Combined Preoperative Mechanical Bowel Preparation With Oral Antibiotics Significantly Reduces Surgical Site Infection, Anastomotic Leak, and Ileus After Colorectal Surgery

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Objectives: To clarify whether bowel preparation use or its individual components [mechanical bowel preparation (MBP)/oral antibiotics] impact specific outcomes after colorectal surgery.

Methods: National Surgical Quality Improvement Program–targeted colectomy data initiated in 2012 capture information on the use/type of bowel preparation and colorectal-specific complications. For patients undergoing elective colorectal resection, the impact of preoperative MBP and antibiotics (MBP+/ABX+), MBP alone (MBP+/ABX−), and no bowel preparation (no-prep) on outcomes, particularly anastomotic leak, surgical site infection (SSI), and ileus, were evaluated using unadjusted/adjusted logistic regression analysis.

Results: Of 8442 patients, 2296 (27.2%) had no-prep, 3822 (45.3%) MBP+/ABX−, and 2324 (27.5%) MBP+/ABX+. Baseline characteristics were similar; however, there were marginally more patients with prior sepsis, ascites, steroid use, bleeding disorders, and disseminated cancer in no-prep. MBP with or without antibiotics was associated with reduced ileus [MBP+/ABX+: odds ratio (OR) = 0.57, 95% confidence interval (CI): 0.48–0.68; MBP+/ABX−: OR = 0.78, 95% CI: 0.68–0.91] and SSI [MBP+/ABX+: OR = 0.39, 95% CI: 0.32–0.48; MBP+/ABX−: OR = 0.80, 95% CI: 0.69–0.93] versus no-prep. MBP+/ABX+ was also associated with lower anastomotic leak rate than no-prep [OR = 0.45 (95% CI: 0.32–0.64)]. On multivariable analysis, MBP with antibiotics, but not without, was independently associated with reduced anastomotic leak (OR = 0.57, 95% CI: 0.35–0.94), SSI (OR = 0.40, 95% CI: 0.31–0.53), and postoperative ileus (OR = 0.71, 95% CI: 0.56–0.90).

Conclusions: These data clarify the near 50-year debate whether bowel preparation improves outcomes after colorectal resection. MBP with oral antibiotics reduces by nearly half, SSI, anastomotic leak, and ileus, the most common and troublesome complications after colorectal surgery.

Keywords: antibiotics, bowel preparation, colorectal, outcomes

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The use of mechanical bowel preparation (MBP) in combination with oral antibiotics became routine practice in the 1970s, with Nichols' and Condon's[1] preparation emerging as the standard preoperative regimen. A significant body of evidence supported its use in reducing the high level of postoperative septic complications associated with colorectal surgery.[2–5] Despite this evidence, there is no longer general consensus among colorectal surgeons as to the appropriate use of MBP or its individual components. This is in part due to research showing that MBP alone does not confer protection against postoperative sepsis[6–9] and may be harmful.[10–12] As a result, many have recommended that it be completely abandoned.[6,9,13] Recently, there has been renewed interest in the effects of MBP with oral antibiotics. There is some evidence that this combined approach in addition to intravenous (IV) prophylaxis results in significantly improved postoperative outcomes[14–16]; however, large-scale studies are lacking. In an attempt to clarify this 50-year debate as to whether MBP or its components improve outcomes in elective colorectal surgery, we analyzed data from the American College of Surgeons 2012 National Quality Improvement Program, looking specifically at surgical site infection (SSI), anastomotic leak, and postoperative ileus.

METHODS

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP)–targeted colectomy data initiated in 2012 were used. ACS-NSQIP collects information on more than 150 variables, including preoperative and operative details and 30-day postoperative complications. NSQIP benefits from trained data collectors adhering to standardized variable definitions and is available on a large-scale, providing data from more than 400 hospitals (121 in the targeted data set) across the United Sates. Full details of ACS-NSQIP data collection have been published before.[17] As of 2012, among other colorectal-specific variables, the use of preoperative MBP and oral antibiotics was introduced. According to ACS definitions, MBP does not include enemas or suppositories. NSQIP records the use of MBP and oral antibiotics separately according to "yes," "no," or "unknown,"[18] All elective colorectal operations from the targeted colectomy Participant User File (puf) were analyzed according to *Current Procedural Terminology* (*CPT*) code (colectomy: 44140,44141,44143,44144,44150,44151,44160,44204,44205, 44206,44210 and proctectomy: 44145, 44146,44147,44207,44208) (Appendix). "Proctectomy" group included those operations with colorectal and low pelvic anastomoses. The ACS-NSQIP–targeted colectomy data contained information on 16,981 patients. After excluding emergency operations and patients with unknown information on MBP or oral antibiotics, 8442 patients remained. Patients were divided into 3 groups: (1) MBP alone (MBP+/ABX−), (2) MBP and antibiotics (MBP+/ABX+), and (3) neither MBP nor antibiotics (No-prep).

Endpoints

The primary endpoint was overall SSI (superficial, deep, and organ space), with secondary endpoints including anastomotic leak, paralytic ileus, and 30-day mortality. Standard definitions for the variables and outcomes of interest as defined in the NSQIP database were employed. In NSQIP, SSIs are categorized according to CDC

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definitions.[18] Anastomotic leak is defined as any leak of endoluminal contents through an anastomosis. This could include air, fluid, gastrointestinal contents, or contrast material, with the presence of an infection/abscess thought to be related to an anastomosis, even if the leak is not definitively identified as visualized during an operation, or by contrast extravasation also considered a leak. Paralytic ileus is defined as the presence of a nasogastric tube and/or the patient is nil per os (NPO) for postoperative day 3 or more.[18]

Statistical Analysis

Descriptive statistics were used to summarize patients' preoperative characteristics, comorbidities, and intraoperative characteristics (Table 1). Continuous variables were reported as medians (interquartile range) because of data skewness and compared between groups using the Kruskal-Wallis test. Categorical variables were expressed as proportions (%) and compared between the 3 groups using χ^2 or Fisher exact tests. All significance tests were 2-tailed with type I error (α) set at 0.05.

Based on clinical relevance, variables were dichotomized: American Society of Anesthesiologists score of 3 or more and body mass index of 30 kg/m^2 or more, whereas surgical approach was collapsed into 2 categories (laparoscopic: laparoscopic and laparoscopic converted to open and open: open, open planned) and prolonged operation time was defined as 180 minutes or more. Variables with more than 90% missing data were not included in the analysis (alcohol use/ETOH, level of residency supervision). Six percent to 7% of the total number of observations were excluded from the multivariable analyses (for each outcome) because of missing values for the response or explanatory variables. It is good practice that if there are 10% or more missing values, methods for dealing with missing data are employed, for example, multiple imputation techniques and sensitivity analysis. Given the low rate of missing data in this study, it is unlikely to change results. Univariable (unadjusted) logistic regressions were used to test the significance of individual predictors (MBP regimen, preoperative factors, operative factors, etc) for each outcome. Finally, multivariable (adjusted) logistic regressions were fitted to determine predictors of the primary and secondary outcomes while controlling for other significant covariates identified on univariable analyses. All tests used a type I error set at α 0.05. Statistical analyses were carried out using SAS software (version 9.4, SAS Institute, Inc., Cary, NC).

TABLE 1. Preoperative Patient Factors According to Type of Mechanical Bowel Preparation

Variable	No Prep (N = 2296)	MBP+/ABX− (N = 3822)	MBP+/ABX+ (N = 2324)	*P*†
Age, median (IQR), yr	62 (52–73)	62 (52–72)	62 (52–71)	0.53
Sex (male), n (%)	1111 (48.4)	1855 (48.5)	1175 (50.6)	0.23
Race/ethnicity (white), n (%)*	1766 (86.9)	3093 (86.8)	2038 (90.5)	<0.0001
BMI ≥ 30 kg/m^2, n (%)*	690 (30.2)	1337 (35.2)	825 (35.5)	0.0001
Smoking, n (%)	403 (17.6)	648 (17.0)	407 (17.5)	0.78
ASA, n (%)*				
1	63 (2.7)	124 (3.2)	66 (2.8)	<0.0001
2	1060 (46.2)	1921 (50.3)	1300 (56.0)	
3	1050 (45.8)	1657 (43.4)	899 (38.7)	
4	117 (5.1)	113 (3.0)	57 (2.5)	
5	5 (0.2)	2 (0.1)	0 (0)	
Functional status, n (%)*				0.003
Independent	2225 (97.1)	3748 (98.3)	2289 (98.8)	
Partially dependent	58 (2.5)	56 (1.5)	23 (1.0)	
Totally dependent	9 (0.4)	8 (0.2)	4 (0.2)	
Comorbidities				
Diabetes, n (%) (insulin and non-insulin)	317 (13.8)	560 (14.7)	333 (14.3)	0.66
Hypertension, n (%)	1058 (46.1)	1892 (49.5)	1057 (45.5)	0.003
Ventilator dependent, n (%)	6 (0.3)	5 (0.1)	0 (0)	0.048
History of severe COPD, n (%)	107 (4.7)	181 (4.7)	101 (4.3)	0.77
Dyspnea, n (%)	187 (8.1)	271 (7.1)	135 (5.8)	0.008
Chronic heart failure, n (%)	18 (0.8)	23 (0.6)	13 (0.6)	0.58
Ascites, n (%)	20 (0.9)	16 (0.4)	5 (0.2)	0.004
Chronic steroid use, n (%)	210 (9.1)	204 (5.3)	148 (6.4)	<0.0001
Bleeding disorders, n (%)	101 (4.4)	112 (2.9)	56 (2.4)	0.003
Renal failure, n (%)	8 (0.3)	1 (0.03)	1 (0.04)	0.001
Dialysis, n (%)	18 (0.8)	17 (0.4)	5 (0.2)	0.018
Prior sepsis, n (%)	98 (4.3)	31 (0.8)	26 (1.1)	<0.0001
Disseminated cancer, n (%)	176 (7.7)	176 (4.6)	94 (4.0)	<0.0001
Weight loss, n (%) (>10% body weight)	94 (4.1)	130 (3.4)	76 (3.3)	0.21
Prior wound infection, n (%)	57 (2.5)	45 (1.2)	30 (1.3)	0.001
Hematocrit, median (IQR),%	38.3 (34.3–41.8)	39.3 (35.6–42.4)	40.3 (36.6–43.4)	0.001
WBC, median (IQR), $\times 10^9$/L	7.1 (5.6–8.8)	6.8 (5.6–8.4)	7.0 (5.7–8.5)	0.001
Albumin, median (IQR), mg/dL	3.9 (3.5–4.3)	4.0 (3.6–4.3)	4.0 (3.7–4.4)	0.001
Creatinine, median (IQR), mg/dL	0.87 (0.71–1.0)	0.87 (0.71–1.0)	0.90 (0.76–1.0)	0.003

*Total Ns differ because of missing information for that particular variable.

†*P* values generated by Kruskal-Wallis test (medians) and χ^2/Fisher exact tests (proportions).

ASA indicates American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; WBC, white blood cell.

RESULTS

Of 8442 patients, 2296 (27.2%) had no-prep, 3822 (45.3%) MBP+/ABX−, and 2324 (27.5%) MBP+/ABX+. Patients in all 3 groups were comparable for age (median 62 years, $P = 0.53$) and sex (48.4% male, 48.5% and 50.6%, $P = 0.23$). There were more white patients in the group with MBP and antibiotics (MBP+/ABX+) and MBP with no antibiotics (MBP+/ABX−) than those in the no-prep group (90.5% vs 86.8% vs 90.5%; $P < 0.0001$). A greater proportion of patients in the no-prep group (51%) than in MBP+/ABX− (46.4%) or MBP+/ABX+ (41.1%) ($P < 0.0001$) had patients with American Society of Anesthesiologists class 3 or more. Obese patients were more common in the groups prescribed MBP than in the no-prep group (35.2% vs 30.2%; $P = 0.0001$). There was no statistically significant difference in the proportion of smokers ($P = 0.8$) (Table 1).

Patient groups were similar with respect to frequency of diabetes, heart failure, chronic obstructive pulmonary disease, and weight loss ($P > 0.05$). MBP+/ABX+ group had fewer patients with ascites, bleeding disorders, hypertension, and disseminated cancer than the MBP+/ABX− and no-prep groups (0.2% vs 0.4% vs 0.9%, $P = 0.004$; 2.4% vs 2.9% vs 4.4%, $P = 0.003$; 45.5%, 49.5%, 46.1%, $P = 0.003$ and 4.0%, 4.6%, 7.7%, $P < 0.0001$). More patients in the no-prep and MBP+/ABX+ groups had a history of chronic steroid use than MBP+/ABX− patients (9.2% and 6.4% vs 5.3%, $P < 0.0001$). The rate of prior sepsis was higher in patients with no prep and then MBP+/ABX+ over MBP+/ABX− (4.3%, 1.1%, and 0.8%; $P < 0.0001$) (Table 1).

Prolonged operative time (≥ 180 minutes) was more common in MBP+/ABX+ and MBP+/ABX− groups than in no-prep group (41.7% vs 41.4% vs 38.4%, $P = 0.032$). The rates of laparoscopic surgery were higher in patients who had any MBP versus patients with no prep (72.3% vs 60.5%, $P < 0.0001$). More patients in the no-prep group (1.9%) had received a transfusion in the 72 hours preoperatively than either the MBP+/ABX− (1.0%) or MBP+/ABX+ (0.5%) groups ($P = 0.001$), and more colectomies versus rectal resections were performed on patients without preparation (75.7% vs 74.0% and 66.9%, $P = 0.001$) (Table 2).

Outcomes

The overall SSI rate (any superficial, deep, or organ space infection) was higher in the no-prep and MBP+/ABX− groups than in the MBP+/ABX+ groups (14.7% vs 12.1% vs 6.2%, $P < 0.0001$). There was also a higher rate of postoperative ileus in the no-prep and MBP+/ABX− groups than in the MBP+/ABX+ group (15.1% vs 12.3% vs 9.2%, $P < 0.0001$). The rates of anastomotic leak and 30-day mortality also differed significantly and followed the same pattern (no-prep 4.6% vs MBP+/ABX− 3.5% vs MBP+/ABX+ 2.1%, $P < 0.0001$ and 1.6% vs 0.6% vs 0.3%, $P < 0.0001$) (Fig. 1). With all measured 30-day colorectal specific outcomes, MBP+/ABX+ had the lowest rate compared with the other 2 groups, and this was statistically significant throughout (Table 3).

Comparison of other medical and surgical complications was also mostly favorable for MBP+/ABX+ (Table 3).

On univariable analyses, patients who were given MBP+/ABX+ had reduced odds of an SSI compared with patients who had no bowel preparation at all, and this was statistically significant [odds ratio (OR) = 0.39, 95% confidence interval (CI): 0.32–0.48]. MBP+/ABX− also conferred protection against developing SSI, although the association was not as strong (OR = 0.80, 95% CI: 0.69–0.93). Postoperative ileus was less likely in both MBP groups regardless of the addition of antibiotics than in patients who had no preparation at all (MBP+/ABX+: OR = 0.57, 95% CI: 0.48–0.68 and MBP+/ABX−: OR = 0.78, 95% CI: 0.68–0.91), although MBP+/ABX+ showed a greater association. Anastomotic leak was less likely to occur in patients who had MBP+/ABX+ than in the no-prep group (OR = 0.45, 95% CI: 0.32–0.64), and this was borderline in patients who had MBP without antibiotics (OR = 0.77, 95% CI: 0.59–0.99) (Tables 4–6).

On multivariable analyses adjusting for all preoperative and operative factors that were statistically significantly different ($P < 0.05$) between the 3 groups, MBP with antibiotics (MBP+/ABX+), but not without antibiotics, was independently associated with reduced SSI (OR = 0.40, 95% CI: 0.31–0.53), anastomotic leak (OR = 0.57, 95% CI: 0.35–0.94), and postoperative ileus (OR = 0.71, 95% CI: 0.56–0.90) compared with patients who had no MBP at all.

The odds of developing an SSI were reduced in both MBP groups regardless of antibiotics on univariable analysis; however, the effect reached statistical significance only on multivariable analysis for the MBP+/ABX + group. Other factors found to independently affect the odds of developing an SSI were body mass index of

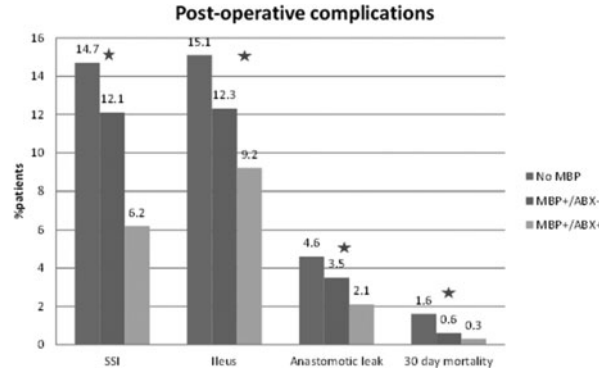

FIGURE 1. Postoperative complications according to type of bowel preparation. *Statistical significance, $P < 0.0001$.

TABLE 2. Operative Factors According to Type of Mechanical Bowel Preparation

Variable	No Prep (N = 2296)	MBP+/ABX− (N = 3822)	MBP+/ABX+ (N = 2324)	P*
Work relative value units, median (IQR)	26.4 (22.6–28.6)	26.4 (23.0–30.1)	26.4 (22.9–28.9)	0.89
Total operation time (≥180 min), n (%)	881 (38.4)	1584 (41.4)	968 (41.7)	0.032
Transfusion 72 hr before surgery, n (%)	44 (1.9)	39 (1.0)	12 (0.5)	<0.001
Laparoscopic surgery, n (%)	1389 (60.5)	2723 (71.2)	1720 (74.0)	<0.0001
Colon vs rectum, n (%)	1737 (75.7)	2554 (66.8)	1719 (74.0)	0.001

*P values generated by Kruskal-Wallis test (medians) and χ^2/Fisher exact tests (proportions).

TABLE 3. Thirty-day Outcomes According to Type of Mechanical Bowel Preparation

Variable	No Prep (N = 2296)	MBP+/ABX− (N = 3822)	MBP+/ABX+ (N = 2324)	*P*†
SSI (superficial/deep/organ space), n (%)	337 (14.7)	462 (12.1)	145 (6.2)	<0.0001
Development of ileus, n (%)*	344 (15.1)	467 (12.3)	214 (9.2)	<0.0001
Anastomotic leak, n (%)*	104 (4.6)	135 (3.5)	49 (2.1)	<0.0001
30-day mortality, n (%)	37 (1.6)	23 (0.6)	8 (0.3)	<0.0001
Superficial site infection, n (%)	190 (8.3)	268 (7.0)	81 (3.5)	<0.0001
Deep SSI, n (%)	33 (1.4)	52 (1.4)	15 (0.6)	0.018
Organ space SSI, n (%)	130 (5.7)	160 (4.2)	57 (2.5)	<0.0001
Wound disruption, n (%)	25 (1.1)	39 (1.0)	13 (0.6)	0.11
Pneumonia, n (%)	52 (2.3)	60 (1.6)	32 (1.4)	0.045
Unplanned reintubation, n (%)	39 (1.7)	48 (1.3)	19 (0.8)	0.027
PE, n (%)	10 (0.4)	20 (0.5)	15 (0.6)	0.61
Failure to wean, n (%)	46 (2.0)	44 (1.2)	18 (0.8)	0.001
Renal insufficiency, n (%)	9 (0.4)	18 (0.5)	12 (0.5)	0.82
Acute renal failure, n (%)	15 (0.7)	17 (0.4)	9 (0.4)	0.38
UTI, n (%)	65 (2.8)	107 (2.8)	65 (2.8)	1.00
CVA and neuro deficit, n (%)	4 (0.2)	6 (0.2)	3 (0.1)	0.92
Cardiac arrest, n (%)	12 (0.5)	11 (0.3)	6 (0.3)	0.22
MI, n (%)	13 (0.6)	23 (0.6)	8 (0.3)	0.37
Bleeding, n (%)	240 (10.5)	281 (7.4)	138 (5.9)	<0.0001
DVT, n (%)	32 (1.4)	31 (0.8)	33 (1.4)	0.036
Sepsis, n (%)	100 (4.4)	106 (2.8)	53 (2.3)	<0.0001
Septic shock, n (%)	39 (1.7)	41 (1.1)	14 (0.6)	0.002
Return to OR, n (%)	120 (5.2)	175 (4.6)	77 (3.3)	0.005
Any readmission, n (%)	275 (12)	356 (9.3)	187 (8.0)	<0.0001

*Total Ns differ because of missing information for that particular variable.

†*P* values generated by χ^2/Fisher exact tests (proportions).

CVA indicates cerebrovascular accident; DVT, deep vein thrombosis; MI, myocardial infarction; OR, operating room; PE, pulmonary embolism; UTI, urinary tract infection.

TABLE 4. Univariable and Multivariable Logistic Regression Analyses to Identify Factors Associated With Any Surgical Site Infection (Superficial/Deep/Organ)

	Univariable Logistic		Multivariable Logistic	
Variable	OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Mechanical bowel preparation		<0.0001		<0.0001
MBP+/ABX+	0.39 (0.32–0.48)	<0.0001	0.40 (0.31–0.53)	<0.0001
MBP+/ABX− No prep/ABX− (reference)	0.80 (0.69–0.93)	0.004	0.88 (0.72–1.09)	0.25
Race/ethnicity (white)	1.09 (0.87–1.36)	0.45	1.02 (0.77–1.34)	0.91
BMI (≥ 30)	1.73 (1.51–1.98)	<0.0001	1.66 (1.37–2.00)	<0.0001
ASA (≥ 3)	1.49 (1.30–1.71)	<0.0001	1.21 (0.99–1.48)	0.064
Functional status		0.60		0.49
Partially dependent	0.76 (0.42–1.38)	0.36	0.87 (0.43–1.75)	0.69
Totally dependent	1.32 (0.39–4.48)	0.66	0.30 (0.04–2.42)	0.26
Independent (reference)				
Hypertension	1.05 (0.92–1.21)	0.45	0.91 (0.75–1.11)	0.35
Dyspnea	1.18 (0.92–1.52)	0.19	0.99 (0.72–1.39)	0.99
Ascites	0.86 (0.31–2.41)	0.77	0.41 (0.12–1.42)	0.16
Steroid use	1.48 (1.16–1.88)	0.001	1.31 (0.96–1.79)	0.089
Bleeding disorder	1.08 (0.74–1.56)	0.71	0.95 (0.59–1.52)	0.82
Disseminated cancer	1.54 (1.19–2.01)	0.001	1.20 (0.87–1.67)	0.26
Transfusion	0.94 (0.48–1.81)	0.84	0.83 (0.36–1.89)	0.65
Prior sepsis	1.25 (0.79–1.99)	0.35	0.99 (0.53–1.89)	0.99
Prior wound infection	1.88 (1.21–2.92)	0.005	1.03 (0.55–1.93)	0.94
Hematocrit	0.99 (0.98–1.01)	0.39	1.02 (1.00–1.04)	0.091
WBC × 10^9/L	1.04 (1.02–1.06)	0.001	1.03 (1.00–1.06)	0.050
Creatinine, mg/dL	0.98 (0.85–1.13)	0.74	0.95 (0.78–1.15)	0.57
Albumin, mg/dL	0.74 (0.64–0.84)	<0.0001	0.81 (0.68–0.97)	0.019
Laparoscopy	0.51 (0.45–0.59)	<0.0001	0.54 (0.45–0.65)	<0.0001
Colon vs rectum	0.79 (0.69–0.92)	0.002	0.75 (0.62–0.91)	0.004
Total operation time (≥180 min)	1.68 (1.47–1.92)	<0.001	1.56 (1.30–1.88)	<0.0001

ASA indicates American Society of Anesthesiologists; BMI, body mass index; WBC, white blood cell.

TABLE 5. Univariable and Multivariable Logistic Regression Analysis to Identify Factors Associated With Developing Anastomotic Leak

	Univariable Logistic		Multivariable Logistic	
Variable	**OR (95% CI)**	***P***	**Adjusted OR (95% CI)**	***P***
Mechanical bowel preparation		<0.0001		0.026
MBP+/ABX+	0.45 (0.32–0.64)	<0.0001	0.57 (0.35–0.94)	0.026
MBP+/ABX−	0.77 (0.59–0.99)	0.049	1.05 (0.72–1.54)	0.79
No prep/ABX− (reference)				
Race/ethnicity (white)	1.16 (0.77–1.73)	0.48	1.33 (0.76–2.35)	0.32
BMI (≥30 kg/m^2)	1.20 (0.94–1.54)	0.13	1.11 (0.78–1.58)	0.55
ASA (≥3)	1.23 (0.97–1.55)	0.090	1.20 (0.83–1.74)	0.32
Functional Status		0.89		0.77
Partially dependent	0.87 (0.32–2.36)	0.78	0.70 (0.16–3.00)	0.63
Totally dependent	1.48 (0.20–11.09)	0.70	1.80 (0.21–15.69)	0.59
Independent (reference)				
Hypertension	0.91 (0.72–1.15)	0.44	0.84 (0.59–1.19)	0.33
Dyspnea	1.10 (0.71–1.71)	0.68	1.48 (0.86–2.54)	0.15
Prior sepsis	1.18 (0.52–2.69)	0.70	1.05 (0.32–3.39)	0.93
Ascites	N/A*	N/A	N/A	N/A
Steroid use	0.99 (0.62–1.59)	0.96	1.13 (0.62–2.06)	0.68
Bleeding disorder	1.22 (0.66–2.25)	0.53	0.92 (0.39–2.17)	0.84
Disseminated cancer	1.21 (0.74–1.97)	0.45	1.23 (0.69–2.20)	0.50
Transfusion	0.62 (0.15–2.55)	0.51	N/A	
Prior wound infection	1.61 (0.74–3.47)	0.23	1.22 (0.42–3.54)	0.71
Laparoscopic	0.63 (0.50–0.80)	0.002	0.67 (0.47–0.95)	0.024
Hematocrit, %	1.02 (0.99–1.04)	0.15	1.04 (1.01–1.08)	0.018
WBC, $\times 10^9$/L	1.04 (1.00–1.07)	0.034	1.02 (0.97–1.07)	0.51
Creatinine, mg/dL	1.04 (0.84–1.29)	0.71	1.25 (0.99–1.58)	0.064
Albumin, mg/dL	0.87 (0.68–1.12)	0.27	0.85 (0.61–1.17)	0.31
Colon vs rectum	0.67 (0.52–0.85)	0.001	0.61 (0.43–0.87)	0.006
Total operation time (≥180 min)	1.61 (1.27–2.04)	<0.001	1.63 (1.16–2.30)	0.005

*N/A: Predictor not tested in uni-/multivariable model because of low frequencies.
BMI indicates body mass index; WBC, white blood cell.

30 kg/m^2 or more (OR = 1.66, 95% CI: 1.37–2.00), albumin levels (OR = 0.81, 95% CI: 0.68–0.97 per g/dL increase), colectomy (OR = 0.75, 95% CI: 0.62–0.91), and laparoscopic surgery (OR = 0.54, 95% CI: 0.45–0.65).

The odds of developing postoperative ileus on multivariable analyses were also affected by race (white vs nonwhite; OR = 1.41, 95% CI: 1.06–1.88), disseminated cancer (OR = 1.54, 95% CI: 1.15–2.06), preoperative creatinine (OR = 1.21, 95% CI: 1.05–1.39), total operation time (≥180 min) (OR = 1.62, 95% CI: 1.36–1.95) and operative approach, with laparoscopic surgery showing benefit (OR = 0.46, 95% CI: 0.38–0.55).

DISCUSSION

Direct comparisons of the effects of full MBP in comparison with no bowel preparation on a range of colectomy-specific postoperative complications are lacking. Although current data suggest that there may be significant benefit,[8,14–16,19,20,21] the evidence is not conclusive. Such clarification may ideally be obtained from a randomized controlled trial; however, this is constrained by resources and time. The ACS-NSQIP recently modified data collection so as to include colectomy-specific variables such as the use of MBP and oral antibiotics and additional 30-day outcomes including anastomotic leak and postoperative ileus. Because standardized data are obtained by trained abstractors and available from more than 100 participating hospitals, results obtained from analysis of the collected information are reproducible and generalizable. The aim of this study was hence to evaluate whether MBP alone or in combination with antibiotics reduces SSI while impacting other colorectal-specific outcomes using the ACS-NSQIP–targeted colectomy data. Our results suggest that patients receiving combined MBP and oral antibiotics (MBP+/ABX+) before elective colorectal resection have significantly improved outcomes when compared with patients who receive MBP without oral antibiotics (MBP+/ABX−) and when compared with those without any bowel preparation before surgery. Outcomes that were improved included overall SSI, postoperative ileus, anastomotic leak, and 30-day mortality.

Whether any bowel preparation at all, antibiotics alone, or MBP combined with oral antibiotics should be used has long been a matter of debate. A convincing body of evidence suggests that MBP alone does not exert any beneficial effects on postoperative outcomes and, in some cases, causes harm.[12,22–25] Thus, many recommend that it be completely abandoned.[6,7,13,23] However, MBP has continued to be prescribed by a majority of surgeons, both with and without oral antibiotics.[26] This may be due to such other perceived benefits as easier bowel handling, better ability to palpate small tumors and polyps with facilitation of on-table endoscopy[27] and also because consistent guidelines supported by robust evidence are not available. It seems logical that to have maximal effect on colonic bacterial concentration and thus a beneficial effect on postoperative infectious complications, the use of nonabsorbable antibiotics should follow MBP.[28] Nichols et al[29] showed that neomycin and erythromycin given the day before surgery significantly reduced fecal aerobic and anaerobic bacteria. The same group also found that mechanical bowel cleansing had the effect of increasing the concentration of intraluminal erythromycin.[30] Others have similarly suggested that MBP with oral and IV antibiotics combined have the greatest

TABLE 6. Univariable and Multivariable Logistic Regression Analyses to Identify Factors Associated With Developing Ileus

	Univariable Logistic		Multivariable Logistic	
Variable	**OR (95% CI)**	***P***	**Adjusted OR (95% CI)**	***P***
Mechanical bowel preparation		<0.0001		0.012
MBP+/ABX+	0.57 (0.48–0.68)	<0.0001	0.71 (0.56–0.90)	0.005
MBP+/ABX−	0.78 (0.68–0.91)	0.002	0.95 (0.77–1.16)	0.59
No prep/ABX (reference)				
Race/ethnicity (white)	1.19 (0.95–1.48)	0.08	1.41 (1.06–1.88)	0.018
BMI (≥30 kg/m^2)	1.09 (0.95–1.24)	0.28	1.00 (0.83–1.21)	0.97
ASA score (≥3)	1.52 (1.33–1.73)	<0.0001	1.21 (1.00–1.47)	0.051
Functional status		0.005		0.56
Partially dependent	1.95 (1.28–2.97)	0.002	1.19 (0.66–2.14)	0.57
Totally dependent	1.83 (0.61–5.48)	0.28	0.48 (0.10–2.35)	0.37
Independent (reference)				
Hypertension	1.17 (1.03–1.34)	0.02	0.92 (0.77–1.11)	0.36
Dyspnea	1.49 (1.19–1.88)	0.001	1.25 (0.93–1.68)	0.14
Ascites	3.37 (1.74–6.53)	0.003	1.48 (0.67–3.28)	0.34
Steroid use	1.19 (0.93–1.53)	0.16	1.09 (0.80–1.49)	0.57
Bleeding disorder	1.24 (0.87–1.75)	0.23	0.93 (0.60–1.45)	0.75
Disseminated cancer	2.24 (1.78–2.83)	<0.0001	1.54 (1.15–2.06)	0.003
Transfusion	1.43 (0.82–2.49)	0.21	0.96 (0.46–1.98)	0.90
Prior wound infection	2.08 (1.37–3.15)	0.001	1.06 (0.60–1.87)	0.84
Prior sepsis	2.23 (1.51–3.29)	<0.0001	1.52 (0.87–2.65)	0.14
Laparoscopic	0.41 (0.36–0.46)	<0.0001	0.46 (0.38–0.55)	<0.0001
Hematocrit,%	0.97 (0.96–0.98)	<0.0001	1.01 (0.99–1.02)	0.61
WBC, $\times 10^9$/L	1.04 (1.02–1.06)	0.001	1.01 (0.98–1.04)	0.51
Creatinine, mg/dL	1.21 (1.09–1.34)	0.002	1.21 (1.05–1.39)	0.010
Albumin, mg/dL	0.71 (0.62–0.81)	<0.0001	0.86 (0.73–1.01)	0.072
Colon vs rectum	1.03 (0.89–1.19)	0.71	1.02 (0.84–1.24)	0.84
Total operation time (≥180 min)	1.58 (1.39–1.80)	<0.001	1.62 (1.36–1.95)	<0.0001

ASA indicates American Society of Anesthesiologists; BMI, body mass index.

quantitative and qualitative effect on suppressing mucosal-associated flora.[31]

There are very few data examining the use of oral antibiotics without mechanical cleansing. A recent VA study showed that the use of oral antibiotics without MBP had a beneficial effect on SSI when compared with no bowel preparation at all and was associated with similar rates of infection as MBP+/ABX+; however, the numbers of patients receiving antibiotics alone were very small (7%).[21] In a recent Michigan Surgical Quality Collaborative (MSQC) study, so few surgeons prescribed oral antibiotics without MBP that efficacy could not be analyzed.[20] However, the VA study is a retrospective study reliant on pharmacological data to identify those patients who were prescribed, but not necessarily given, oral antibiotics and MBP. Both VA and MSQC studies involved a selected group of hospitals according to geography and payment, respectively, which may restrict their generalizability.

Meta-analyses supporting the use of oral antibiotics and MBP have, to date, consisted mainly of smaller trials with most studies including 100 patients or less.[14,15] Although an additional analysis of only those few larger trials of more than 100 patients confirmed those findings.[32] Furthermore, the currently available literature pertaining to the use of MBP and antibiotics focuses heavily on SSI, with data on other colectomy-specific outcomes lacking.

ACS-NSQIP is a large data source, across different hospital settings, with accurate MBP inclusion criteria and numerous rigidly defined postoperative outcomes. This provides a unique opportunity to clarify the debate concerning the optimum preoperative preparatory regimen. A recent NSQIP analysis of all colectomy patients in 2012 published since the time of submission of our results showed that in addition to improving SSI, readmission and length of stay were significantly lower in patients given oral antibiotics and MBP than those in patients given MBP alone.[33] An additional new NSQIP study showed reduced rates of anastomotic leak.[34] For the purpose of this study, we chose to evaluate all such important colorectal specific outcomes including overall SSI, postoperative ileus, anastomotic leak, and 30-day mortality because these major or common complications are equally, or more, problematic than SSI for patients undergoing colorectal surgery. The results suggested that MBP with the addition of oral antibiotics produces the lowest rate of postoperative ileus when compared with no-prep or MBP+/ABX− groups. When adjusting for potential confounders, the addition of oral antibiotics to MBP, but not without, was independently associated with reduced odds of postoperative ileus. This is in conflict with Enhanced Recovery After Surgery recommendations to avoid routine use of MBP for speedier return of bowel function, but it has been reported elsewhere.[19,33] In this cohort, the unadjusted anastomotic leak rate was also reduced by both MBP+/ABX− and MBP+/ABX+. However, the beneficial effect of MBP+/ABX+ on anastomotic leak was maintained on multivariable analysis, whereas it was not with MBP+/ABX−. The effect of antibiotics on leak rate may be explained by fewer clinically evident events as opposed to actual leaks due to reduced intra-abdominal bacterial burden and less subsequent contamination after leakage. Slim et al conducted a systematic review which showed that there was no difference in anastomotic leak rate with MBP alone, but there was a suggestion of reduced abscess formation in patients who received oral antibiotics with MBP.[6] We also found a significant reduction in overall 30-day mortality with MBP+/ABX+ compared with both no prep and MBP alone, which was maintained on multivariable analysis. This is likely due to the generalized reduction in septic complications.

With regard to SSI, our results showed that MBP with oral antibiotics reduces SSI when compared with MBP alone or no-prep consistent with previous studies. A number of randomized controlled trials have demonstrated clear benefit to MBP and combined oral prophylaxis in reducing surgical wound infection.[2,35–39] A 43% decrease in postoperative surgical wound infections was observed in a recent meta-analysis when MBP and nonabsorbable oral antibiotics were combined with IV prophylaxis compared with IV alone.[14] This supported a previous Cochrane collaboration review demonstrating a 44% surgical wound infection risk reduction with absorbable or nonabsorbable oral antibiotics and MBP.[15] The MSQC has also published a series of retrospective studies, consistent with our findings, showing a reduction in SSI with MBP+/ABX+ and as such recommend full bowel preparation for all eligible elective colorectal surgery patients.[19,20]

The results of this study suggest that although MBP alone does not confer any benefit in colorectal surgery, bowel preparation that combines MBP with oral antibiotics has significant advantages in reducing SSIs, anastomotic leak, postoperative ileus, and 30-day mortality. Although the strengths of this study lie in its large numbers, inclusion of patients from multiple institutions, use of standardized definitions, availability of colorectal specific outcomes data, and detailed patient and operative factors that allow for the control of various confounders, potential limitations need to be discussed. As with any retrospective analysis, some degree of error in potential miscoding or misclassification may be expected. However, NSQIP has been shown to be both accurate and an improvement on data collected for the purpose of administrative databases.[40,41] Although our analysis attempted to control for differences that could directly be measured, there may potentially be other sources of confounding that are not accounted for in the data. The groups are significantly different regarding some preoperative comorbidities and patient characteristics. It is clear that certain patients are less likely to receive MBP at all, for example, those with preoperative renal failure (0.4% no prep vs 0.03% MBP). This could be explained by surgeon concerns over dehydration and subsequent renal injury as a result of significant gastrointestinal tract fluid losses. However, despite these differences in the patient characteristics of each group, after adjustment, the benefits of MBP remain. The decision to prescribe MBP preoperatively should continue to be made on a patient-specific basis. However, whether the different prescribing practices are surgeon's choice due to patient's condition or due to local guidelines is not possible to determine from the data. There is a lack of information regarding the type of MBP given, quality of resulting preparation, and the specific oral antibiotics used. In addition, whether or not patients received IV systemic antibiotics at induction is not included; however, in accordance with evidence that 96% of US hospitals adhere to the Joint Commission's Surgical Care Improvement Program (SCIP) Inf-1 (prophylactic antibiotic received within 1 hour before surgical incision) guideline, we propose that the majority of patients did.[42] Although we were unable to evaluate *Clostridium difficile* rates, a recent study by the MSQC has shown that C. *difficile* rates are unaffected by oral antibiotics and MBP. In fact, there is a suggestion that as MBP+/ABX+ reduces infectious complications, and hence the need for postoperative antibiotics, it may be beneficial.[20]

A final comment regarding our methodology: We utilized multivariable analysis as a statistical tool to adjust for all potential confounding variables. A large proportion of statistical studies have been devoted to the comparison of propensity score methods to adjusted analysis. Rosenbaum and Rubin showed that the estimate effects from the 2 methods are similar and lead to the same conclusions.[43] This study compares 3 groups: no prep, MBP/antibiotics, and MBP/no antibiotics. In this situation, propensity score matching would need to cover multivalued arms and extend the well-known technique for only 2 arms. Besides the challenging methodological aspects (use of multinomial logit), this approach would considerably reduce the number of observations used in the analysis with no real advantage as compared with the adjusted (multivariable) method.

CONCLUSIONS

The findings of this study support the universal adoption of a simple preoperative bowel preparation regimen that combines MBP and oral antibiotics before elective colorectal resection because this significantly reduces postoperative SSI, paralytic ileus, anastomotic leak, and 30-day mortality; however, a well-designed multicenter randomized controlled trial would be required to settle the debate.

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APPENDIX

CPT Codes Included With Name of Procedure and Grouping

CPT Code	Name of Procedure	Group: Colectomy/ Proctectomy
44140	Colectomy, partial; with anastomosis	Colectomy
44141	Colectomy, partial; with skin level cecostomy or colostomy	Colectomy
44143	Colectomy, partial; with end colostomy and closure of distal segment (Hartmann-type procedure)	Colectomy
44144	Colectomy, partial; with resection, with colostomy or ileostomy and creation of mucous fistula	Colectomy
44145	Colectomy, partial; with coloproctostomy (low pelvic anastomosis)	Proctectomy
44146	Colectomy, partial; with coloproctostomy (low pelvic anastomosis), with colostomy	Proctectomy
44147	Colectomy, partial; abdominal and transanal approach	Proctectomy
44150	Colectomy, total; abdominal, without proctectomy; with ileostomy or ileoproctostomy	Colectomy
44151	Colectomy, total; abdominal, without proctectomy; with continent ileostomy	Colectomy
44160	Colectomy, partial; with removal of terminal ileum with ileocolostomy	Colectomy
44204	Laparoscopy, surgical; colectomy, partial, with anastomosis	Colectomy
44205	Laparoscopy, surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy	Colectomy
44206	Laparoscopy, surgical; colectomy, partial, with end colostomy and closure of distal segment (Hartmann-type procedure)	Colectomy
44207	Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis)	Proctectomy
44208	Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis) with colostomy	Proctectomy
44210	Laparoscopy, surgical; colectomy, total, abdominal, without proctectomy, with ileostomy or ileoproctostomy	Colectomy

DISCUSSANTS

H. Nelson (Rochester, MN): I Have No Disclosures

Patients, practitioners, and payers want to reduce rates of surgical site infection, anastomotic leak, and ileus, and we would all like to put to rest the role of mechanical bowel preparation and antibiotics in accomplishing these goals.

After 50 years of investigation, well-powered randomized trials, 836 publications, Cochrane reviews, and Agency for Healthcare Research and Quality analyses, we still cannot achieve agreement on this subject.

In part, this may be explained by the continued evolution of the bowel preparation question from early assessments of wound and anastomotic infections to recent assessments of ileus, length of stay, *Clostridium difficile* infections, and incorporation of practice

changes, including laparoscopic surgery and enhanced recovery programs.

To your credit, Dr Kiran, your study includes key endpoints, except for *C. difficile*, and your study examines the role of oral antibiotics in addition to studying mechanical preparation versus no preparation. Additional strengths are the large size and the real-world nature of the investigation. Despite these strengths, I cannot imagine that this study will satisfy everyone as the definitive word.

Because you and your colleagues are considering your results as definitive and are proposing universal adoption of the practice of mechanical preparation with antibiotics, I hope you will consider conducting a longitudinal National Surgical Quality Improvement Program outcomes study to validate your recommendations. If statewide implementation demonstrates improvements in outcomes, we will be compelled to follow your lead.

In the meantime, critics on the other side of this argument will be concerned about the limitations of your retrospective study design, including the fact that the 3 populations are not comparable. The no-preparation group had more patients with prior sepsis, ascites, steroid use, bleeding disorders, nonwhite race, and disseminated cancer, American Society of Anesthesiologists classification of greater than 3, and fewer laparoscopic resections. As well, you report that the odds of developing a postoperative ileus were adversely affected by nonwhite race, American Society of Anesthesiologists classification of greater than 3, prior sepsis, disseminated cancer, and an open approach.

One question I have for you regarding your thoughts on what constitutes the basis for these significant selection biases. Were there opportunities to manage these major differences statistically?

Also, you mention that you excluded from analysis variables that had more than 50% missing values. Can you please comment on the general completeness of the data?

Finally, just as the study question has evolved from a focus on wound and anastomotic infections to incorporation of other endpoints and practices, is it time to evolve the question in a different direction? If we have not resolved this issue over the past 50 years using clinical research approaches, is it time to answer the question differently using microbial sequencing technologies to probe biologic underpinnings or use big data approaches to understand the discrepancies in results?

Response From R.P. Kiran:

I agree that the management of colorectal resection as it relates to bowel preparation has evolved over time, and we are sort of reinventing the wheel from the 1970s.

I think some of the controversies as these relate to bowel preparation are that medicine and surgery have evolved in the '80s and '90s, perioperative intravenous antibiotic use became routine, and the SCIP guidelines that subsequently came on more universally compelled all of us to judiciously use antibiotics. Because such measures impinge on surgical site infections, this might have led to some confusion as to whether or not to use bowel preparation and which combination to choose. Furthermore, data relating to potential complications associated with the mechanical cleansing portion of the preparation might have led to several of us not using it any longer.

With regard to your question specific to the differences between the groups, multivariate analysis attempted to account for the differences between the groups, for patients, and intraoperative characteristics, and despite controlling for these, the differences continue to persist. Previous studies from the MSQC have done a propensity-based matched analysis and showed similar findings.

With regard to missing data, we excluded all patients who did not have information about the use of mechanical bowel preparation or oral antibiotics or otherwise.

With regard to the overall completeness of the data for the patients who were included, the overall percentage of missing data in the predictors or outcome was less than 10%; given the small percentage, it is very unlikely that the results would change if we were to use others methods as multiple imputation techniques.

Finally, relating to your final thoughts about microbial sequencing and profiling of patients and using big data to answer questions, I think this is true for a lot of the unexplained questions in surgery at large and in colorectal surgery. I'm sure that we would in the future have ways of defining personal risks of patients and be able to target treatments accordingly.

H. Polk (Louisville, KY):

I wanted to direct my first comment to the program committees who keep turning up these massive, aggregate databases on our program. They are, to some degree, flawed. We all know about having too small patients. As Dave Richardson said a couple of years ago, taking about this, "When your denominators get into the tens or hundreds of thousands, everything becomes significant."

We need an adjustment for large numbers, like such age reduction for small numbers. It leads to this sort of thing, what is true and what is clinically relevant?

I think the person who would have enjoyed this talk most is Bob Condon, of course, who is not with us. This is his theme, his lifetime work, and something he believed in more than anyone. I was particularly pleased to see that you referenced what I've always used as the best analysis of the role of combined systemic and oral antibiotics, and when did it really matter? There's a wonderful paper from Dr Arthur Localio's service at NYU, with Gene Coppa and John Ranson as coauthors, and showed that anastomoses of the extraperitoneal rectum did benefit from both systemic and local antibiotics and a bowel prep.

I also had a little bit of trouble, as did Dr Nelson, to some exclusion of the place you took down a murderer's row of complications and said you put them off to the side, sepsis, ascites, steroids, bleeding, disseminated cancer. I didn't know which pocket they ended up in.

Finally, I would remind people to get over the need once in a while to do things. The only place you can sterilize a colon is in an autoclave.

Second, the point that systemic antibiotics, which you made reference to here, is the backbone of what people use here, it's still amazing that exactly a quarter of those patients get a wrong drug that won't get into the wound and still a third of the patients have them going for several days. This problem, I think, rather than being solved, is going to continue to be discussed.

Response From R.P. Kiran:

Thank you, Dr Polk, for those comments. With regard to your question about the differences between the groups for the various characteristics and the complications, all of these were controlled for in the analysis, but I do recognize that despite our best efforts, there are likely still potential confounders, both known and unknown, that may not have been corrected for.

Regardless, though, similar to the initial results that came out with laparoscopy, where a lot of the benefits were attributed to the selection of patients, these data clearly show that the use of the combined mechanical cleansing with oral antibiotic preparations before colorectal resection is associated with good outcomes. In particular, in a good risk patient, combined bowel preparation is certainly worth using because it reduced the most common complications by almost 50%. Of course, one of the problems of this study is that we were unable to look for such complications as *C. difficile* infection, which antibiotics may themselves potentiate. Also, we were not able to

really assess how many of these patients were compliant with the bowel preparation.

D. Fry (Chicago, IL):

I will declare Merck, Carefusion, IrriMax Corporation, and Ethicon as potential, albeit remote, conflicts for my comments.

The authors are to be congratulated for adding to the continued litany of convincing evidence that reaffirms the 75-year-old observations of Edgar Poth, Warfield Furor, and Isadore Cohn that mechanical preparation of the colon does not reduce SSIs. Eventually, this will filter out to some of the centers in Europe so that they can stop doing randomized trials of mechanical preparation versus no preparation.

I think the evidence is clear. I'm curious as to why we have stopped doing antibiotic bowel preparation in the United States.

Dr Nichols and Dr Rothenberger of this organization have published surveys in the '90s showing that the majority of colorectal surgeons used systemic antibiotics and oral antibiotics during the 1990s, 85+%, and we have turned around and abandoned it, abandoned it to the point that the Enhanced Recovery After Surgery Initiative and the Canadian Colorectal Surgery Society have recommended no preparation. It almost makes evidence-based medicine seem to be mythology at this time, so I'm curious as to why we have abandoned it. Why have we walked away from it?

I think it's because managed care trashed the day of preoperative inpatient hospitalization. I would be interested in your reflections. Do you have evidence as to what was the mechanical preparation used? Was it the GoLYTELY preparation or was it, as Dr Itani and associates have suggested, that perhaps sodium phosphate preparations have a role in reduction of infection rates?

Finally, what were the SSI differences in the open procedures? The laparoscopic procedures reduce SSI rates. I would argue that for open colon surgery, the use of the oral antibiotic bowel prep has a tremendous impact in reducing SSI rates.

Response From R.P. Kiran:

I would like to answer your second 2 questions first.

With regard to the type of bowel preparation used, unfortunately, detailed information about the exact type of preparation, and also as to whether patients really did complete those, is not available in the National Surgical Quality Improvement Program data set.

As regards the specific subset of patients who had open procedures despite controlling for the laparoscopic approach, we did find that the use of a combined bowel preparation did significantly reduce all the various complications. Previous authors using the same subset, and others, have shown that even within a subgroup of patients undergoing open procedures, oral antibiotics and mechanical cleansing does significantly reduce complications when compared with mechanical cleansing alone.

With regard to my reflections as to why I think we have not been using oral antibiotics despite evidence, I think it is a combination of factors. I think that with the evolution of the use of intravenous antibiotics, perhaps the role of oral antibiotics was questioned by surgeons. Perhaps it is the difficulty of preparing these patients with both mechanical cleansing and oral antibiotics. We personally have problems in terms of telling our patients about how to combine the mechanical bowel preparation with oral antibiotics, particularly considering that most of these patients now come in on the day of surgery. Most of them do not want to take the previous day off to spend the morning cleansing themselves and taking antibiotics. I suspect it's a combination of these various factors that might have led to the abandonment of the combined preparation.

M. Otterson (Milwaukee, WI):

I stand up as one of Dr Condon's boys.

One of the things that we talked about when he was alive was the issue of nausea with the erythromycin part of the bowel prep. I asked him, "Why did you choose the dose of erythromycin that you did?" He said, "Well, if we went any higher, they all vomited." One of the issues that's come up is that these patients who are trying to bowel prep at home have a lot of nausea and you get a lot of unplanned admissions with electrolyte abnormalities. I think that that's probably one issue that probably should be addressed if you decide to do a prospective randomized controlled trial, because the erythromycin dose that many people have used for the antibiotic prep is very close to the nausea and vomiting dose. Just a comment.