Cirrhosis and Portal Hypertension Worsen Bowel Preparation for Screening Colonoscopy

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Background: Colonoscopy is a diagnostic and therapeutic procedure that reduces colorectal cancer incidence and mortality but requires adequate bowel cleansing for high-quality examination. Past studies have suggested cirrhosis as a risk factor for worse bowel preparation.

Methods: We carried out a match-controlled retrospective study evaluating patients with and without cirrhosis who underwent outpatient screening colonoscopies to assess the effect of cirrhosis and portal hypertension complications on preparation quality and endoscopic measures. We also did a subgroup analysis excluding patients with obesity.

Results: We examined 1464 patients with cirrhosis and matched controls. Cirrhotic patients had lower mean Boston Bowel Preparation Scale (BBPS) scores and slower cecal intubation times. We found a single point increase in the Model for End-stage Liver Disease (MELD) score, as well as ascites, hepatic encephalopathy, and variceal hemorrhage were all associated with a longer cecal intubation time. Subgroup analysis excluding patients with obesity again found a significantly lower BBPS score and longer cecal intubation time while also finding a 24% drop in polyp detection.

Conclusions: Patients with cirrhosis have worse BBPS scores and longer cecal intubation times. Nonobese cirrhotic patients additionally have a lower polyp detection rate. Portal hypertension complications were associated with worsened preparation quality and longer cecal intubation times. Each incremental increase in MELD score lengthened cecal intubation time. These findings support a more aggressive bowel preparation strategy for patients with cirrhosis, especially patients with severe disease or portal hypertension complications.

Key Words: cirrhosis, portal hypertension, colonoscopy, bowel preparation, MELD

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Colorectal cancer remains one of the cancers with the highest mortality in the United States.[1,2] Colonoscopy is the most performed gastrointestinal procedure in the country and is not only diagnostic of colorectal cancer but also therapeutic as it allows for the removal of polyps and confers long-term protection from colorectal cancer incidence and mortality.[3,4] For a thorough endoscopic evaluation, adequate bowel cleansing is essential. Inadequate bowel preparation occurs in up to 25% of colonoscopies,[5] leading to impaired visualization, missed polyps, lower adenoma detection rates, longer cecal intubation time, increased costs, and an overall increased risk of interval colorectal cancer.[1] Prior studies have suggested that underlying conditions or patient demographics such as diabetes, obesity, narcotic use, male gender, older age, and cirrhosis are associated with worse bowel cleansing.[6–12]

Cirrhosis as a risk factor for worse bowel preparation and colonoscopy has been suggested as part of larger data analyses.[8,10,12–17] Only a few series with a relatively small cohort of patients looking specifically at cirrhosis have been reported.[12–16] Gastrointestinal motility disorders have been described in this population and in particular those with more advanced liver disease and portal hypertension.[18] Intestinal dysmotility complications such as small intestinal bowel overgrowth, increased risk of spontaneous bacterial peritonitis, and worsening of hepatic encephalopathy have been described in patients with cirrhosis.[19] Any worsened bowel preparation in patients with cirrhosis can be disastrous as chronic liver diseases may place patients at increased risk of colon cancer, making screening with colonoscopy even more important.[20] Nonalcoholic fatty liver disease and primary sclerosing cholangitis have been associated with an increased risk of colorectal polyps and cancer.[21,22]

To evaluate the effect of cirrhosis on bowel preparation, we carried out a match-controlled retrospective study evaluating patients with cirrhosis who underwent outpatient colonoscopy at the University of Utah Health System between 2016 and 2021. We compared the Boston Bowel Preparation Scale (BBPS), cecal intubation time and success rates, and polyp detection rates. We also evaluated the influence of the MELD score or the presence of portal hypertension complications (ascites, hepatic encephalopathy, and variceal hemorrhage) on outpatient colonoscopy preparations.

MATERIALS AND METHODS

Design and Study Population

This was a retrospective study including patients 18 years old or above with and without the diagnosis of cirrhosis that underwent first-time outpatient screening colonoscopy within the University of Utah Health System between 2016 and 2021. We matched cases to controls in a

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1:1 ratio. Controls were patients without cirrhosis who underwent outpatient colonoscopy at the University of Utah Health System between 2016 and 2021 matched to cases by age, gender, and race/ethnicity. Patients with any lifetime diagnosis of cirrhosis were identified by searching the electronic medical record (EMR) for ICD 9 and 10 codes (ICD 9 571.5 and ICD-10 K74.6). Colonoscopy data were obtained by searching the electronic medical record for ICD-10 codes (ICD-10 Z12.11) and CPT codes (45378, G0105, G0121). We excluded patients with known risk factors for worse colonoscopies, such as opioid use (ICD-10 F11.9), opioid dependence (ICD-10 F11.2), and constipation (ICD-10 K59.0l). We manually extracted BBPS, cecal intubation time and success rate as well as polyp detection rate data from colonoscopy reports. We obtained portal hypertension complication information using the following ICD codes: variceal hemorrhage (ICD-10 185.01), ascites (ICD-10 R18.8), and hepatic encephalopathy (ICD-10 572.2). We also performed a subgroup analysis excluding patients with obesity (ICD-10 E66.9).

Statistical Analysis

We summarized and compared the distributions of baseline covariates and various outcomes by cirrhotic status. We used chi-squared tests for categorical factors and the Wilcoxon rank sum test for continuous factors. We then fit separate linear/generalized linear models to compare the various outcomes between patients with or without cirrhosis. We adjusted for age, gender, and self-reported race/ethnicities.

For BBPS data, we used a generalized linear regression model from the Gaussian family with the identity link function. For cecal intubation time success rate and polyp detection rate, we used a generalized linear regression model from the Poisson family with the log link function. Cirrhotic status was included as an exposure in the models. To determine the impact of the MELD score, we restricted the data to only cirrhotic patients and used a generalized linear model similar to the above for all outcomes, including the MELD score as the predictor.

Next, we investigated if specific complications from portal hypertension, such as ascites, HE, or VH, influenced bowel cleansing in patients with cirrhosis . We restricted the data to only patients with cirrhosis and fitted generalized linear regression models for each outcome similar to the above with each individual portal hypertension complication as predictors. We also fit a generalized regression model for the presence of portal hypertension in general as a predictor.

Finally, we fit a random forest model with individual portal hypertension complications to better evaluate each complication's importance and to determine which specific complications influenced bowel cleansing the most. This model creates a percentage increase in mean squared error (MSE) associated with each complication. The percentage increase in MSE correlates with the importance of each complication with a higher percentage increase correlating with a stronger influence on bowel preparation.

Subgroup analysis excluding obese patients were performed with the same techniques.

RESULTS

We found 732 patients with cirrhosis who underwent first-time outpatient screening colonoscopy at the University of Utah Health System between 2016 and 2021 that met our inclusion and exclusion criteria (Table 1). Patients with cirrhosis had lower mean BBPS scores (7.3 ± 1.8) than controls matched for age, gender, and self-reported race/ethnicities (7.7 ± 1.6; $P < 0.001$) (Table 2, Fig. 1). Cecal intubation time was about 9% slower for patients with cirrhosis (8.2 ± 5.5 min) compared with controls (7.5 ± 5.2 min; $P = 0.01$) (Table 2, Fig. 2). Successful cecal intubation rates did not differ between patients with or without cirrhosis (95.8% vs 96.8%; $P = 0.27$). Likewise, mean polyp detection rates did not differ between patients with cirrhosis (2.3 ± 3.4 polyps detected) and patients without cirrhosis (2.4 ± 4.2 polyps; $P = 0.99$).

For patients with cirrhosis, we studied how worsening cirrhosis severity as determined by the MELD score affected their BBPS score, cecal intubation times and rates, and polyp detection rates. The mean MELD score for patients with cirrhosis was 11.0. For each increase in MELD score by 1 point, the BBPS score decreased by 0.02 ($P = 0.063$), and cecal intubation time increased by 2% ($P < 0.001$; Table 3). Successful cecal intubation rate trended towards significance with a 1-point increase in MELD score. Each increase in MELD score by 1 point led to a 2% decrease in polyp detection rate ($P = 0.064$).

We also studied the influence of portal hypertension complications (including ascites, HE, and VH) on BBPS score, cecal intubation times and rates, and polyp detection rates (Table 4, Figs. 1–2). Ascites significantly decreased BBPS score by 0.42 points ($P = 0.002$), increased cecal intubation time by 19% ($P = 0.001$), and lowered polyp detection rate by 23% ($P = 0.008$). It trended towards lowering the successful cecal intubation rate by 3% ($P = 0.081$). Likewise, HE also significantly decreased BBPS score by 0.32 points ($P = 0.034$), increased cecal intubation time by 24% ($P < 0.001$), and lowered polyp detection rate by 24% ($P = 0.014$). It trended towards lowering the successful cecal intubation rate by 4% ($P = 0.061$). VH lengthened cecal intubation time significantly by 23% ($P = 0.043$) but did not

TABLE 1. Characteristics of Cirrhotic Patients and Noncirrhotic Matched Controls at Baseline

Characteristics	All patients (N = 1464)	Cirrhotic patients (N = 732)	Noncirrhotic patients (N = 732)	*P*
Female gender, no. (%)	618 (42.2)	309 (42.2)	309 (42.2)	1.00
White/Caucasian, no. (%)	1198 (81.8)	599 (81.8)	599 (81.8)	1.00
Hispanic/Latino, no. (%)	190 (13.0)	95 (13.0)	95 (13.0)	1.00
MELD score, mean (SD)	—	11.0 (6.4)	—	—
History of ascites, no. (%)	—	208 (28.4)	—	—
History of HE, no. (%)	—	254 (34.7)	—	—
History of VH, no. (%)	—	50 (6.8)	—	—

HE indicates hepatic encephalopathy; MELD, Model of End-stage Liver Disease; VH, variceal hemorrhage.

TABLE 2. Effect of cirrhosis on Boston Bowel Preparation Scale (BBPS) Score, Cecal Intubation Time, Cecal Intubation Success Rates, and Polyp Detection Rates

Outcomes	Cirrhotic patients (N = 732)	Noncirrhotic patients (N = 732)	*P*	Nonobese cirrhotic patients (N = 408)	Nonobese noncirrhotic patients (N = 408)	*P*
BBPS score, mean (SD)	7.3 (1.8)	7.7 (1.6)	< 0.001	7.4 (1.8)	7.7 (1.7)	0.029
Cecal intubation time, mean min (SD)	8.2 (5.5)	7.5 (5.2)	0.01	8.2 (5.5)	7.4 (5.0)	0.029
Cecal intubation success rate, no. (%)	699 (95.8)	706 (96.8)	0.27	393 (96.3)	394 (96.8)	0.71
Polyp detection rate, mean polyps (SD)	2.3 (3.4)	2.4 (4.2)	0.99	2.0 (2.4)	2.7 (5.2)	0.015

BBPS indicates Boston Bowel Preparation Scale.

significantly lower BBPS or cecal intubation or polyp detection rates.

Using a random forest model adjusted for age, gender, race, and ethnicity, we found HE to have the highest effect on BBPS and cecal intubation time (Fig. 3). Ascites affected polyp detection rate and cecal intubation rate the most, though no portal hypertension complication had more than a minimal impact on cecal intubation rate. In all outcomes, VH did not greatly influence bowel cleansing when other complications from portal hypertension were present.

We analyzed 408 patients with cirrhosis in a subgroup of patients excluding patients with obesity. We found that patients with cirrhosis had a mean BBPS score 0.3 points lower than for controls (7.4 ± 1.8 vs. 7.7 ± 1.7; $P = 0.030$, Table 3, Fig. 4). Cecal intubation time was about 11% slower for patients with cirrhosis (8.2 ± 5.5 min) compared with controls (7.4 ± 5.0 min; $P = 0.032$) (Table 2, Fig. 5). Mean polyp detection rate was about 24% lower for patients with cirrhosis (2.0 ± 2.4 vs. 2.7 ± 5.2 polyps detected, $P = 0.015$). Successful cecal intubation rates did not differ (96.3% vs. 96.8% of controls, $P = 0.71$).

The mean MELD score for our obesity-excluded subgroup was 10.9. For each increase in the MELD score by 1 point cecal intubation time increased by 2% ($P < 0.001$; Table 3). BBPS score, successful cecal intubation rate, and polyp detection rate changed little with each incremental increase in MELD score (Table 3).

When examining the effects of portal hypertension complications on our subgroup, we found that ascites significantly decreased BBPS score by 0.51 points ($P = 0.016$) and increased cecal intubation time by 18% ($P = 0.03$; Table 4, Fig. 5). It did not have a significant effect on cecal intubation or polyp detection. HE worsened the polyp detection rate by 22% ($P = 0.04$) but did not significantly affect BBPS, cecal intubation time or rate, or polyp detection. VH was not associated with worse bowel preparation or endoscopy outcomes (Table 4, Fig. 5).

Again, using a random forest model, we found that for our subgroup ascites had the greatest effect on BBPS score and polyp detection rate (Fig. 6). HE had the greatest effect on cecal intubation time. No portal hypertension complication was associated with a worse cecal intubation rate.

DISCUSSION

Adequate bowel preparation for screening colonoscopy is accepted as one of the tenets of high-quality exams. Screening is especially important for patients with cirrhosis, as previous studies have found a higher rate of adenomatous polyps in this population.[20–24] We found that patients with cirrhosis had significantly worse bowel preparation and longer cecal intubation times without statistically significant reductions in cecal intubation success rates or polyp detection rates in all patients; subgroup analysis of patients without obesity did find a lower polyp detection rate.

Multiple studies and systematic reviews have found an association between cirrhosis and poor bowel preparation.[8,10,12–16] There are competing etiologies for this finding. One reason for poorer bowel preparation may be altered intestinal fluid permeability, possibly due to salt

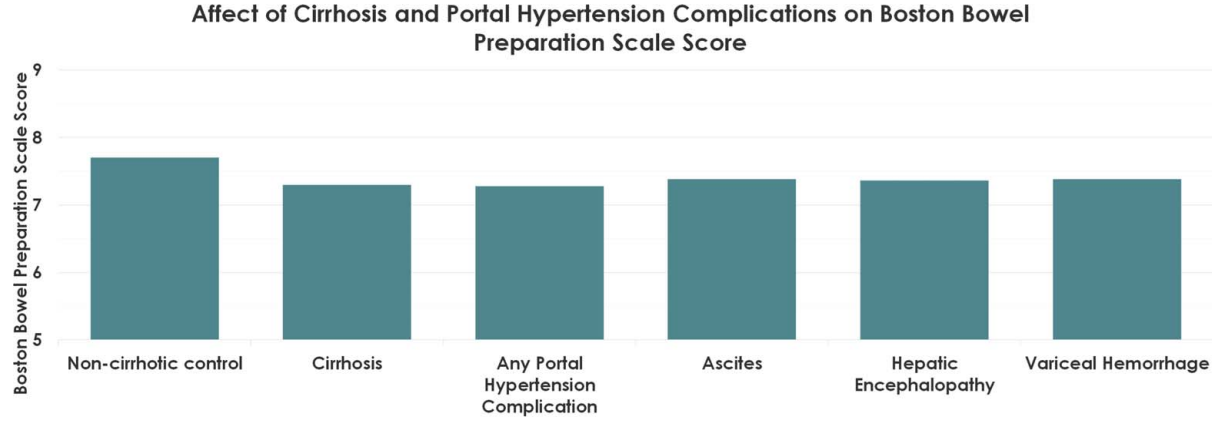

FIGURE 1. Bowel preparation, as measured by the Boston Bowel Preparation Scale score, was significantly worse for patients with cirrhosis and any portal hypertensive complication in general, as well as with ascites and hepatic encephalopathy. Preparation trended towards lower quality in patients with a history of variceal hemorrhage.

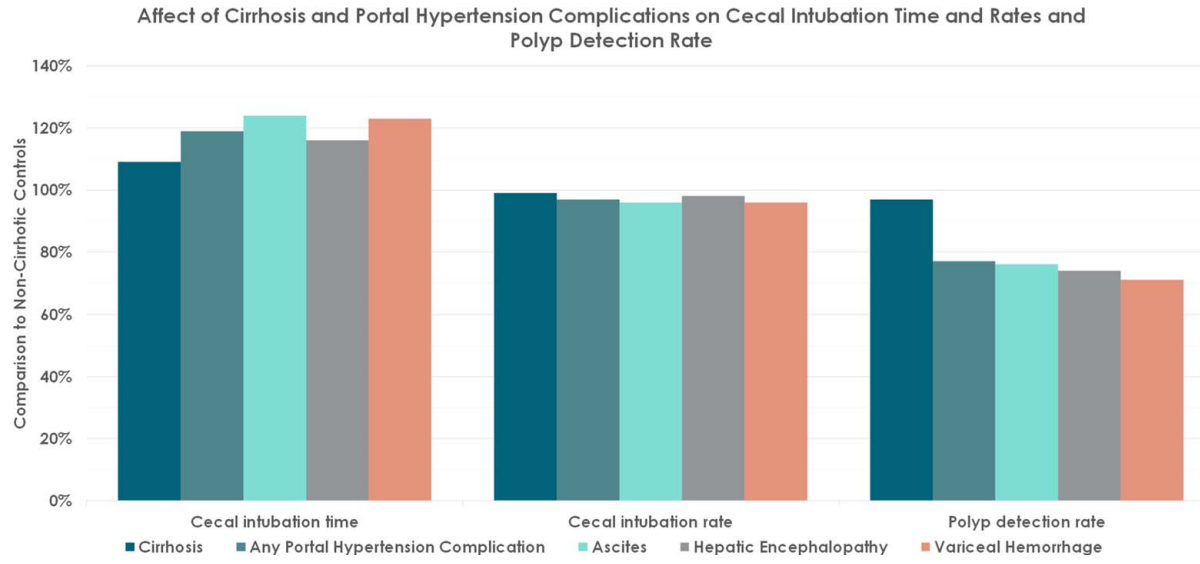

FIGURE 2. Cecal intubation time was significantly elevated for patients with cirrhosis and patients with any portal hypertension complication and each individual complication. Cecal intubation rate trended towards less success with cirrhosis and any portal hypertension complication and each individual complication but was not significant. Polyp detection rates were significantly decreased for portal hypertension complications as a whole and for patients with ascites and/or hepatic encephalopathy but were not significantly decreased for patients with cirrhosis or patients with a history of variceal hemorrhage.

and water imbalances that are more prevalent in patients with cirrhosis.[25] Additionally, intestinal dysmotility in patients with cirrhosis may also contribute to poorer bowel preparation. Past studies have found ascites to worsen colonoscopy success rates, possibly through challenges with creating and reducing loops.[17] Tolerance of the bowel preparation solution and ability to complete the preparation may also contribute; however, Salso et al in 2015 found no reduced tolerability or bowel preparation adherence when comparing cirrhotic and normal patients.[14]

A 2015 study from Salso et al compared 53 patients with cirrhosis undergoing first-time screening colonoscopies to 52 healthy sex and age-matched controls.[14] Like our results, they found a worse quality of bowel preparation and longer time to cecal intubation but no significant decline in polyp detection rate in patients with cirrhosis (though the rate did trend lower for cirrhotic patients). Similarly, a 2016 study from Anam et al compared 210 patients with chronic liver disease to 120 patients with cirrhosis, all undergoing outpatient screening colonoscopies.[15] Again, they found significantly worse bowel preparation in patients with cirrhosis but no difference in polyp detection rate. Our study differs from these 2 previous studies by finding a decreased polyp detection rate in nonobese patients. Both of these studies found no correlation between MELD score and bowel preparation or polyp detection rate. We did find that an increase in MELD score did significantly lengthen cecal intubation time in patients both with and without obesity. This longer time could be due to factors such as suboptimal preparation or increased looping in an increasingly diseased abdomen. Our study differs from previous studies by having a larger sample size with subsequent higher power to find an association between MELD score, bowel preparation, and endoscopy measures. Physiologically it is plausible for more severe cirrhosis to more greatly affect bowel preparation through the mechanisms previously discussed (eg, impaired intestinal motility, poorer fluid permeability, etc.). Other studies have found significantly longer small bowel transit times in patients with more severe cirrhosis and a trend toward prolonged colonic transit time in decompensated cirrhotic patients.[26]

TABLE 3. Effect of Worsening Cirrhosis Severity as Measured by Rising Model of End-stage Liver Disease (MELD) Score on Boston Bowel Preparation Scale (BBPS) Score, Cecal Intubation Time and Success Rates, and Polyp Detection Rates in Patients with Cirrhosis

	All cirrhotic patients (N = 732)		Nonobese cirrhotic patients (N = 408)	
Outcomes	**Single point increase in MELD score (95% CI)**	***P***	**Single point increase in MELD score (95% CI)**	***P***
BBPS score, mean difference (95% CI)	−0.02 (−0.04, 0)	0.063	−0.01 (−0.04, 0.02)	0.42
Cecal intubation time, rate ratio (95% CI)	1.02 (1.01, 1.03)	< 0.001	1.02 (1.01, 1.03)	< 0.001
Cecal intubation success rate, rate ratio (95% CI)	1 (1, 1)	0.297	0.999 (0.996, 1.004)	0.847
Polyp detection rate, rate ratio (95% CI)	0.98 (0.97, 1)	0.064	0.999 (0.98, 1.02)	0.972

BBPS indicates Boston Bowel Preparation Scale; CI, confidence interval; MELD, Model of End-stage Liver Disease.

TABLE 4. Influence of Portal Hypertension Complications (including ascites, hepatic encephalopathy, and variceal hemorrhage) on Boston Bowel Preparation Scale (BBPS) Score, Cecal Intubation Times and Success Rates, and Polyp Detection Rates in Patients with Cirrhosis

		All cirrhotic patients (N = 732)		All noncirrhotic patients (N = 408)	
	Outcomes	**Estimate (95% CI)**	***P***	**Estimate (95% CI)**	***P***
Any portal hypertension complication	BBPS score, mean difference	−0.42 (−0.68, −0.15)	0.002	−0.38 (−0.74, −0.01)	0.045
	Cecal intubation time, rate ratio	1.19 (1.07, 1.31)	0.001	1.17 (1.02, 1.34)	0.028
	Cecal intubation success rate – rate ratio	0.97 (0.94, 1)	0.081	0.99 (0.95, 1.03)	0.638
	Polyp detection rate, rate ratio	0.77 (0.63, 0.93)	0.008	0.85 (0.67, 1.07)	0.171
Ascites	BBPS score, mean difference	−0.32 (−0.62, −0.02)	0.034	−0.51 (−0.92-−0.1)	0.016
	Cecal intubation time, rate ratio	1.24 (1.11, 1.4)	< 0.001	1.18 (1.01, 1.39)	0.037
	Cecal intubation success rate, rate ratio	0.96 (0.93, 1)	0.061	0.96 (0.92, 1.02)	0.167
	Polyp detection rate, rate ratio	0.76 (0.61, 0.94)	0.014	0.78 (0.59, 1.04)	0.086
Hepatic Encephalopathy	BBPS score, mean difference	−0.34 (−0.62, −0.05)	0.019	−0.2 (−0.58, 0.18)	0.30
	Cecal intubation time, rate ratio	1.16 (1.05, 1.29)	0.005	1.15 (0.996, 1.34)	0.056
	Cecal intubation success rate, rate ratio	0.98 (0.95, 1.01)	0.246	0.999 (0.96, 1.04)	0.969
	Polyp detection rate, rate ratio	0.74 (0.60, 0.90)	0.003	0.78 (0.61, 0.99)	0.04
Variceal hemorrhage	BBPS score, mean difference	−0.32 (−0.88, 0.25)	0.270	−0.33 (−1.06, 0.41)	0.385
	Cecal intubation time, rate ratio	1.23 (1.01, 1.51)	0.043	1.08 (0.81, 1.43)	0.601
	Cecal intubation success rate, rate ratio	0.96 (0.88, 1.04)	0.312	0.96 (0.87, 1.07)	0.494
	Polyp detection rate – rate ratio	0.71 (0.48, 1.04)	0.079	0.73 (0.47, 1.14)	0.173

BBPS indicates Boston Bowel Preparation Scale; CI, confidence interval.

We found that a history of portal hypertension complications tended to worsen BBPS score and lengthen cecal intubation time with HE as the complication most strongly associated with worsened outcomes in all of our patients and with ascites having a higher effect in nonobese patients. To our knowledge, past studies have not analyzed the association of portal hypertension and its various complications to bowel preparation quality. To optimize bowel preparation

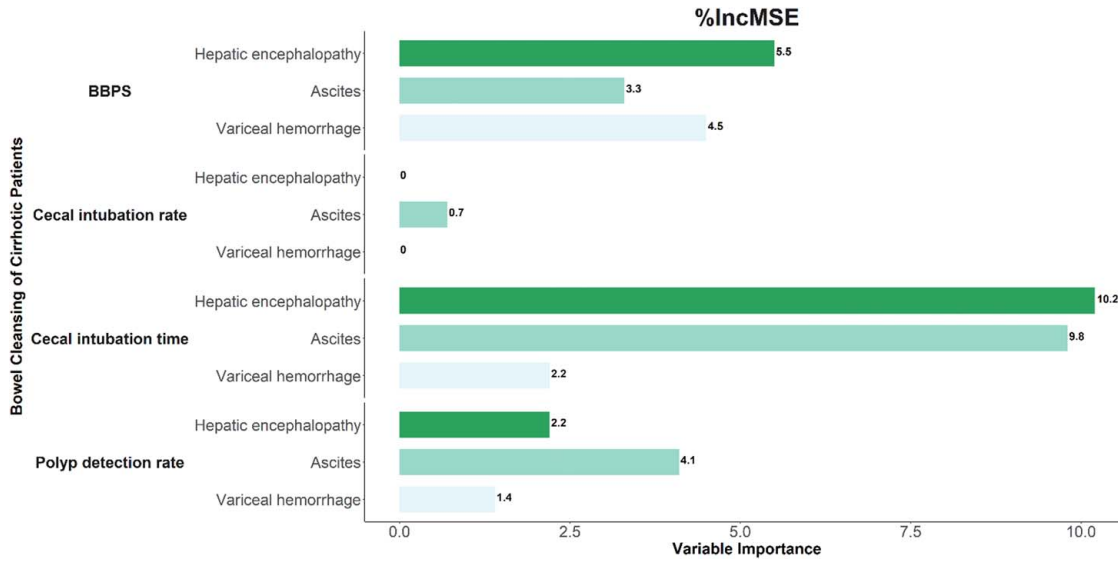

FIGURE 3. Random forest model indicating the importance of each portal hypertension complication on various bowel cleansing quality parameters adjusted for age, gender, race, and ethnicity. A higher increase in mean SE (MSE) indicates a higher degree of importance on affecting bowel cleansing. Hepatic encephalopathy had the largest effect on BBPS and cecal intubation time. Ascites had the highest effect on polyp detection rate and cecal intubation rate.

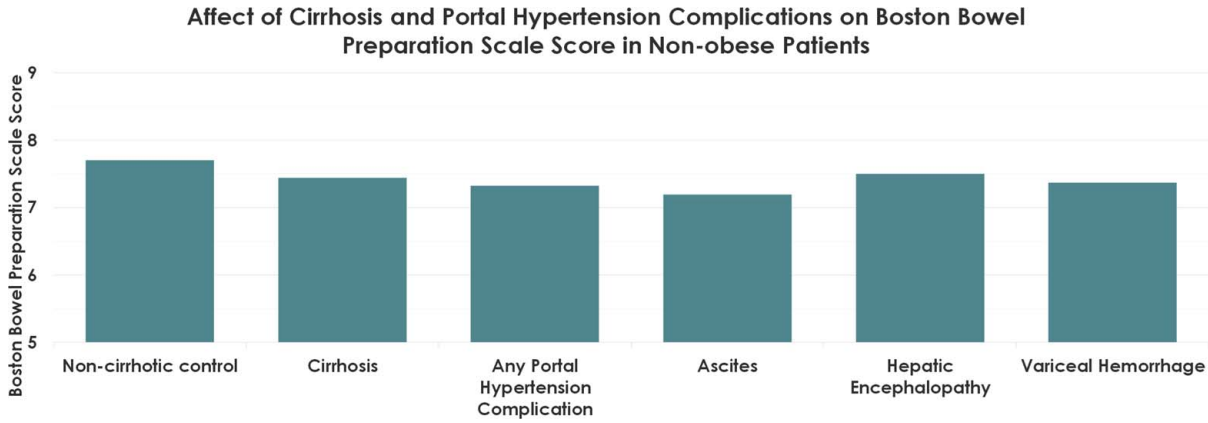

FIGURE 4. Boston Bowel Preparation Scale scores were significantly worsened for nonobese patients with cirrhosis as well as nonobese patients with portal hypertension complications in general and ascites.

and efficient and effective screening, clinicians should recommend aggressive bowel preparations for patients with portal hypertension.

Our subgroup analysis suggests that nonobese patients with cirrhosis have significantly decreased polyp detection. Poor polyp visualization could be a direct result of the suboptimal bowel preparations that other studies and ours found patients with cirrhosis to have. When comparing both obese and nonobese patients, we found no difference in polyp detection. This disparity can be explained by considering the number of polyps patients may have. Other studies[27–30] have suggested that polyps are found with higher frequency in patients with obesity. Perhaps a difference in polyp detection rates was only seen in nonobese patients because these patients had fewer, if any, polyps to be discovered so even a slight difference in bowel preparation quality would have a larger effect.

Our study has some limitations. Our study was a single-center, retrospective study that may not be generalizable to larger populations and is vulnerable to confounders, including variable bowel preparation formulations and different endoscopists with varying adenoma detection rates and subjective BBPS scoring rates. However, our protocol bowel preparation did not differ between cases and controls, and most subjects in both arms likely received the same bowel preparation. While we did exclude patients with a history of opioid use and dependence and a history of constipation, we did not control for patients with motility-affecting conditions such as diabetes mellitus or cystic fibrosis, or patients taking motility-affecting medications such as beta-blockers, lactulose, or drugs with anti-cholinergic effects such as tricyclic antidepressants as this dramatically limited patients that could be included in our study. We also did not control for patients with potentially untreated or undertreated hepatic encephalopathy as data were not available regarding whether patients with hepatic encephalopathy were adequately treated; therefore, our data can only show that patients with cirrhosis with hepatic encephalopathy, whether treated adequately or not, had worse bowel preparations. Another limitation is our analysis of

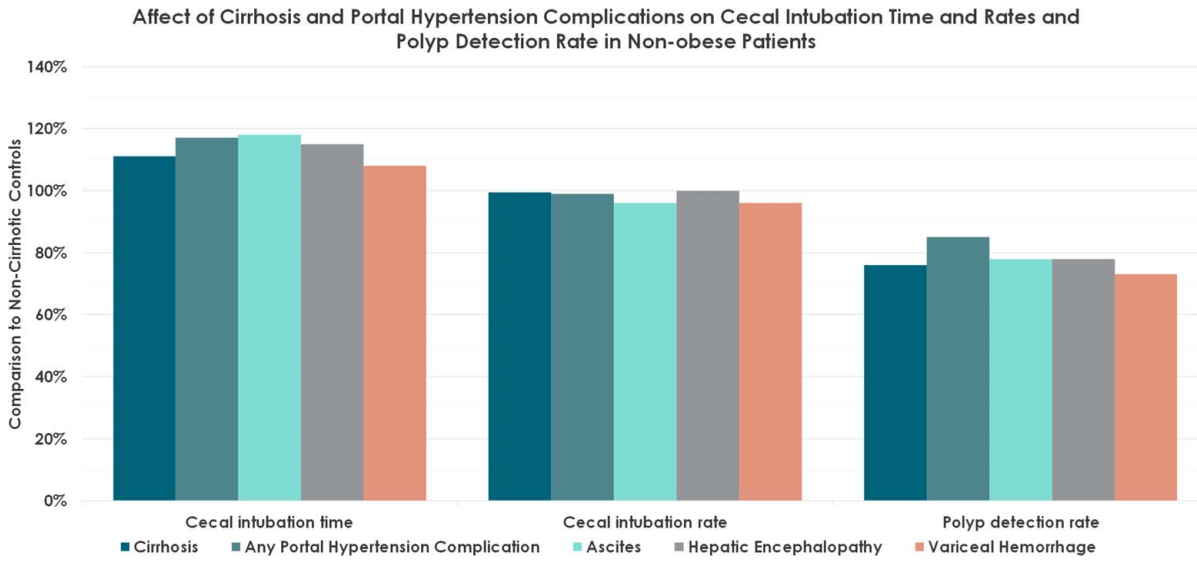

FIGURE 5. Cecal intubation time was significantly longer for nonobese patients with cirrhosis and for nonobese patients with portal hypertension complications in general and ascites. Nonobese patients with cirrhosis and nonobese patients with hepatic encephalopathy had worse polyp detection rates.

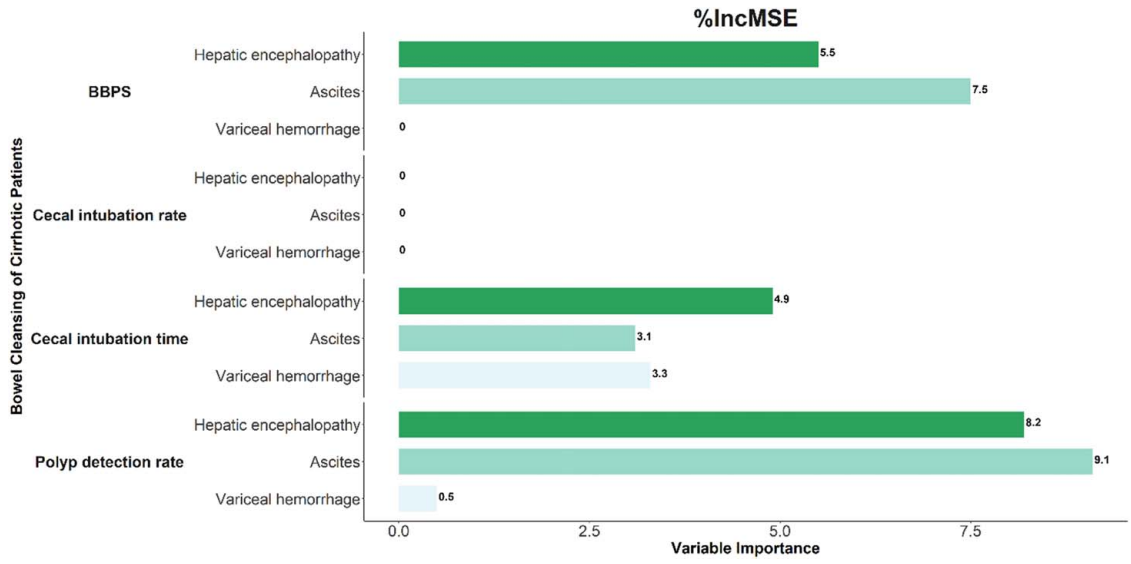

FIGURE 6. Random forest model of nonobese patients indicating the importance of each portal hypertension complication on bowel cleansing and endoscopy quality adjusted for age, gender, race, and ethnicity. A higher increase in mean SE (MSE) indicates a higher degree of importance on affecting bowel cleansing. Ascites had the largest effect on BBPS score and polyp detection rate, while hepatic encephalopathy was associated with the highest effect on cecal intubation time.

bowel preparation quality by comparing the BBPS score as a whole instead of evaluating individual segments. Previous studies have suggested including adequate BBPS segment scores as criteria for adequate bowel preparation.[31,32] In addition, we did not collect data regarding in which colonic segments endoscopists aborted the colonoscopy which could affect the reported BBPS score. Future studies could compare bowel preparation both on the segmental level and the global level. Finally, patient factors such as waist circumference or waist-to-height ratio were not available for patients in this retrospective study, which may influence cecal intubation times and rates.[33]

CONCLUSIONS

We found that patients with cirrhosis have significantly worse bowel preparation and longer cecal intubation times than matched patients without cirrhosis. Nonobese patients with cirrhosis also had lower polyp detection. In addition, cecal intubation time worsened with a rising MELD score. A history of portal hypertension complications was associated with a longer cecal intubation time. These findings amplify the importance of strict compliance with standard bowel preparations and consideration of more aggressive bowel preparation strategies for patients with cirrhosis, especially for patients with severe disease or portal hypertension complications.

REFERENCES

1. Siegel RL, Miller KD, Goding Sauer A, et al. Colorectal cancer statistics, 2020. *CA Cancer J Clin*. 2020;70:145–164.
2. Shaukat A, Kahi CJ, Burke CA, et al. ACG Clinical Guidelines: Colorectal Cancer Screening 2021. *Am J Gastroenterol*. 2021;116:458–479.
3. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *N Engl J Med*. 2012;366:687–696.
4. Brenner H, Chang-Claude J, Seiler CM, et al. Protection from colorectal cancer after colonoscopy: a population-based, case-control study. *Ann Intern Med*. 2011;154:22–30.
5. 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;61:378–384.
6. Lebwohl B, Wang TC, Neugut AI. Socioeconomic and other predictors of colonoscopy preparation quality. *Dig Dis Sci*. 2010;55:2014–2020.
7. Chung YW, Han DS, Park KH, et al. Patient factors predictive of inadequate bowel preparation using polyethylene glycol: a prospective study in Korea. *J Clin Gastroenterol*. 2009;43:448–452.
8. Mahmood S, Farooqui SM, Madhoun MF. Predictors of inadequate bowel preparation for colonoscopy: a systematic review and meta-analysis. *Eur J Gastroenterol Hepatol*. 2018;30:819–826.
9. Yee R, Manoharan S, Hall C, et al. Optimizing bowel preparation for colonoscopy: What are the predictors of an inadequate preparation? *Am J Surg*. 2015;209:787–792.
10. Gandhi K, Tofani C, Sokach C, et al. Patient characteristics associated with quality of colonoscopy preparation: a systematic review and meta-analysis. *Clin Gastroenterol Hepatol*. 2018;16:357–369.e10.
11. Borg BB, Gupta NK, Zuckerman GR, et al. Impact of obesity on bowel preparation for colonoscopy. *Clin Gastroenterol Hepatol*. 2009;7:670–675.
12. Ness RM, Manam R, Hoen H, et al. Predictors of inadequate bowel preparation for colonoscopy. *Am J Gastroenterol*. 2001;96:1797–1802.
13. Hassan C, Fuccio L, Bruno M, et al. A predictive model identifies patients most likely to have inadequate bowel preparation for colonoscopy. *Clin Gastroenterol Hepatol*. 2012;10:501–506.
14. Salso A, De Leonardis F, Lionetti R, et al. Standard bowel cleansing is highly ineffective in cirrhotic patients undergoing screening colonoscopy. *Dig Liver Dis*. 2015;47:523–525.
15. Anam AK, Karia K, Jesudian AB, et al. Cirrhotic patients have worse bowel preparation at screening colonoscopy than chronic liver disease patients without cirrhosis. *J Clin Exp Hepatol*. 2016;6:297–302.
16. Garrido I, Marques M, Macedo G. S306 findings of colonoscopy in patients with liver cirrhosis: a different population? *Am J Gastroenterol*. 2022;117(10S):e221.

17. Macken EJ, Steinhauser A, De Schepper HU, et al. Colonoscopy in patients with liver cirrhosis: Success and safety issues. *Acta Gastroenterol Belg*. 2015;78:411–414.
18. Theocharidou E, Dhar A, Patch D. Gastrointestinal motility disorders and their clinical implications in cirrhosis. *Gastroenterol Res Pract*. 2017;2017:8270310.
19. Gundling F, Luxi M, Seidel H, et al. Small intestinal dysmotility in cirrhotic patients: correlation with severity of liver disease and cirrhosis-associated complications. *Z Gastroenterol*. 2021;59:540–550.
20. Naveau S, Chaput JC, Bedossa P, et al. Cirrhosis as an independent risk factor for colonic adenomas. *Gut*. 1992;33:535–540.
21. Chen W, Wang M, Jing X, et al. High risk of colorectal polyps in men with non-alcoholic fatty liver disease: a systematic review and meta-analysis. *J Gastroenterol Hepatol*. 2020;35:2051–2065.
22. Horsley-Silva JL, Rodriguez EA, Franco DL, et al. An update on cancer risk and surveillance in primary sclerosing cholangitis. *Liver Int*. 2017;37:1103–1109.
23. Jeschek P, Ferlitsch A, Salzl P, et al. A greater proportion of liver transplant candidates have colorectal neoplasia than in the healthy screening population. *Clin Gastroenterol Hepatol*. 2015; 13:956–962.
24. Sorensen HT, Friis S, Olsen JH, et al. Risk of liver and other types of cancer in patients with cirrhosis: A nationwide cohort study in Denmark. *Hepatology*. 1998;28:921–925.
25. Aguirre Valadez JM, Rivera-Espinosa L, Méndez-Guerrero O, et al. Intestinal permeability in a patient with liver cirrhosis. *Ther Clin Risk Manag*. 2016;12:1729–1748.
26. Chander Roland B, Garcia-Tsao G, Ciarleglio MM, et al. Decompensated cirrhotics have slower intestinal transit times as compared with compensated cirrhotics and healthy controls. *J Clin Gastroenterol*. 2013;47:888–893.
27. Sato Y, Nozaki R, Yamada K, et al. Relation between obesity and adenomatous polyps of the large bowel. *Dig Endosc*. 2009; 21:154–157.
28. Comstock SS, Hortos K, Kovan B, et al. Adipokines and obesity are associated with colorectal polyps in adult males: a cross-sectional study. *PLoS One*. 2014;9:e85939; Published 2014 Jan 17.
29. Lee K, Kim YH. Colorectal polyp prevalence according to alcohol consumption, smoking and obesity. *Int J Environ Res Public Health*. 2020;17:2387; Published 2020 Mar 31.
30. Lee JY, Kwak SM, Myung SK, et al. Obesity and colorectal adenomatous polyps: A cross-sectional study in Korean adults. *Obesity (Silver Spring)*. 2014;22:518–525.
31. Kluge MA, Williams JL, Wu CK, et al. Inadequate Boston Bowel Preparation Scale scores predict the risk of missed neoplasia on the next colonoscopy. *Gastrointest Endosc*. 2018; 87:744–751.
32. Clark BT, Protiva P, Nagar A, et al. Quantification of Adequate Bowel Preparation for Screening or Surveillance Colonoscopy in Men. *Gastroenterology*. 2016; 150:396–e15.
33. Goksoy B, Kiyak M, Karadag M, et al. Factors affecting cecal intubation time in colonoscopy: Impact of obesity. *Cureus*. 2021;13:e15356.