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Impact of Obesity on Bowel Preparation for Colonoscopy

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Abstract

Background & Aims—An inadequately cleansed colon can lead to missed lesions, repeat procedures, increased cost, and complications from colonoscopy. Because obesity, with its known link to colorectal neoplasia, might be associated with inadequate bowel cleansing, we investigated the impact of increased body mass index (BMI) on quality of bowel preparation at colonoscopy.

Methods—All colonoscopy procedures performed at a tertiary referral center during a 4-month period were evaluated. Bowel preparation was assigned a unique composite outcome score that took into account a subjective bowel preparation score, earlier recommendation for follow-up colonoscopy as a result of inadequate bowel preparation, and the endoscopist's confidence in adequate evaluation of the colon. Univariate and multivariate logistic regression analyses were performed to identify the role of BMI in predicting an inadequate bowel preparation.

Results—During the study period, 1588 patients (59.1% female; mean age, 57.4 ± 0.34 years) fulfilled inclusion criteria. An abnormal BMI (>25) was associated with an inadequate composite outcome score ($P = .002$). In multivariate logistic regression analyses, both BMI >25 ($P = .04$) and >30 ($P = .006$) were retained as independent predictors of inadequate bowel preparation. Each unit increase in BMI increased the likelihood of an inadequate composite outcome score by 2.1%. Additional independent predictors of inadequate preparation exponentially increased the likelihood of an inadequate composite outcome score; 7 additional risk factors identified 97.5% of over-weight patients with an inadequate composite outcome score.

Conclusions—Obesity is an independent predictor of inadequate bowel preparation at colonoscopy. The presence of additional risk factors further increases the likelihood of a poorly cleansed colon.

Optimal visualization of the colonic mucosa during colonoscopy depends on multiple factors, including image resolution, angle of view of the endoscope, time spent looking for lesions, and the skills of the endoscopist. However, all of these are contingent on how well the colon has been cleansed, making bowel preparation an important prerequisite for an

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Conflicts of interest

The authors disclose no conflicts.

Supplementary Data

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optimal colonoscopy. Despite this, the definition of an adequate colon preparation is far from precise. Task forces from the American Society of Colon and Rectal Cancer (ASCRS), American Society of Gastrointestinal Endoscopy (ASGE), and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) consider ideal preparation for colonoscopy to reliably empty the colon of all fecal material in a rapid fashion, with no gross or histologic alteration of the colonic mucosa and without causing patient discomfort and fluid or electrolyte imbalance; furthermore, it should be inexpensive.¹ These criteria are unfortunately not adequately served by any of the currently available standard bowel preparation regimens, leaving physicians to address cleansing outcomes on a post hoc basis. Therefore, recognizing patient-related variables and, consequently, tailoring the intensity of bowel preparation to patient-related criteria at the initial encounter might impact the quality of colonoscopy and recommendations made after the procedure.

Obesity has become an epidemic in the present era, both in the United States and in other developed nations. Abnormal elevation of body mass index (BMI) is associated with several gastrointestinal diagnoses, including diverticular disease, gastroesophageal reflux disease, colon polyps, and colon cancer.^{2,3} The increased risk for colon neoplasia is most pronounced in men, with an estimated 2-fold to 3-fold increase in risk compared with normal weight controls.⁴ Despite this increased risk, the obese patient is less likely to undergo screening procedures for colorectal cancer.^{5,6} Although a low BMI has been reported to increase the likelihood of an incomplete colonoscopy related to inability to reach the cecum,^{7,8} the effect of obesity on the quality of bowel preparation and consequently on the adequacy of colonoscopic examination has not been addressed in the literature. It has been our observation that obese patients frequently have an inadequate bowel preparation, necessitating repeat procedures, and prolonged or aggressive bowel preparation regimens, increasing the overall cost of health care in this patient cohort.

In this study, we aimed to determine whether obesity independently predicted an inadequate bowel preparation, taking into consideration the endoscopist's confidence level in making follow-up recommendations, while controlling for other potential factors hindering bowel preparation. In addition, we evaluated the impact of additional risk factors superimposed on obesity in determining the quality of colon cleansing at colonoscopy.

Methods

All patients presenting for outpatient and inpatient colonoscopy at the endoscopy suites of the Division of Gastroenterology at Washington University Medical Center during a 4-month period (June–October 2007) were eligible for inclusion in this study. Consecutive index colonoscopy procedures performed on adults with adequate documentation of bowel preparation and colonoscopy findings were included. Exclusion criteria included patients <18 years of age, patients with a history of partial or complete colon resection, and follow-up or repeat procedures performed after incomplete colonoscopy consequent to a poor bowel preparation. In addition, incomplete documentation of the procedure and inability to retrieve documentation because of archiving errors were also grounds for exclusion. This protocol was approved by the Human Research Protection Office (institutional review board) of Washington University School of Medicine.

Eligible patients were retrospectively identified from interrogation of the computerized endoscopic procedure records (Provation, Minneapolis, MN); their colonoscopy reports were electronically captured and scrutinized. In our institution, the following are routinely recorded as part of the procedure record: demographic data (age, gender, race, weight, height), clinical information (indication for colonoscopy, inpatient vs outpatient status, medical and surgical history, comorbidities, current medications, alcohol consumption, tobacco use), and procedure details (sedation, method of bowel cleansing, quality of bowel preparation, depth of colonoscope insertion, colonoscopic findings, complications, final diagnosis). These data were collected from electronically stored procedure records and corroborated as needed with inpatient and outpatient electronic medical records. BMI was calculated by using the standard formula (weight (kg)/height (m)²) and recorded. Patients were designated overweight when BMI was ≥ 25 and obese when ≥ 30 . Detailed spread sheets were prepared with the collected data and preserved in accordance with institutional review board requirements.

The quality of the bowel preparation was extracted from the procedure report, where this is typically given a descriptive preset designation by the endoscopist by using a forced drop-down menu. This was converted to an ordinal score by using a predetermined Aronchick scale⁹ as follows: excellent, 1; good, 2; fair, 3; poor, 4; and unsatisfactory, 5. For the purpose of this study, all bowel preparation scores ≤ 2 (excellent or good) were considered acceptable or adequate, whereas scores ≥ 3 were designated unacceptable or inadequate.

Because the bowel preparation score does not take into account the impact of the quality of bowel preparation on follow-up recommendations and the confidence level of the endoscopist in the adequacy of the procedure, an additional unique score was created a priori for the purpose of this study, which we termed *composite outcome score*. The composite outcome score was a sum of 3 variables scored as follows:

1. Bowel preparation score, as described above. This was converted to a binary score, 0 indicating an acceptable bowel preparation and 1 indicating an unacceptable preparation.
2. Change in standard postprocedure recommendation for follow-up consequent to the quality of the bowel preparation. The recommendation for follow-up made after the colonoscopy was compared with accepted American Gastroenterological Association (AGA) and ASGE recommendations for follow-up for each lesion identified, and follow-up intervals shorter than recommended were given a score of 1; follow-up intervals in accordance with society recommendations were scored 0. Procedure reports wherein the basis for shorter follow-up recommendations was not evident were individually discussed with the endoscopist on a case-by-case basis.
3. Adequate visualization of the entire colonic mucosa and endoscopists' confidence in adequacy of the examination. When available, these were extracted from the procedure reports, wherein a drop-down menu allows the endoscopist to designate whether the preparation was good enough to identify polyps <5 mm in size. When this designation or other statements describing the endoscopists' confidence in the

adequacy of the examination were not explicit in the report, the procedure report was directly discussed with the endoscopist for clarification. This was also scored in binary fashion, 0 indicating adequate visualization and good confidence that the examination was adequate and 1 indicating incomplete visualization or lack of confidence in an adequate examination.

A composite outcome score of 0 was deemed acceptable, whereas scores of 1 (1, 2, or 3) were designated inadequate.

Statistical Analysis

For the purpose of this study, we assumed that a 10% decrease in cecal intubation rate consequent to an inadequate bowel preparation would be clinically significant, considering 100% cecal intubation as the gold standard. This was used to calculate our sample size. In addition, we estimated the prevalence of overweight individuals (BMI ≥ 25) to be 55% and that of individuals with BMI ≥ 35 to be 5%–10% (on the basis of NHANSES III data, National Center for Health Statistics, www.cdc.gov/nchs). Therefore, the required sample for 95% power ($\alpha = .05$) was estimated at 1600 patients.

Data are reported as means $\pm$ standard errors of mean unless indicated otherwise. Continuous and categorical variables were compared by using Student *t* test and χ^2 or Fisher exact tests, respectively. Univariate and multivariate analyses were performed by using SAS v9.0 and SAS Enterprise Guide v2.2 programs (SAS Institute Inc, Cary, NC). A multivariate logistic regression predictive model was created by using the composite outcome score as the outcome variable and included all variables with at least a trend toward statistical significance ($P < .1$) on univariate analysis. Predictability for an inadequate composite outcome when additional risk factors ($P < .05$ on multivariate logistic regression) were individually added was further determined.

Results

During the 4-month study period, 1815 colonoscopy procedures were recorded in our institution's electronic database. Of these, 114 procedures had been performed on patients with prior colectomy, 61 were repeat procedures on patients with an unsatisfactory bowel preparation, and 52 had inadequate information or were not adequately archived. Therefore, 1588 unique colonoscopy procedures were identified that fulfilled study inclusion criteria. The mean age of the patients was 57.4 ± 0.34 years (range, 18–98 years), and 59.1% were female (Table 1). BMI within the upper limits of normal (<25) was noted on 31.2%, whereas 68.8% were overweight (BMI ≥ 25); 37.4% were obese (BMI ≥ 30), and 16.3% had a BMI ≥ 35 . The vast majority of the procedures (87.9%) were performed on outpatients, and screening or surveillance for colon polyps and neoplasia was the most frequent indication (58.4%) (Table 1). Hypertension and diabetes mellitus were the most frequently reported comorbidities. Bowel cleansing was most often performed by using a polyethylene glycol–based preparation (Table 1).

The raw bowel preparation score was adequate in 74.7% of patients, whereas the more stringent composite outcome score was adequate in 60.7%. Thus, with the composite

outcome score, an additional 14.0% were found to have an inadequate bowel preparation compared with the bowel preparation score, by virtue of a lack of confidence in identifying colonic mucosal lesions ($n = 75$), and a recommendation for an earlier repeat colonoscopy than dictated by conventional guidelines ($n = 184$). Colonoscopy was designated as complete in 93.2%, and 37.5% of the procedures identified polyps; both parameters were significantly higher when bowel preparation was designated adequate by using the composite outcome score (99.9% and 41.7%, respectively; $P < .0001$ and $P < .04$). Endoscopists recommended a repeat procedure earlier than accepted guideline recommendations in 26.9% patients; by definition, none of the subjects with an adequate composite outcome score had earlier repeat procedure recommendations.

On univariate analysis, 41.9% of overweight patients (BMI 25) had an inadequate composite outcome score ($P = .002$; odds ratio, 1.4; 95% confidence interval, 1.12–1.74). In addition, increasing BMI values were associated with higher proportions of inadequate bowel preparation scores (Figure 1). Obese patients (BMI 30) had 43.8% with inadequate composite outcome score, whereas 45.0% of patients with a BMI 35 had similar inadequate bowel preparation. Other variables associated with an inadequate composite outcome score ($P < .1$) included demographics (older age, male gender), inpatient status, comorbidities (diabetes mellitus, hypertension, coronary artery disease, obstructive sleep apnea, depression, decreased mental capacity), social habits (smoking, lack of alcohol use), and medications (narcotics, antidepressants). To further determine whether abnormal BMI independently impacted colonoscopy outcome and postcolonoscopy recommendations, a multivariate logistic regression model was created including all variables that demonstrated statistical trends or significance on univariate analysis. On such analysis, abnormal BMI (≥ 25) remained an independent predictor of an abnormal composite outcome score ($P = .041$; odds ratio, 1.28; 95% confidence interval, 1.01–1.61) (Table 2). Obesity (BMI 30) showed an even higher odds ratio when the multivariate logistic regression model was run after BMI was dichotomized to obese and non-obese ($P = .006$; odds ratio, 1.35; 95% confidence interval, 1.09–1.68). Each unit increase in BMI increased the likelihood of an inadequate composite outcome score by 2.1%, to a maximum of 31.5% in patients with a BMI 40 compared with normal subjects ($P = .05$; odds ratio, 1.48; 95% confidence interval, 1.00–2.19).

We further assessed the contribution of additional variables to an abnormal BMI in predicting inadequate bowel preparation, taking into account all variables identified as independent predictors of an abnormal bowel preparation on multivariate analysis. Adding just 1 additional risk variable to an abnormal BMI increased the likelihood of an abnormal composite outcome score by 7.8% (Figure 2). This proportion increased exponentially by the inclusion of additional variables and ultimately plateaued at 97.5% after inclusion of 7 variables. In other words, nearly all with abnormally elevated BMI and an inadequate composite outcome score could be predicted by the presence of an abnormal BMI and 7 additional risk factors.

Discussion

In this retrospective study, we demonstrated that an abnormal BMI ≥ 25 is an independent predictor of inadequate bowel preparation at colonoscopy, leading to a change in the recommendations after colonoscopy toward an earlier repeat procedure. Furthermore, our results indicated that the presence of additional risk factors in conjunction with an abnormal BMI exponentially increase the likelihood of an undesirable bowel preparation.

The implications of our findings are profound. An abnormally increased BMI is associated with cancer morbidity and mortality, in addition to the risk of metabolic syndrome and all its implications.^{10,11} Colon cancer has been identified as one of the neoplasms seen more often in obese patients.^{2,3,12,13} Because the majority of colon cancers arise from adenomatous colon polyps, proper screening for polyps becomes crucial while performing colonoscopy on these patients. A poor bowel preparation can therefore jeopardize the effectiveness of screening or surveillance colonoscopy, exposing these patients at higher risk for colorectal neoplasia to detriments from missed lesions and higher cost of repeat colonoscopy.¹⁴ The impact of this factor can conceivably be particularly high in non-safety net health care systems, in which patients could be lost to follow-up.¹⁵ It is also evident from our results that higher BMI values are independently associated with increasing odds ratios for the likelihood of an inadequate bowel preparation, such that patients at highest risk for colorectal neoplasia are also most likely to have a suboptimal preparation at colonoscopy.

Our study identifies abnormal BMI as an independent risk factor for an inadequate bowel preparation at colonoscopy. Searching the literature, we only found mention of a low BMI as a predictor of incomplete or unsuccessful procedures (defined by inability to reach the cecum), without taking bowel preparation quality into account.^{7,8} Others have not confirmed such a relationship.¹⁶ The low power of those studies for detection of the effect of elevated BMI might have been the reason for negative findings.¹⁶ Several studies in the literature have identified patient-related and procedure-related predictors of the quality of colon cleansing. Factors identified as predictors of a poor bowel preparation have included delayed procedure time (procedures performed later in the day), poorly followed instructions, history of cirrhosis, inpatient status, constipation as an indication, concurrent use of tricyclic antidepressants, male gender, and history of stroke or dementia.^{14,17} Our results corroborate many of these factors (Table 2). On the other hand, surveillance colonoscopy on patients with past polyps or colorectal neoplasia predicted an adequate bowel preparation.¹⁷ Interestingly, constipation as an indication for colonoscopy had no impact on quality of bowel preparation on univariate analysis ($P = .16$; odds ratio, 0.79; 95% confidence interval, 0.57–1.10). In many centers including ours, patients with constipation are formally or informally directed to include additional laxatives as part of their bowel preparation, which can be a potential explanation for why constipation as an indication for colonoscopy failed to predict an abnormal composite outcome score.

A “clean colon” is a prerequisite for a successful diagnostic and therapeutic colonoscopy. It should allow a thorough examination of mucosal surface for the detection of neoplasia and other disorders. However, this is not always the case in clinical practice.^{14,17} With conventional parameters, 74.7% of our patients had raw bowel preparation scores in the

adequate range, comparable to the 67.5%–78.3% reported in the literature. Thus, more than one fourth of colonoscopic examinations were performed with a suboptimal preparation. This proportion is not evenly distributed among different BMI subgroups; >43% of obese and morbidly obese patients had unsatisfactory preparation quality, compared with 33.1% of patients with a normal BMI.

In most studies investigating colonoscopy outcome, completion or success of the procedure is defined by the ability of the endoscopist to reach the cecum or ileocolonic anastomosis,^{18,19} which does not adequately reflect the quality of visualization of the colonic mucosa. These studies are also hampered by an unclear, subjective definition of an “adequate preparation.” Several scales have been developed to overcome this problem. The Ottawa Preparation Quality Score is based on the cleanliness of each part of the colon (right, mid, and rectosigmoid), with a summary score indicating overall cleanliness, with a total score of 14. However, this method is complex and impractical to use in a busy endoscopy center with a rapid turnover of patients.²⁰ The Aronchick scale and ASGE/American College of Gastroenterology task force versions are even more subjective.^{9,21,22} In our study, the simple bowel preparation score was a forced menu item on the computerized report writing program, but it remained a very subjective depiction that could not be adequately corroborated even with scrutiny of the procedure reports.

To overcome the subjectiveness of the bowel preparation score, we developed the composite outcome score for the purpose of this study. The endoscopist's confidence in adequacy of the bowel preparation in identifying mucosal lesions was incorporated into the subjective impression of bowel preparation quality. Therefore, lack of confidence in the bowel preparation can translate into a shorter than standard interval for a repeat procedure, especially when limited sections of the bowel are inadequately visualized, while the remainder of the bowel is adequately clean. We took special pains to exclude other patient-related reasons for an early repeat procedure and discussed unclear situations directly with the endoscopist. The composite outcome score improved segregation of adequate procedures from incomplete ones. The applicability and practical value of this variable, however, need to be validated in future prospective studies.

We are aware that our study has several limitations. Any retrospective study is limited by inability to corroborate facts recorded in patient charts and by recall bias on discussions with individual endoscopists. Our gastroenterology endoscopy facility is manned by 26 gastroenterologists of various skill levels and areas of interest; some are assisted by gastroenterology trainees, adding an additional dimension of endoscopist skill into the equation. We understand that endoscopists' perception of adequacy of bowel preparation can differ broadly, and this might impact the reporting of raw bowel preparation scores. We tried to overcome this limitation by using the composite outcome score, wherein the endoscopists' confidence in adequacy of the colonoscopy procedure was factored into the equation. The colon preparation regimens were not standardized, and adequacy of patient comprehension of preparation instructions could not be assessed. Because of the retrospective nature of the study, we were unable to determine whether abnormal BMI itself is directly to blame for the abnormal bowel preparation, or whether other factors such as compliance with the bowel preparation regimen, socioeconomic status and education level

of the patients, ability to follow instructions, and willingness to complete the bowel preparation are indirectly associated with an abnormal BMI. However, our patient population is diverse, and our endoscopy facility has a very high turnover rate, ensuring a large and representative sample size. Our calculated differences between different cohorts are highly significant, suggesting that these numbers will probably hold up on more rigorous prospective evaluations and might be applicable to many large endoscopy centers.

Is this a time to consider individualized bowel preparation regimens? Because more than one fourth of all patients had an inadequate examination and could have benefited from a more aggressive bowel preparation regimen, identification of those needing an aggressive preparation will likely prove worthwhile. Benefits appear even more substantial when viewed against the risk of missing potentially neoplastic lesions, the extra time and effort spent in repeating bowel preparations and colonoscopy, and the dangers of patients not following up. Thus, identification of a patient profile with a high risk for poor colon preparation will be helpful in capturing those who would benefit from an initial individualized (designer) preparation regimen. This could improve patient satisfaction, reduce the economic burden, and maximize the efficiency of detection and treatment of colon pathology. In this context, our results suggest that the obese patient should at least be subject to more precise instructions and possibly a more aggressive bowel preparation regimen; these general principles might apply even to the over-weight patient. As the number of risk factors for an inadequate bowel preparation increases, the need for a more rigorous bowel preparation regimen escalates. A longer period of liquid diet before colonoscopy and repeat daily laxative regimens leading up to the actual bowel preparation might need to be considered. Other interventions including but not limited to improved patient education and handout materials, training videos, directing patients to self-help web sites, and follow-up telephone calls to address questions should be considered. There have also been recent reports on the utility of a split-dose, split-day bowel preparation regimen, with part of the bowel preparation regimen being administered a few hours before colonoscopy to clear remnant fecal residue.²³ Some studies suggested improved results with oral sodium phosphate solutions administered in 2 doses, the second dose during the morning of the procedure.²⁴ However, the utility and efficacy of such split-dose protocols in patients with high BMI have not been specifically tested.

In conclusion, an abnormal BMI independently predicts inadequate bowel preparation at colonoscopy, with implications for the possibility of missed mucosal lesions and the need for early repeat colonoscopy with more intense cleansing. Future outcome studies could evaluate the impact of individualized bowel cleansing regimens on adequacy of bowel preparation, particularly in patients with an abnormal BMI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations used in this paper

AGA	American Gastroenterological Association
ASCRS	American Society of Colon and Rectal Cancer
ASGE	American Society of Gastrointestinal Endoscopy
BMI	body mass index
SAGES	Society of American Gastrointestinal and Endoscopic Surgeons

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Figure 1.

Distribution of raw and composite outcome scores determining adequacy of bowel preparation at colonoscopy, in relationship to BMI. As the BMI increased, the proportion of patients with inadequate bowel preparation scores (*dark bars*) also increased.

Figure 2.

Cumulative likelihood of an inadequate bowel preparation as measured by the composite outcome score, with the inclusion of additional risk factors for inadequate bowel preparation (as identified by multivariate logistic regression) in patients with an abnormal BMI (≥ 25).

Table 1**Clinical Demographics of the Study Population**

Total no. of patients	1588
Mean age (range)	57.4 ± 0.34 y
Gender (F/M)	938/650
Outpatient status	1396 (87.9%)
Race	
White	990 (62.3%)
African American	551 (34.7%)
Hispanic	10 (0.6%)
Other	37 (2.3%)
Indication	
Screening/surveillance	928 (58.4%)
Gastrointestinal bleeding	341 (21.5%)
Constipation	193 (12.1%)
Other	126 (7.8%)
Comorbidities	1326 (83.5%)
Hypertension	822 (51.7%)
Diabetes mellitus	312 (19.6%)
Mental retardation/dementia	35 (2.2%)
Pertinent medications	
Antidepressant use	191 (12.0%)
Narcotic use	91 (5.7%)
Type of bowel preparation	
Polyethylene glycol	1394 (87.0%)
Phosphosoda	185 (11.5%)
Other	9 (0.5%)

Table 2

Likelihood of Inadequate Composite Outcome Score on Multivariate Logistic Regression

Variables	Odds ratio	95% Confidence interval	P value
BMI 25	1.28	1.01–1.61	.04
Male gender	1.36	1.10–1.61	.004
Inpatient status	1.54	1.11–2.13	.009
Smoking status	1.31	1.03–1.67	.03
Alcohol consumption	0.76	0.61–0.95	.01
Antidepressant use	1.67	1.22–2.29	.002
Narcotic use	2.06	1.30–3.25	.001
Diabetes mellitus	1.37	1.05–1.78	.02
Decreased mental capacity	2.17	1.06–4.45	.03