A pilot study to evaluate the feasibility of implementing a split-dose bowel preparation for inpatient colonoscopy: a single-center experience

Dennis Yang, Robert Summerlee, Brian Rajca, Jonathan B Williamson, Jennifer LeLaurin, Lasheaka McCIellan, Dennis Collins, Shahnaz Sultan

ABSTRACT

Objectives: Feasibility of using split-dose bowel preparation in an inpatient setting has not been extensively studied. We conducted a single-centre multiphase study to (1) understand the perceived barriers to split-dose administration among nursing and providers, (2) develop and implement a split-dose electronic order set and (3) evaluate the use and impact of split-dose administration on 100 consecutive colonoscopies.

Methods: Nurse/provider interviews were conducted to understand perceived concerns and potential barriers to split-dose preparation. Next, an order set containing specific nursing instructions was developed, disseminated and implemented into the electronic health record as the default order set for inpatient colonoscopies. Finally, 100 consecutive inpatients undergoing colonoscopy were interviewed to determine prep consumption, tolerability and rate of procedural delays due to inadequate preparation.

Results: Survey results indicated perceived concerns about inpatients’ ability to tolerate and complete the preparation, insufficient nursing support and complexity of preparation administration. Based on this, prep orders were adjusted to accommodate nursing concerns prior to implementation. 54% of inpatients actually completed the bowel preparation in split doses (SPLIT group); the remainder had the conventional full dose preparation (NON-SPLIT). Less procedural delay and a lower rate of additional laxatives use (13% vs 30.4%) were seen in the SPLIT versus NON-SPLIT group. Split-dose preparation was well tolerated among inpatients.

Conclusions: Split-dose bowel preparation can be implemented for inpatients undergoing colonoscopy. This multiphase study demonstrates the steps used to implement split-dose preparation at our institution and may provide others with strategies that they could use at their institutions.

INTRODUCTION

Optimal bowel preparation for adequate visualisation at the time of colonoscopy among hospitalised patients remains a significant challenge. Inpatients tend to be older, less ambulatory and have more comorbidities than outpatients, which may adversely affect compliance with the bowel regimen and contribute to inadequate bowel cleansing as reflected by several studies that have identified inpatient status as an independent predictor for poor bowel cleansing. The risk of failed bowel preparation for hospitalised patients is twofold higher than that of ambulatory outpatients.

Summary box

What is already known about this subject?

▸ Optimal bowel preparation among hospitalised patients remains a challenge.
▸ Suboptimal bowel preparation results in higher chance of missed pathology and increased costs to the healthcare system.
▸ Outpatient split-dose bowel preparation has been associated with better quality bowel preparation.

What are the new findings?

▸ This feasibility trial demonstrated one strategy for implementing split dose bowel prep in an inpatient setting.
▸ Inpatients who completed the split dose prep underwent more timely colonoscopy (less procedural delays and less additional laxative use).
▸ The split dose regimen was better tolerated than a non split bowel preparation.
▸ Larger studies evaluating the efficacy, tolerance, and uptake of split dose bowel preparation in the inpatient setting are needed.

How might this impact on clinical practice?

▸ We introduce strategies to implement split-dose preparation for colonoscopy among inpatients.
▸ We highlight the importance of ancillary staff education and training in order to optimise uptake of new strategies and thus effectively disseminate efforts of implementation.
implications of a poor prep include a higher chance of missed pathology, aborted or delayed procedures and the need for a repeat procedure; all of which contribute to patient inconvenience as well as increased costs to the healthcare system.3–8

Colon cleansing using a split-dose administration of 4 L polyethylene glycol (PEG) is associated with higher compliance rates, better quality bowel preparations and higher colonoscopy completion rates.9–11 Despite evidence of improved outcomes with the use of a split-dose PEG solution, the majority of patients who are hospitalised receive the standard full dose (NON-SPLIT) 4 L PEG solution prior to inpatient colonoscopy.1 The reasons for this discrepancy remain unclear. Recognising this gap between evidence and clinical practice, we performed this multiphase study to evaluate the feasibility of implementing a split-dose bowel prep regimen for inpatient colonoscopy at our institution.

METHODS
Study design
This was a single-centre, prospective observational study conducted at the Malcom Randall VA Medical Center.

Overview
In this multiphase study, the first phase involved surveying nursing staff and providers to identify perceived barriers to administration of a split-dose bowel preparation and their concerns about patient tolerability. In the next phase, with the help of a multidisciplinary team, an intervention to increase adoption of the split-dose bowel regimen was developed, disseminated and implemented. In the third phase of the study, 100 colonoscopies, performed subsequent to implementation of the intervention, were reviewed to determine use of the intervention, as well as patient compliance with the bowel preparation, procedural delays and colonoscopy completion rates. The phases of the study are detailed in figure 1.

Phase A
Study participants
Recruitment
A cross-sectional list of healthcare providers was obtained from the staff listing. All internal medicine (including hospitalists), critical care and general surgery staff were contacted to participate in a one-time electronic survey. A similar survey was also sent electronically to all medical ward nurses for completion. Survey completion was optional and anonymous.

Data collection and analysis
The 13-item survey included structured questions related to bowel preparation, feasibility of split-dose administration and perceptions of patient compliance and tolerability. Responses were on a 1–5 bipolar scale (with a neutral point in the middle and two ends of the scale at opposite positions). The electronic survey could be completed in 5–6 min. Additional free text was allowed for clarification of responses. Descriptive statistics, including frequencies and percentages, were reported.

Phase B
Split-dose bowel preparation order set development
To facilitate uptake and ease of ordering, an electronic ‘quick order set’ was developed. In a quick order set, series of orders can be grouped together with each order dialogue box having predefined, default values. Launching the order set allows for all of its components to be selected and prepared for electronic signature. This is the fastest way to enter orders and saves the ordering provider from having to enter each order manually. The objective was to develop an order set that contained explicit guidance on timing and volume of laxative administration for the nursing staff. Feedback from the nursing surveys was used to modify the order set prior to incorporation into the electronic health record system and for dissemination. Post implementation, all orders for inpatient colonoscopy were placed using this split-dose quick order set.

Phase C
Study participants
To evaluate the feasibility of implementation of the split-dose bowel preparation, consecutive inpatients scheduled to undergo colonoscopy between October 2012 and April 2013 were approached for study participation until 100 patients were enrolled. Patient interviews were conducted to obtain information regarding bowel preparation consumption, nursing instruction and adverse effects, and colonoscopy outcomes were obtained from chart review.

Data collection
After completing informed consent, the study team collected basic demographic information including body mass index, comorbid medical conditions, age, gender and prior surgical history. On the morning of colonoscopy, patients were interviewed by one of the investigators (DY, RS, BR, JBW) about completion of the bowel preparation, nursing instructions, quantity and timing of preparation consumption using a standardised patient survey. Patients were asked to report any adverse events or inconveniences (including nausea, vomiting, abdominal bloating/pain, lack of instructions and/or sleep disturbances), identify any obstacles for completing the laxative regimen (including taste, volume, instructions and time of the bowel preparation administration) and, finally, their willingness to repeat the same bowel preparation for future colonoscopies. All colonoscopy procedures were performed by a staff gastroenterologist, or a gastroenterology fellow under the supervision of an attending gastroenterologist. The quality of the bowel preparation was assessed using a standard scale.15 On the morning of the colonoscopy, patients were
interviewed to determine the quantity and timing of bowel laxative consumption and side effects using a standardised patient survey. Additionally, patients were asked to recall what specific instructions they received regarding bowel cleansing.

**Study outcomes**

‘Completion of the bowel preparation’ was defined as successful completion of at least three quarters (75%) of the PEG solution. This was evaluated by asking the patient, the nurse and/or the physician if the entire PEG solution (4 L) was consumed and, when applicable, by examining the amount of PEG remaining in the container. ‘Colonoscopy completion’ was defined as a completed colonoscopy conducted on the scheduled day. If clear liquid stool output void of sediment was not achieved by the time of the scheduled colonoscopy, then the colonoscopy was delayed while additional bowel purgatives were administered. In that situation the procedure was considered ‘delayed secondary to suboptimal bowel preparation’. Actual completion of the bowel regimen as a split-dose regimen was measured based on patient and nurse interview on the morning of the procedure by one of the investigators (DY, RS, BR, JBW).

**Statistical analyses**

All data were entered into an electronic database. The statistical analysis was performed using Statistical Analysis System software (SAS Institute Inc, Cary, North Carolina, USA). A paired t test was used for continuous variables and to compare means between the groups. Fisher’s exact test was used for categorical variables and proportions in two by two contingency tables. A p value less than 0.05 was considered significant. In some instances, survey item responses were collapsed to ensure adequate numbers in each cell for comparison.
testing was not performed between groups, percentages and frequencies were presented.

RESULTS

Phase A

A total of 65 physicians and 41 nurses completed the electronic survey. Based on survey responses, the most common bowel preparation for an inpatient colonoscopy was Go-Lytely (86.4%). The majority of nurses (80.5%) had never heard of a split-dose bowel regimen. Survey results indicated considerable nursing and provider concern over the feasibility of implementing an inpatient split-dose regimen. Concerns regarding patients’ ability to complete the bowel preparation and follow instructions were also reported (with providers expressing slightly more concern than patients).

Providers also expressed concern about complexity of nursing instructions (see tables 1 and 2).

Phase B

Taking into account information from the surveys, the study team developed a quick order set for split-dose bowel preparation. The timing of the first and second dose of the preparation was based on nursing concerns over adequate staff for bathroom or commode assistance and minimal overlap of preparation administration with nursing shift changes or medication administration times. The final order set included the following instructions: nursing order to administer first dose of the 4 L PEG solution at 1700 and the second dose at 2400 and nursing to instruct patients to drink 240 mL (8 ounce) increments every 15–20 min for a total of 2 L at each dose (based on nurse feedback). Charge nurses on the

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Perceived patient tolerability and outcome barriers</th>
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<tbody>
<tr>
<td></td>
<td>Very/somewhat concerned</td>
</tr>
<tr>
<td>More nausea</td>
<td></td>
</tr>
<tr>
<td>Physician/PA</td>
<td>12.5% (7)</td>
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<tr>
<td>Nursing staff</td>
<td>32.4% (12)</td>
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<tr>
<td>More vomiting</td>
<td></td>
</tr>
<tr>
<td>Physician/PA</td>
<td>10.7% (6)</td>
</tr>
<tr>
<td>Nursing staff</td>
<td>32.4% (12)</td>
</tr>
<tr>
<td>More abdominal pain</td>
<td></td>
</tr>
<tr>
<td>Physician/PA</td>
<td>7.1% (4)</td>
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<tr>
<td>Nursing staff</td>
<td>40.5% (15)</td>
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<tr>
<td>Lower quality bowel prep</td>
<td></td>
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<tr>
<td>Physician/PA</td>
<td>25.0% (14)</td>
</tr>
<tr>
<td>Nursing staff</td>
<td>51.4% (19)</td>
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</table>

PA, physician assistant.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Baseline characteristics</th>
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<tr>
<td></td>
<td>NON-SPLIT* (n=46)</td>
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<tr>
<td>Comorbidities, n(%)</td>
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<tr>
<td>Coronary artery disease</td>
<td>17 (37)</td>
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<tr>
<td>Pulmonary disease</td>
<td>29 (63)</td>
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<tr>
<td>Hypertension</td>
<td>29 (63)</td>
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<td>Neurological disease</td>
<td>14 (30.4)</td>
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<td>Diabetes mellitus</td>
<td>13 (28.3)</td>
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<td>Liver disease</td>
<td>3 (6.5)</td>
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<td>Renal disease</td>
<td>5 (10.9)</td>
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<tr>
<td>History of abdominal surgeries</td>
<td>12 (26.1)</td>
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<tr>
<td>Chronic narcotic use</td>
<td>13 (28.3)</td>
</tr>
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<td>Indication</td>
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<td>Overt GI bleeding</td>
<td>21 (45.7)</td>
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<tr>
<td>Occult GI bleeding</td>
<td>4 (8.7)</td>
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<tr>
<td>Anaemia</td>
<td>5 (10.9)</td>
</tr>
<tr>
<td>Weight loss</td>
<td>6 (13.0)</td>
</tr>
<tr>
<td>History of colorectal polyps</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>GI symptoms‡</td>
<td>9 (19.6)</td>
</tr>
</tbody>
</table>

*Age 63.7±13.2, BMI 28.0±7.3.
†Age 63.2±14.2, BMI 29.5±7.2.
‡GI symptoms: abdominal pain, nausea, vomiting and or change in bowel habit patterns.
BMI, body mass index; GI, gastrointestinal.
wards, nurse managers and nurse educators were responsible for educating staff about the rationale for and proper usage of the new quick order set (prior to implementation). With IT and pharmacy support, the quick order set was incorporated into the computerised medical record system (CPRS) in October 2012 and became the default order set that was primarily used for all inpatient colonoscopies.

**Phase C**

One hundred and two consecutive inpatients undergoing colonoscopy were approached; only two patients declined to participate (citing disinterest in participation in research studies). Baseline characteristics are summarised in table 3. Despite use of the split-dose order set for all 100 inpatients, a little over a half (54%) of the inpatients consumed the bowel preparation as a split-dose (we refer to these patients as the SPLIT group), the remainder had the 4 L PEG laxative as the conventional non-split bowel regimen (these were referred to as the NON-SPLIT group). Since approximately half of the patients received the preparation as the conventional full dose administration, we chose to use the NON-SPLIT group of patients as an internal control group allowing for comparisons between groups. There were no significant differences between the two groups (SPLIT and NON-SPLIT). The majority of procedures were considered diagnostic colonoscopies. Overt gastrointestinal bleeding was the most frequent indication (43%), followed by gastrointestinal symptoms (17%), such as new onset abdominal pain and/or changes in bowel habits.

Completion of bowel preparation rates are depicted in figure 2. Approximately 97% of patients in the SPLIT group completed the bowel preparation (ie, consumed at least 75% of the PEG solution). Again using the NON-SPLIT group as a control group, we found that a lower percentage of patients in the SPLIT group (13%) required additional laxatives to aid in the cleansing process than the NON-SPLIT group (30.4%). Importantly, inpatient colonoscopy was more commonly delayed due to inadequate bowel preparation in the NON-SPLIT group (32.6%) compared to only 7% in the SPLIT group (p=0.002). Figure 3 depicts the need for additional laxatives and procedural delays in the two groups.

Since survey data indicated nursing concerns about patient tolerability (nausea, vomiting, abdominal pain), our postbowel preparation interviews included assessment of side effects. Overall, the most common patient symptom was nausea (26%) in each group. Abdominal bloating and pain were reported more frequently in the NON-SPLIT group (30% vs 9%). Only one patient in the SPLIT group reported inability to wake up and/or to stay awake as a factor impeding the completion of the split-dose bowel preparation. Among patients in the SPLIT group, 90.7% favoured split-dose administration as their preference for future bowel preparation prior to colonoscopy, suggesting it was well tolerated. To evaluate the process of implementation, patients were explicitly asked about the nursing instructions they received; interestingly, a large percentage in the NON-SPLIT group (38/46, 83%) indicated that they had not received instructions to split the dose.

**DISCUSSION**

Despite evidence demonstrating the superiority of split dosing for bowel cleansing, there has been reluctance in uniformly adopting this strategy for inpatient colonoscopy. Hospitalised patients represent a challenging population in which to achieve adequate bowel preparation, due to immobility, narcotic use and worse overall health. In this study, we demonstrate reasonable success with implementing split-dose administration of the 4 L bowel prep for hospitalised patients undergoing colonoscopy, which was the primary focus of our feasibility study.

Feasibility studies on implementation are focused on the extent, likelihood and manner in which an intervention can be fully implemented, often in an uncontrolled design, taking into account the contexts, settings and cultures that might translate the intervention into practice. Keeping this in mind, we incorporated several steps in our multiphase study including: (1) evaluating

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**Figure 2** Rates of completion of bowel preparation was significantly higher in the SPLIT group (96.3%).

**Figure 3** Suboptimal bowel preparation and colonoscopy delay. Lower rates of additional laxative use and less procedural delay among the SPLIT group.
perceived barriers to implementation of a split dosing preparation; (2) adapting the intervention to maximise nursing uptake; (3) engaging stakeholders upfront to maximise buy-in; (4) working with a multidisciplinary team of nurse managers, nurse educators, pharmacy and IT support; and (5) measuring outcomes related to the intervention to demonstrate its success.

One of the key steps in implementing a split-dose bowel preparation for inpatients related to engaging and working with nursing staff, as they played a significant role in ensuring that the intervention would be successful. To maximise uptake, we adapted the intervention for the nurses in our clinical setting. We adjusted the administration of the split-dose regimen to a time more suitable for the nursing staff (first dose at 17:00 and second dose at midnight) in response to concerns of interference with nursing shift changes, charting and medication administration, insufficient staff and perceived concerns about patients’ ability to complete the second dose prior to colonoscopy. Additionally, we relied on nurse educators to help disseminate information about the importance and value of split-dose preparations. Furthermore, we also used patient interviews to evaluate inpatients’ ability to complete the split-dose preparation and assessed patient tolerability as this was a concern expressed by nurses and providers and a potential barrier to its implementation.

Despite these measures, 46% of inpatients did not receive the split-dose bowel preparation (as instructed in the quick order set). One of the contributing factors may have been the lack of information or education provided by the nurses: 94% in the SPLIT group reported receiving instruction about split dosing whereas only 17% in the NON-SPLIT group reported receiving instruction. This information, however, was based on patient reports and subject to recall bias as well as reporting bias. To overcome this limitation, we could have provided more repeated efforts at nursing education emphasising the value of the split-dose preparation. Additionally, providing nurse feedback with preliminary results from our colonoscopy interviews may also have helped increase uptake as our results showed decreased procedural delays and higher rates of preparation completion. Another explanation could be that nurses did not adopt the split-dose strategy because they questioned its clinical utility. This is consistent with diffusion of innovation theories, which describe a predictable process of adoption based on individuals’ level of readiness to accept new ideas.

Though our rate of uptake was modest, we demonstrated that among inpatients who did have the split bowel prep, there were fewer procedural delays, decreased use of additional laxatives to ensure complete clean-out as well as high-bowel preparation completion rates. The majority of inpatient colonoscopies in our cohort were performed for evaluation (and/or therapy) of GI bleeding or GI symptoms and timely colonoscopy was important for clinical decision-making and management in these patients. Adverse effects were similar across groups. Among the SPLIT group, patient adherence with the nocturnal dose was not an obstacle for bowel cleansing (only 1/56 patients could not wake up or remain awake to complete split-dose regimen). Moreover, the vast majority of inpatients expressed willingness to repeat the split-dose regimen for future colonoscopies. While our results appear to be in line with other reports indicating patient willingness to awaken during the night to complete a split-dose bowel preparation when educated about the benefits of split-dosing,

There are several limitations of our study. This was an uncontrolled, single centre study with a small number of patients, which limited our ability to make comparisons between the SPLIT group and NON-SPLIT group. Also, despite explicit nursing orders regarding timing of preparation administration, there was variability in the actual administration of the two doses as well as the variability in the exact timing of colonoscopy, which could have impacted our findings. A limitation with respect to our dissemination efforts included reliance on nurse educators and charge nurses to provide education to the nurses; this was neither standardised nor monitored, thus leading to variability in how the importance of split-dose was communicated and perhaps affecting uptake. However, this direct communication by nursing may also have been an important factor influencing uptake and early adoption among nursing staff that did demonstrate uptake. Furthermore, while a patient survey following bowel preparation was obtained to assess tolerability and acceptability of split-dosing, a postintervention survey was not obtained from the nursing staff and/or providers. This may have been a valuable tool to help identify any potential barriers for split-dose bowel preparation implementation. Another limitation is that this study utilised an intervention (quick order set) that was specific for the VA hospital’s electronic health record, and may not be available nor generalisable in other settings.

At our institution, this was the first attempt to implement a process for split-dose bowel preparation among hospitalised patients. While there have been studies evaluating the implementation of split dosing for outpatient colonoscopy, we found only one other study (presented in abstract form) that reported on outcomes associated with split-dose bowel preparation for inpatient colonoscopies.
colonoscopy, however, no data on implementation was provided.22

In conclusion, there is a lack of data on the optimal bowel preparation for inpatients undergoing colonoscopy. Overall, this multiphase study demonstrated one strategy for implementing split-dose bowel preparation for inpatient colonoscopy with reasonable success and suggests that split-dose bowel preparation may be better tolerated among inpatients. Based on our results, we emphasise the importance of ancillary staff education and training in order to optimise uptake of new strategies and thus effectively disseminate efforts of implementation. Larger studies evaluating the efficacy and tolerance of split dose bowel preparation as well as strategies for implementing a split dose bowel prep among inpatients are needed.

Contributors DY and JBW performed the literature search. DY, RS, BR, SS and DC were involved in the design of the study and survey questionnaire. DY, RS, BR, JL and LM were involved in data and statistical analyses. DY and RS wrote the first draft of the manuscript. SS provided critical appraisal of the manuscript. All authors were involved with the critical revision of the final manuscript.

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Competing interests None.

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REFERENCES