

Evaluation of the combined effect of factors influencing bowel preparation and adenoma detection rates in patients undergoing colonoscopy

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ABSTRACT

Background Colonoscopy is a commonly used modality for screening and surveillance of colorectal cancer (CRC). Therefore, it is essential to have adequate bowel preparation (prep) for the procedure which depends on type of bowel regimens, diet before colonoscopy and timing of the procedure.

Aims The purpose of this study is to analyse the effect of multiple factors on adenoma detection rate (ADR) and prep quality of colonoscopy. This is the also the first study determining outcomes based on various combinations of diet, timing of the procedure and bowel prep regimens.

Methods This is a retrospective single-centre observational study. Data about diet before procedure, bowel prepprep regimen and timing of the procedure were collected for patients coming for screening colonoscopy.

Results Patients with split prep had higher good prep rates (73.8% vs 56.2%) and higher ADRs (34.2 % vs 29.9%) as compared with non-split prep. The good prep quality (65.8% vs 62.1%) and ADRs (31.9% vs 31.5%) were comparable in patients who received clear liquid diet as compared with low residue diet. The good results of bowel prep were obtained with split prep with either clear liquids or low residue diet irrespective of the timing of procedure. The poor prep was noticed in patients who underwent procedure in afternoon, with a low restrictive diet and non-split bowel regimen.

Conclusions The current study adds to our knowledge about the combined effect of multiple variables affecting the bowel prep quality and ADR. It is imperative to opt for the best combination required for colonoscopy, as this will influence the effectiveness of colonoscopies regarding timely cancer detection and prevention.

INTRODUCTION

Cancer is the second leading cause of global mortality and leads to about 8.8 million deaths in the 2015.¹ Colorectal cancer (CRC) is the third most common cancer. It is the second leading cause of cancer-related mortality and is responsible for about 8% of cancer-related deaths.^{2,3} CRC is a major

Summary box

What is already known about this subject?

- ▶ Adequate bowel preparation while screening for colorectal cancer depends on factors like bowel regimens, diet before colonoscopy and timing of the procedure.
- ▶ It is reported in different studies that for bowel preparation, split regimen is better than non-split regimen, clear liquid diet is not superior to low residue diet, and some disparity exists regarding the effect of timing of colonoscopy. So individual effects of these factors are known but the combined effect and determining the best possible combination is still not known.

What are the new findings?

- ▶ This is the first study determining the outcomes based on various combinations of diet, timing of the procedure and bowel preparation regimens.
- ▶ The superior results of bowel preparation were obtained utilising split regimen with either clear liquids or low residue diet irrespective of the timing of procedure.

How might it impact on clinical practice in the foreseeable future?

- ▶ The current study adds to our knowledge the best combinations needed for preparation of colonoscopy which can enhance the overall effectiveness of colonoscopy and aid in timely detection and treatment of colonic polyps or colorectal cancers.
- ▶ It will be useful to conduct prospective studies or randomised trials including larger and diverse patient populations and comparing different factors for bowel preparation.

health burden. The incidence is about 10% in males and 9.2% in females among all cancers.⁴ The lifetime likelihood of developing CRC is about 5%, with 90% of cancers developing after the age of 50 years.³ Timely



screening for adenomatous and serrated polyps, which may develop into CRC, reduces overall CRC incidence and mortality.^{5–7}

Colonoscopy is a commonly used modality for screening and surveillance of CRC. It reduces the CRC mortality and morbidity by detecting precancerous lesions like adenomas at an early stage when they can be endoscopically resected and before these lesions develop into malignant lesions.⁷ The adenoma detection rate (ADR) is the percentage of patients aged ≥ 50 years undergoing first-time screening colonoscopy that have one or more conventional adenomas detected and removed. It is an acceptable benchmark for quality in colonoscopy. According to the current guidelines, the target ADR of

physicians should be above 25%, that is, $\geq 20\%$ for female and $\geq 30\%$ for male patients.⁸

ADRs are significantly associated with the subsequent development of interval CRC.⁹ Corley *et al* reported inverse relationship of ADR and interval CRC by demonstrating that every 1.0% increase in the ADR was significantly associated with a 3.0% decrease in the risk of CRC (HR 0.97; 95% CI 0.96 to 0.98).¹⁰ Several factors contribute to the effectiveness of the colonoscopy which include increase in the bowel preparation (prep), meticulous inspection, withdrawal times and timing of the procedure.^{11–13} Bowel prep depends on the patient's acceptance and understanding of the procedure. The quality of bowel prep determines the procedure duration, ADR and the need

Table 1 Study demographics based on the presence and absence of adenomas

	Adenoma absent (N=1124) (%)	Adenoma present (N=518) (%)	Total (N=1642) (%)	P value
Age				
50–60	696 (61.9)	284 (54.8)	980 (59.6)	0.054
60–70	334 (29.7)	179 (34.6)	513 (31.2)	
70 and above	94 (8.4)	55 (10.6)	149 (9.1)	
Gender				
Female	588 (52.4)	216 (41.7)	804 (49.0)	<0.001
Male	535 (47.6)	302 (58.3)	837 (51.0)	
Diabetes	311 (27.7)	168 (32.6)	479 (29.2)	0.052
Hypertension	645 (57.5)	327 (63.5)	972 (59.4)	0.025
BMI				
<25	224 (20.9)	105 (21.5)	329 (21.1)	0.342
25–30	372 (34.8)	166 (34.0)	538 (34.5)	
30–40	355 (33.2)	176 (36.1)	531 (34.1)	
>40	119 (11.1)	41 (8.4)	160 (10.3)	
Opiate use	51 (4.5)	19 (3.7)	70 (4.3)	0.502
History of abdominal surgery	317 (28.2)	120 (23.2)	437 (26.6)	0.037
Anticholinergic drugs	20 (1.8)	8 (1.5)	28 (1.7)	0.891
Tricyclic antidepressants	24 (2.1)	7 (1.4)	31 (1.9)	0.374
Use of psychiatric meds	137 (12.2)	76 (14.7)	213 (13.0)	0.189
Thyroid medications	57 (5.1)	19 (3.7)	76 (4.6)	0.258
Laxatives	272 (24.2)	111 (21.4)	383 (23.3)	0.242
Use of antidiarrhoeal drugs	5 (0.4)	0 (0.0)	5 (0.3)	0.299
Diet before colonoscopy				
CLD	235 (20.9)	110 (21.2)	345 (21.0)	0.931
LRD	889 (79.1)	408 (78.8)	1297 (79.0)	
Bowel preparation regimen				
NSDR	713 (63.4)	304 (58.7)	1017 (61.9)	0.066
SDR	411 (36.6)	214 (41.3)	625 (38.1)	
Timing of colonoscopy				
AM	465 (41.4)	197 (38.0)	662 (40.3)	0.220
PM	659 (58.6)	321 (62.0)	980 (59.7)	

ADR, adenoma detection rate; AM, morning; BMI, body mass index; CLD, clear liquid diet; LRD, low residue diet; NSDR, non-split dose regimen; PM, afternoon; SDR, split-dose regimen.

Table 2 Outcomes based on bowel preparation regimen (NSDR vs NSDR)

	NSDR (N=1017) (%)	SDR (N=625) (%)	Total (N=1642) (%)	P value
Preparation quality				
Fair	290 (28.5)	109 (17.4)	399 (24.3)	<0.001
Good	572 (56.2)	461 (73.8)	1033 (62.9)	
Poor	155 (15.2)	55 (8.8)	210 (12.8)	
ADR	29.9	34.2	31.5	0.074

ADR, adenoma detection rate; NSDR, non-split dose regimen; SDR, split-dose regimen.

to follow-up.^{11 13} Careful examination of the colon with longer withdrawal time has been reported to increase the ADR in certain studies.^{14–16} ADR determines the safe intervals for scheduling surveillance colonoscopies.^{9 17 18}

The purpose of this study was to analyse the effect of multiple factors on ADR and prep quality of colonoscopy; individually and combined. This is the first study determining the outcomes based on various combinations of diet, the timing of the procedure and bowel prep types.

METHODS

This is a retrospective single-centre observational study. The period of study was 18 months between 1 January 2016 and 30 June 2017. The study was performed according to the Declaration of Helsinki.

Patient selection

The data was collected from the electronic medical records of patients and tabulated in Microsoft Excel. Findings at colonoscopy were extracted from the final procedure reports, and pathology information was extracted from the final pathology reports. Asymptomatic patients, aged between 50 and 80 years, undergoing screening colonoscopy were included in the study population. Symptomatic patients, patients with indications for therapeutic colonoscopy, such as rectal bleeding, iron-deficiency anaemia, inflammatory bowel disease, incomplete colonoscopy examination, CRC, chronic diarrhoea, and abnormal imaging, were excluded from the study. Patients with missing information/data were also excluded from the study. All the patients included underwent colonoscopies performed by four staff endoscopists at our institute. All the four endoscopists involved in the study are in practice for more than 5 years have consensus in reporting the quality of bowel prep. The

average annual caecal intubation rate for all the four endoscopists was 98.95%. The average annual ADR of these endoscopists was 33%.

Diet type

Data were collected on whether the patient had received instructions for clear liquid diet (CLD) or low residue diet (LRD) for the day before the procedure (breakfast, lunch and dinner). All patients received verbal as well as written instructions regarding the diet and bowel prep regimen by the gastroenterologists and the registered nurses during the visit before the colonoscopy and it was made sure that the patient verbalised understanding. CLD is a refined regime of normal diet. It does not include any substances which can increase the bulk of stool like solids, dairy products and fruit juices containing pulp.¹⁹ LRD is also a modified version of the standard diet, and it includes a daily supply of less than 10–15 g fibre.²⁰ Our dietary instructions given to the patients to consume LRD a day before colonoscopy included foods such as Jell-O (not red or green), boiled egg, scrambled egg, mashed potatoes, pancakes, apple juice, tea or coffee without milk, Gatorade, honey, popsicle, lemonade. The foods to avoid day before the colonoscopy included all solid foods, which cause residue in colon like vegetable soup, bread, dairy, fruits, vegetable, meat, rice. On the day of the procedure, patients were advised to take no solid food at all.

Bowel prep regimen types

Data were collected on whether the patients had received non-split dose regimen (NSDR), where the entire bowel prep was ingested the night before the procedure or split-dose regimen (SDR), where half of the bowel prep was ingested the night before the procedure and half on

Table 3 Outcomes based on the diet recommended before the colonoscopy (CLD vs LRD)

	CLD (N=345) (%)	LRD (N=1297) (%)	Total (N=1642) (%)	P value
Prep quality				
Fair	81 (23.5)	318 (24.5)	399 (24.3)	0.340
Good	227 (65.8)	806 (62.1)	1033 (62.9)	
Poor	37 (10.7)	173 (13.3)	210 (12.8)	
ADR	110 (31.9)	408 (31.5)	518 (31.5)	0.931

ADR, adenoma detection rate; CLD, clear liquid diet; LRD, low residue diet.

**Table 4** Outcomes based on the timing of the procedure (AM vs PM)

	AM (N=662) (%)	PM (N=980) (%)	Total (N=1642) (%)	P value
Preparation quality				
Fair	165 (24.9)	234 (23.9)	399 (24.3)	0.576
Good	407 (61.5)	626 (63.9)	1033 (62.9)	
Poor	90 (13.6)	120 (12.2)	210 (12.8)	
ADR	197 (29.8)	321 (32.8)	518 (31.5)	0.220

ADR, adenoma detection rate; AM, morning; PM, afternoon.

the morning of the procedure, 3 hours before the scheduled time of the colonoscopy.

The same bowel prep agent, polyethylene glycol (PEG), and dosage (238 g) were used in each group, making the only difference between groups the time of bowel prep ingestion

Timing of colonoscopy

We collected the data on the timing of the procedure based on the scope insertion time. Morning colonoscopies were defined as those that started before 12 noon and afternoon colonoscopies as those that started after 12 noon.

Quality of bowel prep

To make the results more widely applicable, we used the four-point Aronchick scale of excellent, good, fair and poor that was described by the endoscopist in the report.²¹ For analysis purpose, we combined the excellent and good preps together. Adequate prep included excellent, good and fair bowel prep. Preparations reported as inadequate were grouped with poor prep. Comparison between the adequate and inadequate preps was done in the online supplementary table 2s-9s. The scoring was done after manual colon cleansing during colonoscopy. All the endoscopists involved in the study are in practice for more than 5 years and each endoscopist performs more than 1000 procedure every year and have consensus in reporting the quality of bowel prep. We also use specialised endoscopy software in our endoscopy unit. For all the procedures, verification of caecum intubation was documented with exact time in the electronic medical record and the photographic evidence.

Adenoma detection rate

ADR, which is the percentage of average-risk patients for CRC who are found to have at least one adenoma or adenocarcinoma during a screening colonoscopy was calculated for all patients.²² Sessile serrated polyp were included in the calculation of ADR.

Statistical analysis

Demographic information, clinical measurements, other potential confounders including age categories, gender, diabetes status, hypertension status, body mass index (BMI) values in categories, opiate usage status, abdominal surgery status, anticholinergic status, tricyclic antidepressants (TCAs) status, psych med status, thyroid disease, laxatives use, antidiarrhoeal use were stratified by adenoma status. The three interventions (diet, prep type and time) and the mediator (prep quality) were stratified by adenoma prevalence. Pearson's χ^2 tests were conducted to assess the association between adenoma status and other variables. The associations were tested by analysis of variance tests for continuous variables and Pearson's χ^2 tests for categorical variables. Baron-Kenny procedures were used to assess the mediational hypothesis between adenoma prevalence status and prep on diet, split status and time three interventions separately. Multiple logistic regressions were used to assess the association between adenoma prevalence and prep quality, the association between the preparation quality and intervention status and the association between adenoma prevalence and prep quality controlling intervention. All regression models were controlled for confounders including age, gender, diabetes status and hypotension

Table 5 Outcome based on the bowel preparation regimen (SDR or NSDR) and the diet recommended before colonoscopy (CLD or LRD)

	CLD+NSDR (N=291) (%)	CLD+SDR (N=54) (%)	LRD+NSDR (N=726) (%)	LRD+SDR (N=571) (%)	Total (N=1642) (%)	P value
Preparation quality						
Fair	72 (24.7)	9 (16.7)	218 (30.0)	100 (17.5)	399 (24.3)	<0.001
Good	188 (64.6)	39 (72.2)	384 (52.9)	422 (73.9)	1033 (62.9)	
Poor	31 (10.7)	6 (11.1)	124 (17.1)	49 (8.6)	210 (12.8)	
ADR	94 (32.3)	16 (29.6)	210 (28.9)	198 (34.7)	518 (31.5)	0.167

ADR, adenoma detection rate; CLD, clear liquid diet; LRD, low residue diet; NSDR, non-split dose regimen; SDR, split-dose regimen.

Table 6 Outcomes based on bowel preparation regimen (SDR or NSDR) and timing of the procedure (AM or PM)

	NSDR+PM (N=457) (%)	NSDR+AM (N=560) (%)	SDR+PM (N=523) (%)	SDR+AM (N=102) (%)	Total (N=1642) (%)	P value
Preparation quality						
Fair	137 (30.0)	153 (27.3)	97 (18.5)	12 (11.8)	399 (24.3)	<0.001
Good	241 (52.7)	331 (59.1)	385 (73.6)	76 (74.5)	1033 (62.9)	
Poor	79 (17.3)	76 (13.6)	41 (7.8)	14 (13.7)	210 (12.8)	
ADR	137 (30.0)	167 (29.8)	184 (35.2)	30 (29.4)	518 (31.5)	0.194

ADR, adenoma detection rate; AM, morning; NSDR, non-split dose regimen; PM, afternoon; SDR, split-dose regimen.

status, BMI, opiate usage, abdominal surgery, TCAs, psych medication, thyroid, laxatives and antidiarrhoeal medication.

RESULTS

Table 1 shows the study population including the demographics, confounders, interventions and mediators stratified by the primary outcome (presence of adenomatous polyps). There were 518 patients with adenomas present and 1124 without any adenoma found on colonoscopy. The sample was mostly balanced in demographic and clinical information except for gender (more females), hypertension status and abdominal surgery. Most of the patients were on LRD (79%), non-split prep (61.9%) and did the colonoscopy in the afternoon (59.7%). We compared the outcomes based on prep type (**table 2**), diet type (**table 3**) and the timing of colonoscopy (**table 4**). Patients with split prep had higher good prep rates (73.8% vs 56.2%) and higher ADRs (34.2% vs 29.9%) as compared with non-split prep. The prep quality (good prep 65.8% vs 62.1%) and ADRs (31.9% vs 31.5%) were comparable in patients who received CLD as compared with LRD. Similarly, the timing of the procedure did not affect either the prep quality or the ADR.

Next, we evaluated various combinations of diet, prep type and timings to evaluate their effect on prep quality and ADR. **Table 5** shows the outcomes based on various combinations of diet and prep types. We found that the prep quality was significantly superior when either CLD or LRD was used with split prep, though it did not translate into a significantly higher ADR. The worst prep quality was achieved by using a LRD and non-split prep. Split prep

was significantly superior to non-split prep irrespective to the timing of the day when the procedure was performed, although it was not associated with a higher ADR (**table 6**). The worst prep quality was achieved by using a non-split prep with the procedure being done in the afternoon. There was no significant difference in prep quality and ADR when various combinations of diet and timing of procedure were evaluated (**table 7**).

In addition, we included all variables with all possible combinations to evaluate whether one was superior to others (**table 8**). We found that split prep with either CLD or LRD was associated with a significantly superior prep irrespective of the timing of procedure as compared with respective non-split prep groups. Interestingly, there were a significantly increased number of patients with a poor prep who underwent procedure in afternoon, with a LRD and non-split prep. There was no significant difference in ADR in any of the groups.

Table 9 indicates the result from the Baron-Kenny procedure. The multiple logistic regression indicates that the OR of having good or fair prep rather than poor was 1.90 (95% CI 1.34 to 2.68) with a split prep. But good or fair prep was not associated with higher adenoma prevalence. There was no effect of timing of procedure on either prep quality or ADR. Comparisons of outcomes between the adequate and inadequate prep is also mentioned in the online supplementary table 2s-9s.

DISCUSSION

This is the first study analysing the combined effect of multiple variables on the bowel prep quality and ADR. The quality of the bowel preparation is essential for the

Table 7 Outcomes based on the diet recommended before the colonoscopy (CLD or LRD) and timing of the procedure (AM or PM)

	CLD+PM (N=190) (%)	CLD+AM (N=155) (%)	LRD+PM (N=790) (%)	LRD+AM (N=507) (%)	Total (N=1642) (%)	P value
Preparation quality						
Fair	39 (20.5)	42 (27.1)	195 (24.7)	123 (24.3)	399 (24.3)	0.499
Good	130 (68.4)	97 (62.6)	496 (62.8)	310 (61.1)	1033 (62.9)	
Poor	21 (11.1)	16 (10.3)	99 (12.5)	74 (14.6)	210 (12.8)	
ADR	58 (30.5)	52 (33.5)	263 (33.3)	145 (28.6)	518 (31.5)	0.317

ADR, adenoma detection rate; AM, morning; CLD, clear liquid diet; LRD, low residue diet; PM, afternoon.



Table 8 Outcome based on bowel preparation regimen (SDR or NSDR), diet recommended before the colonoscopy (CLD or LRD) and timing of the procedure (AM or PM)

Preparation quality	CLD+NSDR+AM (N=138) (%)	CLD+NSDR+PM (N=153) (%)	CLD+SDR+AM (N=17) (%)	CLD+SDR+PM (N=37) (%)	LRD+NSDR+AM (N=422) (%)	LRD+NSDR+PM (N=304) (%)	LRD+SDR+AM (N=85) (%)	LRD+SDR+PM (N=486) (%)	Total (N=1642) (%)	P value
	Fair	41 (29.7)	31 (20.3)	1 (5.9)	8 (21.6)	112 (26.5)	106 (34.9)	11 (12.9)	89 (18.3)	399 (24.3)
Good	84 (60.9)	104 (68.0)	13 (76.5)	26 (70.3)	247 (58.5)	137 (45.1)	63 (74.1)	359 (73.9)	1033 (62.9)	
Poor	13 (9.4)	18 (11.8)	3 (17.6)	3 (8.1)	63 (14.9)	61 (20.1)	11 (12.9)	38 (7.8)	210 (12.8)	
ADR	46 (33.3)	48 (31.4)	6 (35.3)	10 (27.0)	121 (28.7)	89 (29.3)	24 (28.2)	174 (35.8)	518 (31.5)	0.377

ADR, adenoma detection rate; AM, morning; CLD, clear liquid diet; LRD, low residue diet; NSDR, non-split dose regimen; PM, afternoon; SDR, split-dose regimen.

detection of the clinically significant neoplastic lesions. A meta-analysis by Sulz *et al* reported that inadequate (poor/insufficient) bowel prep reduces the ADR. Reduction in the ADR was more obvious in early lesions as compared with advanced colonic lesions (OR 0.53, 95% CI 0.46 to 0.62, $p<0.001$).²³ Inadequate bowel prep can reduce detection of high-risk cancerous lesions including adenomas. A study described the adenoma miss rate of 47.9% in patients with inadequate prep. However, in the same study, the ADR was higher on repeat colonoscopy with good prep but the mean time between colonoscopies was 340 days.²⁴ A poor bowel prep not only results in procedure abortion/incompleteness but also causes significant economic and health burden.²⁵

Split regimen versus non-split regimen

In our study, SDR was associated with improved bowel cleaning. The patients with split prep had higher adequate prep rates (73.8% vs 56.2%) as compared with non-split prep. A meta-analysis of 29 studies also reported that adequate prep was obtained in 85% of patients in the split-dose group and 63% in the non-split dose group. The rate difference of 22% was found between degree of colon cleansing between split dose and non-split dose²⁶ in this analysis.

We also found higher ADRs in the split prep group (34.2% vs 29.9%) as compared with the non-split prep group. This was consistent with previously published studies. Radaelli *et al* conducted an RCT involving 690 patients and demonstrated that split regimen increases the detection of adenomas and clinically significant cancerous lesions and thereby enhancing the yield of colonoscopy. It was observed that at least one adenoma was significantly higher in the split dose group than in the non-split group (53.0% vs 40.9%, relative risk (RR) 1.22, 95% CI 1.03 to 1.46). In addition, the total numbers of both adenomas and advanced adenomas per subject were significantly higher in the split dose group (1.15 vs 0.8, $p<0.001$; 0.36 vs 0.22, $p<0.001$).²⁷

CLD versus LRD

Our study analysis revealed that the bowel prep quality (good prep 65.8% in the CLD vs 62.1% in the LRD) and ADR (31.9% in the CLD vs 31.5% LRD) were comparable in patients who received CLD when compared with LRD. This is consistent with the trial conducted by Stolpman *et al*. This randomised controlled trial reported that the quality of bowel prep with LRD was non-inferior to the bowel preparation with CLD. Adequate bowel prep was seen in 97% of patients in the CLD group and 94.5% in the LRD groups. In addition, polyp detection rates were comparable between the two groups (68% vs 65.4%).²⁸ Several previous studies also favoured these findings.^{29–31}

Nguyen *et al* did a meta-analysis and described interesting findings of significantly higher odds of tolerability (OR 1.92; 95% CI 1.36 to 2.70, $p<0.01$) and willingness to repeat prep (OR 1.86; 95% CI 1.34 to 2.59, $p<0.01$) in the LRD as compared with CLD. In addition, comparable

Table 9 OR and CIs from regression

		Outcome on treatment	Mediator on treatment	Outcome on mediator controlling treatment
Timing of the procedure	AM	–	–	–
	PM	1.16 (0.93 to 1.45)	1.07 (0.79 to 1.46)	1.31 (0.93 to 1.84)
Bowel preparation regimen	NSDR	–	–	–
	SDR	1.25 (1.00 to 1.56)	1.90 (1.34 to 2.68) ***	1.28 (0.91 to 1.80)
Diet recommended before colonoscopy	CLD	–	–	–
	LRD	1.00 (0.76 to 1.32)	0.90 (0.60 to 1.37)	1.31 (0.94 to 1.84)

Significance codes: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

ADR, adenoma detection rate; AM, morning; CLD, clear liquid diet; LRD, low residue diet; NSDR, non-split dose regimen; PM, afternoon; SDR, split-dose regimen.

findings were seen in adequate bowel preps (OR 1.21; 95% CI 0.64 to 2.28, $p = 0.58$) and adverse effects (OR 0.88; 95% CI 0.58 to 1.35, $p = 0.57$) between these two groups.³⁰ Another systematic review by Song *et al* reported similar findings.³¹ The combination of SDR+LRD has comparable though slightly better statistically significant results in bowel prep for colonoscopy as compared with SDR+CLD in our analysis (91.4% vs 88.9%, $p < 0.001$). This is consistent with a recent RCT. In a prospective, randomised, single-centre non-inferiority trial, Walter *et al* concluded that the LRD a day before colonoscopy was non-inferior to CLD for getting adequate bowel cleansing using a split-dose regimen.³² In our study, ADR was higher in the SDR+LDR versus SDR+CLD (34.7% vs 29.6%), but the results were not statistically significant, $p = 0.167$. Similar results were seen in the RCT by Walter *et al* in which ADR was not statistically significant between the LRD versus CLD (35.3% vs 44.4%, $p = 0.30$) using the split-dose regimen.

Morning versus afternoon procedures

In our study, the timing of the procedure (morning=AM vs afternoon=PM) did not affect the prep quality (86.4% vs 87.2%, $p = 0.466$) and neither the ADR (29.8% vs 32.8%, $p = 0.220$).

In contrast to our study, ADR was reported higher in the morning than in the afternoon in some previous studies.³³ Singh *et al* also reported that ADR was significantly higher in AM than in PM procedures. Interestingly, the difference in ADR between AM and PM procedures seems to apply mainly to affect only female patients in this study. However, no significant differences in ADR were found in male patients in the afternoon.³⁴

A randomised trial conducted by Matro *et al* evaluated SDR+PM procedures versus NSDR+PM procedures.³⁵ They concluded that for patients undergoing colonoscopy in the afternoon, NSDR and SDR are clinically comparable with respect to bowel cleansing quality and ADR. In our study, however, it was seen that SDR+PM procedure was superior to NSDR+PM procedure (92.2% vs 82.7%, $p < 0.001$). The ADR in our study between SDR+PM procedures were comparable to the NSDR+PM procedures (35.2%–30.0%, $p = 0.194$).

The study by Waye *et al* showed that colonoscopies in the PM were associated with poor prep and high incomplete colonoscopies rates.³⁶ Our study did not show any effect of the timing of procedure on these outcomes. In our study, the best results for the bowel cleansing were seen with the combination of LRD+SDR+PM in 92.2% cases. The ADR was also highest with the same combination as compared with others, but results were not statistically significant.

To our best knowledge, this is the first study evaluating multiple factors together, which may affect the bowel prep quality and ADR. Our study has a few limitations. It is a retrospective study. Given the retrospective nature, there is a possibility for unmeasured bias. We did not include physician fatigue in our analysis, which might affect ADR. No statistical analyses based on gender was conducted separately for the outcomes.³⁴ This may be important because caecal intubation times and total time of colonoscopy can be affected by gender.^{37,38} This study was conducted using Aronchik's scale of bowel prep which is subjective and may have contributed towards bias due to interobserver reliability. Future studies using a more validated score like Boston Bowel Preparation Scale may help eliminate this bias. Lastly, participant's dietary instruction compliance is unknown which may have influenced the results. To ensure excellent dietary compliance before colonoscopy, telephonic counselling or short message service can be used in further studies as this has shown to improve the quality of bowel prep.^{39,40} It will avoid the bias of poor prep which might be associated with poor patient adherence to dietary instructions.

CONCLUSIONS AND RECOMMENDATIONS

The current study adds to our knowledge about the combined effect of multiple variables affecting the bowel prep quality and ADR. It is imperative to opt for the best combination, as this will influence the effectiveness of colonoscopies regarding timely cancer detection and prevention. Prospective and randomised trials including larger and diverse patient populations, using objective scales of bowel quality assessment along with strategies enhancing dietary compliance are required for the further validations of these findings.

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