

Impact of Bowel Preparation on Efficiency and Cost of Colonoscopy

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OBJECTIVES: The impact of bowel preparation on the cost and efficiency of colonoscopy is uncertain. The aim of this study was to measure the impact of bowel preparation on total direct cost as well as procedure time and volume.

METHODS: For 200 consecutive outpatient colonoscopies in persons with intact colons both at a private university hospital and at a public university hospital, we recorded the time spent suctioning fluid and feces from the colon and the time spent washing the colon to clean the mucosa. We prospectively asked colonoscopists to designate examinations that should be repeated at an interval sooner than would otherwise be recommended because of imperfect preparation. The data were used to perform a cost analysis of the economic effect of bowel preparation on direct costs of colonoscopy.

RESULTS: Suctioning fluid and washing occupied 6% and 1.5% of total examination time (including insertion and withdrawal) at the public hospital and 9% and 1.3% at the private hospital. Patients at the public hospital were more likely to have an aborted examination (6.5% vs 1%, $p = 0.004$) and to be brought back earlier than suggested or required by current practice standards because of imperfect bowel preparation (20% vs 12.5%, $p = 0.04$). Cost analysis indicated that to complete the initial examinations and the first round of surveillance, imperfect bowel preparation resulted in a 12% increase in costs at the university hospital and a 22% increase at the public hospital.

CONCLUSIONS: The increase in colonoscopy costs associated with imperfect preparation is substantial, and seems likely to vary among practices. Aborted examinations and surveillance examinations performed earlier than recommended because of imperfect preparation are appropriate targets for continuous quality improvement programs. More reliable bowel preparations, or measures to improve patient compliance with bowel preparation, could significantly reduce the costs of colonoscopy in clinical practice. (Am J Gastroenterol 2002;97:1696–1700. © 2002 by Am. Coll. of Gastroenterology)

INTRODUCTION

The quality of examination during colonoscopy can be impaired by imperfect bowel preparation. The impact of various bowel preparations on the quality of colonoscopy has been recently reviewed (1). The impact of imperfect bowel preparation on the cost and efficiency of colonoscopy is uncertain.

To measure the impact of bowel preparation on the efficiency of colonoscopy and the cost of colonoscopy, we prospectively evaluated 400 colonoscopies, including 200 at a private university hospital and 200 at a public university hospital serving an indigent population.

MATERIALS AND METHODS

Study Procedures

The study was approved by the Institutional Review Board at Indiana University Purdue University at Indianapolis. Those eligible for the study were outpatients with no history of prior bowel resection who were scheduled to undergo colonoscopy for screening, diagnosis, or surveillance. A total of 200 eligible patients were evaluated at each hospital. Observers separate from the colonoscopist and endoscopy nurse recorded demographic features, indication for the examination, and the findings. Eligible patients were recruited consecutively to the extent that the observer was available to measure and record the study data. The observers used a stopwatch to time cecal intubation, withdrawal, effort spent suctioning fluid and feces from the colon, and effort spent washing the colon to clean the mucosa of debris and feces. The number of aborted examinations was recorded. Aborted examinations were those in which the examination was attempted but discontinued because the preparation was ultimately deemed unsatisfactory. These examinations were rescheduled at the shortest time interval available. The colonoscopist also was asked to designate examinations that would be repeated at an interval sooner than recommended because of inadequate preparation. In these cases, the colonoscope was passed to the cecum and the examination was deemed adequate and not requiring immediate rescheduling but the endoscopist lacked the con-

fidence to schedule the procedure at the interval recommended by current guidelines. In almost all cases, this recommendation was to repeat at 1 yr or less. At both hospitals, the decision to bring patients back early because of imperfect preparation was made by the attending physician. The attendings at the public hospital and at the private hospital were generally different individuals, and only one of eight attendings performing or supervising colonoscopies during the study interval attended at both hospitals.

The public hospital evaluated in the study serves a largely indigent population; colonoscopy is performed by experienced attendings and by GI fellows (with supervision by attendings). The private tertiary hospital is also a teaching institution where colonoscopy is performed almost exclusively by experienced attendings without the participation of GI fellows. Preparation at the public hospital was usually done with PEG-electrolyte lavage solution, and preparation at the private hospital was usually done with sodium phosphate liquid, except those cases for which it was contraindicated.

Statistical Analysis

For comparison between the two hospitals, Student's *t* test was used for continuous variables, whereas the χ^2 test was used for dichotomous variables.

We performed a simple cost analysis to determine the economic effect of bowel preparation on the number of subsequent colonoscopies and total direct costs generated by these 400 patients. To generate the expected number of procedures and total direct cost, we made several assumptions regarding the need for repeat colonoscopy because of inadequate preparation and for surveillance colonoscopy. For colonoscopic evaluations that were of adequate quality, we assumed that 10% of persons would require a 3-yr surveillance colonoscopy for three or more adenomas, for advanced adenomas (high grade dysplasia, villous elements, or size >1 cm), or for adenomas plus a positive family history of colorectal cancer (2). We also assumed that 20% would require surveillance in 5 yr because of having only one or two small tubular adenomas. This assumption is based on published data on the prevalence of adenomas and current guidelines for diagnosis and management of colorectal adenomas (2, 3). Second, we assumed that the same percentage of aborted and inadequate examinations would occur at the 3- and 5-yr examinations as occurred at the initial examination. Third, we assumed that all persons with completed examinations in which the endoscopist wanted an earlier repeat study because of imperfect preparation would undergo repeat colonoscopy at 1 yr, and that these repeat examinations were satisfactory in quality. A fourth assumption was that all patients with initial colonoscopies that were aborted because of inadequate quality of preparation repeated the procedure promptly and had a successful examination (*i.e.*, with satisfactory quality preparation). A fifth assumption was that the aborted colonoscopies would not be billed as full colonoscopies, but with the "failed colonos-

copy" modifier. Finally, we assumed that in each subsequent round of colonoscopy, 30% of patients underwent polypectomy and that 10% and 20% would have findings requiring follow-up in 3 and 5 yr, respectively.

The total number of estimated colonoscopies for both groups of 200 patients was computed from initial evaluation through the first cycle of surveillance. The total number of procedures from each hospital was compared with what would be expected if all preparations were adequate. To estimate the impact of bowel preparation on costs of colonoscopy, we used charges as a proxy for cost. We assumed that, during each round of colonoscopy, 30% of patients would undergo and be billed for a polypectomy and associated pathology charges. Charges for colonoscopy preparations were obtained from the 2000 *Red Book* and local pharmacies. Charges for diagnostic colonoscopy, colonoscopy and polypectomy, failed colonoscopy, and pathology fees were obtained from local Medicare-allowable hospital-based and professional fees.

RESULTS

Table 1 describes demographic features, indications for colonoscopy, and bowel movement frequency of the two study populations. The two populations were different with regard to several indications for colonoscopy (Table 1). The mean cecal intubation time at the public hospital was longer than the private hospital (11 min vs 6.4 min; $p < 0.01$), likely reflecting performance by fellows at the public hospital and attending physicians at the private hospital. At the private hospital, 68% of patients had sodium phosphate for bowel preparation, whereas 32% used PEG lavage. At the public hospital, 92% used PEG, whereas 8% used sodium phosphate.

Excluding time taken for polypectomy and biopsy, suctioning fluid and washing occupied 6% and 1.5% of total examination time (including insertion and withdrawal) at the public hospital and 9% and 1.3% at the private hospital. Patients at the public hospital were more likely to have an aborted examination (6.5% vs 1%, $p = 0.004$) and to be brought back early because of imperfect bowel preparation (20% vs 12.5%, $p = 0.04$) compared with patients at the private hospital. Patients receiving sodium phosphate were less likely to have an aborted examination (0.7% vs 5.7%, $p = 0.01$) and less likely to be scheduled at an earlier interval because of imperfect preparation (10.5% vs 19.8%, $p = 0.01$) compared with patients receiving PEG.

Using the data on numbers of aborted examinations and examinations that were expected to be repeated at an earlier interval because of inadequate preparation, we calculated the expected number of colonoscopies in a cohort of 200 individuals under circumstances of varying bowel preparations. Under circumstances of ideal preparation, an average risk cohort of 200 persons would be expected to undergo approximately 260 colonoscopies over 6 yr. This 6-yr period includes the first year for initial colonoscopies and the 3-

Table 1. Demographic Features, Prior Colonoscopy, Bowel Movement Frequency, and Clinical Indications for Colonoscopy in the Study Populations

	Private	Public	<i>p</i>
Mean age (y)	55.7	55.2	0.7
Male (%)	45.5	38.5	0.16
Prior colonoscopy (%)	45.5	46.5	0.84
Bowel habit			
> 1/day	36	34	0.08*
1/day	116	117	
< 1/day	35	23	
< 1/3 days	13	26	
Indication†			
Rectal bleeding	23/164 (14)‡	42/200 (21)	0.08
Previous polyps or cancer	29/164 (18)	54/200 (27)	0.02
Abdominal pain	10/164 (6)	8/200 (4)	0.36
Chronic diarrhea	12/164 (7.3)	8/200 (4)	0.03
Inflammatory bowel disease	9/164 (5.5)	3/200 (1.5)	0.007
FOBT positive	18/164 (11)	36/200 (18)	0.06
Abnormal BE or sigmoidoscopy	2/164 (1.2)	14/200 (7)	<0.001
Screening	48/164 (29)	11/200 (5.5)	<0.0001
Other	23/164 (14)	32/200 (16)	0.60

BE = barium enema; FOBT = fecal occult blood test.

**p* for overall difference in bowel frequency.

†Indication not available for 36 patients from the private hospital.

‡For all indications these numbers reflect the number of patients with this indication/total no. of patients (%); some patients had more than one indication.

and 5-yr surveillance interval examinations. For the private hospital, where the quality of the preparation for 173 (86.5%) of 200 initial colonoscopies was adequate, the total number of expected colonoscopies including the first cycle of surveillance is 293.6, or 12.9% above the ideal number. In contrast, for the public hospital, where the quality of the preparation for 147 (73.5%) of 200 initial colonoscopies was adequate, the total number of expected colonoscopies including the first cycle of surveillance is 322.6, or 24.1% above the ideal number (Table 2). In addition, because of the assumption that all initially inadequate examinations are repeated at 1 yr, the cycle length for initial colonoscopy and first surveillance colonoscopy requires a total of 7 yr, which is 1 yr more than under ideal conditions. Table 2 shows the number of colonoscopic procedures by year for both groups.

Table 3 shows the costs, using charges as a proxy for costs, of performing colonoscopy under conditions of variable bowel preparations as identified in this study, in a cohort of 200 individual followed for 7 yr. Under conditions of ideal preparation, the use of lavage rather than sodium phosphate was associated with a 3% increase in colonos-

copy costs. At the private hospital, imperfect preparation was associated with an increase of nearly 12% in the total direct cost of colonoscopy, whereas at the public hospital, imperfect bowel preparation was associated with a cost increase of nearly 22%. The choice of bowel preparation (assuming equal effectiveness) had less impact on total colonoscopy costs than the effect of extra colonoscopies generated by aborted examinations and repeated examinations at shorter intervals.

DISCUSSION

In this study, we examined the time devoted during colonoscopy to management of preparation, and estimated the impact of imperfect bowel preparation on colonoscopy costs because of aborted examinations or examinations in which the interval for postpolypectomy surveillance was shortened because of a reduction in the colonoscopist's degree of confidence about a complete examination. We found differences between a public hospital and a private tertiary hospital in the percentage of aborted examinations and in the

Table 2. Numbers of Projected Colonoscopies by Year at University-Based Private and Public Hospitals

Year	Ideal Preparation	Private Hospital	Public Hospital
0-1	200	202	213
1-2	0	25	40
2-3	0	0	0
3-4	20	17.5	16
4-5	0	4.7	7.2
5-6	40	35	32
6-7		9.4	14.4
Total	260	293.6	322.6

Table 3. Costs of Colonoscopy Using Medicare Charges in a Cohort of 200 Individuals Followed for 7 Yr With Ideal Bowel Preparation and With the Levels of Imperfect Bowel Preparation Identified in This Study

Cost	Ideal Preparation	Private Hospital	Public Hospital
Cost (FPS)	\$213,841	\$239,068	
Cost (PEG)	\$220,260		\$267,566
% Increase in cost vs ideal (PEG or FPS)	3%	11.8%	21.5%

FPS = Fleet phosphosoda oral laxative; PEG = polyethylene glycol electrolyte lavage.

percentage of examinations that were completed but for which a recommendation was made to bring the patient back earlier than would otherwise be needed. We did not standardize the decision-making process with regard to what bowel preparations would lead to a recommendation to repeat examination at a short interval or to abort an examination. Thus, these decisions were based on subjective criteria. However, our impression is that this process is based on subjective criteria in clinical practice. Although endoscopists are aware that a completed "clearing colonoscopy" requires adequate bowel preparation, there are no strict criteria that define an adequate bowel preparation. It might be appropriate to repeat this study using arbitrarily defined strict criteria for an adequate preparation, and for what degree of imperfect preparation an examination should be repeated at an earlier interval. However, it would require repeat examinations at defined intervals in persons with and without adequate initial examinations to validate the appropriateness of any arbitrarily defined criteria. We believe that the process chosen for this study is a reasonable reflection of the day-to-day decision making of endoscopists and the impact of these decision on costs.

We found that the percentage of procedure time during insertion and withdrawal devoted to suctioning fluid varied from 6% to 9.6% between the two practice settings. The percentage of time devoted to washing residual debris was small at both hospitals, representing 1.5% and 1.3% of the examination time. Thus, to the extent that colonoscopy could be performed without retained fluid and feces, we estimate a small reduction in the average time it takes to perform a colonoscopy.

Of greater significance, we found that colonoscopists in these two practice settings frequently had less confidence in their examination, and recommended colonoscopy at an earlier interval than they would have otherwise. When patients are brought back at an earlier interval than otherwise, the number of colonoscopies performed during a given time interval increases. Our results indicate that imperfect bowel preparation increases colonoscopy costs about by 12–22%, given the percentages of aborted examinations and completed examinations with imperfect bowel preparation noted.

Our cost model is simple and is based on estimates of the frequency of events during follow-up. However, our calculations are likely to underestimate the impact of imperfect bowel preparation on colonoscopy costs. First, we assumed that patients with aborted or suboptimal preparations had adequate preparation on repeat examination. However, our anecdotal experience is that patients with suboptimal preparation are more likely to have a suboptimal preparation on repeat examination. Second, imperfect preparation results in repeated examination of the same patients. This may further increase the use of subsequent surveillance colonoscopy, as multiple examinations will raise the proportion of patients with any adenoma detected, simply because of the inherent miss rate of colonoscopy, particularly for small adenomas

(4, 5). The increase in adenoma detection would have greater impact in settings in which 3-yr follow-up intervals are used even for small tubular adenomas, a practice that is still common in our anecdotal experience, but which likely has minimal impact on colorectal cancer mortality. Finally, our model did not include the indirect costs of time lost from work because of additional examinations. Our results suggest that imperfect preparation may add significantly to the numbers of colonoscopies performed in clinical practice and to the associated costs of colonoscopy. Our results also suggest that there may be substantial variation between practices in the extent to which these increases occur.

These are several possible reasons for the differences between the two hospitals in projected numbers of colonoscopies and direct costs, including differences in patient population, endoscopist experience, differences in the numbers of patients with constipation (Table 1) and method of preparation. The relative importance of these factors is uncertain. In this study, patients receiving sodium phosphate were less likely to have an aborted colonoscopy with impaired preparation compared with those receiving PEG. However, the choice of preparation differed dramatically between the two hospitals, so that it was not possible to establish an independent association between method of preparation and the likelihood of impaired preparation. Sodium phosphate and PEG have, however, been directly compared in several clinical trials (6–12). In aggregate, the evidence suggests that the sodium phosphate preparation is easier to complete, and that it more often results in an adequate or excellent quality preparation (13). Thus, the different bowel preparations used at the two hospitals likely contributed to the observed differences in suboptimal preparation, although the extent of the contribution is unclear.

The generalizability of our results is uncertain. Our goal in studying two different practice settings (which we admittedly perceived as quite different in several regards) was simply to establish whether a range of results could occur with regard to the impact of bowel preparation on the cost and efficiency of colonoscopy. We acknowledge that other practice settings with additional differences including patient population and endoscopist's perceptions might extend further the range of effects of bowel preparation observed in this study. In addition, the two practices evaluated in this study have some similar features, so additional differences with other practices might extend the range of effects. For example, both endoscopy units evaluated in this study are open access units. It is possible that, in closed access units, patients receive superior instruction in preparation and achieve better levels of preparation. In addition, both endoscopy units are in an academic medical center. It is possible that better preparation is achieved in private practice centers. However, the patient population at the university hospital in this study consists almost entirely of private patients. Furthermore, the nurses at this hospital attempt to contact all colonoscopy patients by telephone 48 h before the procedure to reinforce the preparation. Thus, the quality

of preparation at this hospital is likely to approximate the quality at many private practice endoscopy centers. We recommend, however, that similar evaluations be undertaken in other practice settings.

In summary, colonoscopy in two academically based clinical practice settings with different patient populations and different preferences for method of preparation was associated with frequent need for additional colonoscopies, and with greater than expected costs because of inadequate bowel preparation. Based on these observations, we recommend considering the frequency of aborted examinations and examinations in which colonoscopists recommend earlier-than-usual surveillance as appropriate targets for continuous quality improvement intervention. Furthermore, our results suggest that more reliable bowel preparations, or steps to improve patient understanding of and compliance with bowel preparation, could significantly reduce the cost and improve the efficiency of colonoscopy in clinical practice.

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REFERENCES

1. Toledo TK, DiPalma JA. Colon cleansing preparation for gastrointestinal procedures. *Aliment Pharm Ther* 2001;15:605-12 (review).
2. Bond JH. Polyp guideline: Diagnosis, treatment, and surveillance for patients with colorectal polyps. *Am J Gastroenterol* 2000;95:3053-63.
3. Winawer SJ. Appropriate intervals for surveillance. *Gastrointest Endosc* 1999;49:S63-6.
4. Rex DK, Cutler CS, Lemmel GT, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. *Gastroenterology* 1997;112:24-8.
5. Hixson LS, Fennerty MB, Sampliner RE, et al. Prospective study of the frequency and size distribution of polyps missed by colonoscopy. *J Natl Cancer Inst* 1990;82:1769-72.
6. Vanner SJ, MacDonald PH, Paterson WG, et al. A randomized prospective trial comparing oral sodium phosphate with standard polyethylene glycol-based lavage solution (GoLyteLy) in the preparation of patients for colonoscopy. *Am J Gastroenterol* 1990;85:422-7.
7. Kolts BE, Lyles WE, Achem SR, et al. A comparison of the effectiveness and patient tolerance of oral sodium phosphate, castor oil, and standard electrolyte lavage for colonoscopy or sigmoidoscopy preparation. *Am J Gastroenterol* 1993;88:1218-23.
8. Marshall JB, Pineda JJ, Barthel JS, King PD. Prospective, randomized trial comparing sodium phosphate solution with polyethylene glycol-electrolyte lavage for colonoscopy preparation. *Gastrointest Endosc* 1993;39:631-4.
9. Cohen SM, Wexner SD, Binderow SR, et al. Prospective, randomized, endoscopic-blinded trial comparing precolonoscopy bowel cleansing methods. *Dis Colon Rectum* 1994;37:689-96.
10. Afshari SA, Barthel JS, King PD, et al. Prospective, randomized trial comparing a new sodium phosphate bisacodyl regimen with conventional PEG-ES lavage for outpatient colonoscopy preparation. *Gastrointest Endosc* 1995;41:485-9.
11. Golub RW, Kerner BA, Wise WE, et al. Colonoscopic bowel preparations—which one? A blinded, prospective, randomized trial. *Dis Colon Rectum* 1995;38:594-9.
12. Henderson JM, Barnett JL, Targeon DK, et al. Single-day, divided dose oral sodium phosphate laxative versus intestinal lavage as preparation for colonoscopy: Efficacy and patient tolerance. *Gastrointest Endosc* 1995;12:238-43.
13. Hsu C-W, Imperiale TF. Meta-analysis and cost comparison of polyethylene glycol lavage versus sodium phosphate for colonoscopy preparation. *Gastrointest Endosc* 1998;3:276-82.