G, et al. The Boston bowel preparation scale: a valid and reliable instrument for colonoscopy-oriented research. *Gastrointest Endosc*. 2009; 69(3 Pt 2):620–625. Epub 2009/01/13. [PubMed: 19136102]
31. Calderwood AH, Jacobson BC. Comprehensive validation of the Boston Bowel Preparation Scale. *Gastrointest Endosc*. 2010; 72(4):686–692. Epub 2010/10/05. [PubMed: 20883845]
32. Rex DK, Cutler CS, Lemmel GT, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. *Gastroenterology*. 1997; 112(1):24–28. Epub 1997/01/01. [PubMed: 8978338]
33. Payne SR, Church TR, Wandell M, et al. Endoscopic detection of proximal serrated lesions and pathologic identification of sessile serrated adenomas/polyps vary on the basis of center. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*. 2014; 12(7):1119–1126. Epub 2013/12/18. [PubMed: 24333512]
34. Clark BT, Protiva P, Nagar A, et al. Quantification of Adequate Bowel Preparation for Screening or Surveillance Colonoscopy in Men. *Gastroenterology*. 2015 Epub 2015/10/07.
35. Levine JS, Ahnen DJ. Clinical practice. Adenomatous polyps of the colon. *The New England journal of medicine*. 2006; 355(24):2551–2557. Epub 2006/12/15. [PubMed: 17167138]

36. Spring KJ, Zhao ZZ, Karamatic R, et al. High prevalence of sessile serrated adenomas with BRAF mutations: a prospective study of patients undergoing colonoscopy. *Gastroenterology*. 2006; 131(5):1400–1407. Epub 2006/11/15. [PubMed: 17101316]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1

Selected Characteristics

No. of Patients	749
Age (years), mean (IQR)	63 (57–67)
Indication	
Screening	387 (51.7%)
Surveillance	362 (48.3%)
Withdrawal time (minutes), mean $\pm$ S.E.	23.8 $\pm$ 0.4
Aronchick Score	
Excellent	170 (22.7%)
Good	347 (46.3%)
Fair	130 (17.4%)
Poor	102 (13.6%)

Table 2

a. Detection of Sessile Serrated Polyps for High, Intermediate, and Low Bowel Prep Quality				
	Entire Colon		Right Colon	
Prep Quality	Detection Rate n (%; 95% CI)	Adjusted OR (95% CI)	Detection Rate n (%; 95% CI)	Adjusted OR (95% CI)
High (N=517)	62 (12.0%, 9.3–15.1%)	Reference	41 (7.9%, 5.8–10.6%)	Reference
Intermediate (N=130)	6 (4.6%, 1.7–9.8%)	0.37 (0.15–0.87)	2 (1.5%, 0.2–5.4%)	0.19 (0.05–0.81)
Low (N=102)	5 (4.9%, 1.6–11.1%)	0.38 (0.15–0.99)	2 (2.0%, 0.2–6.9%)	0.26 (0.06–1.11)

b. Detection of Sessile Serrated Polyps plus Proximal Large Hyperplastic Polyps* for High, Intermediate, and Low Bowel Prep Quality				
	Entire Colon		Right Colon	
Prep Quality	Detection Rate n (%; 95% CI)	Adjusted OR (95% CI)	Detection Rate n (%; 95% CI)	Adjusted OR (95% CI)
High (N=517)	67 (12.2%, 9.5–15.3%)	Reference	44 (8.1%, 5.9–10.8%)	Reference
Intermediate (N=130)	6 (4.6%, 1.7–9.8%)	0.36 (0.15–0.85)	2 (1.5%, 0.2–5.4%)	0.19 (0.04–0.79)
Low (N=102)	5 (4.9%, 1.6–11.1%)	0.37 (0.14–0.96)	2 (2.0%, 0.2–6.9%)	0.25 (0.06–1.07)

Detection rates are per-patient rates and “n” represents the number of patients in each category.

* Proximal = right and transverse colon (entire colon analysis) or right colon (right colon analysis); large = ≥ 1cm.

Table 3

Detection of Sessile Serrated Polyps in Right Colon Based on Boston Bowel Preparation Scale

Boston Bowel Preparation Scale Segment Score	Detection Rate (n (%), 95% CI)	Adjusted OR (95% CI)
3 (N=262)	25 (9.5%, 6.3–13.8%)	Reference
2 (N=380)	18 (4.7%, 2.8–7.4%)	0.50 (0.26–0.94)
1 (N=103)	2 (1.9%, 0.2–6.8%)	0.21 (0.05–0.92)

Detection rates are per-patient rates and “n” represents the number of patients in each category. 4 patients had right colon segment scores of 0 and therefore were excluded from this analysis

Table 4

Detection of Sessile Serrated Polyps in Entire Colon for Dichotomous Bowel Prep Categories

Prep Quality	Detection Rate n (%; 95% CI)	Adjusted OR (95% CI)
Adequate (N=549)	66 (12.0%, 9.4–15.0%)	Reference
Inadequate (N=200)	7 (3.5%, 1.4–7.1%)	0.27 (0.12–0.60)
All colon segments BBPS=2–3 (N=613)	68 (11.1%, 8.7–13.9%)	Reference
Any colon segment BBPS=1 (N=136)	5 (3.7%, 1.2–8.4%)	0.31 (0.12–0.79)
BBPS=7–9 (N=475)	60 (12.6%, 9.8–16.0%)	Reference
BBPS<7 (N=274)	13 (4.7%, 2.6–8.0%)	0.36 (0.19–0.67)

BBPS=Boston Bowel Preparation Scale

Detection rates are per-patient rates and “n” represents the number of patients in each category.