Wound Infection After Elective Colorectal Resection

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Introduction: Surgical site infection (SSI) is a potentially morbid and costly complication following major colorectal resection. In recent years, there has been growing attention placed on the accurate identification and monitoring of such surgical complications and their costs, measured in terms of increased morbidity to patients and increased financial costs to society. We hypothesize that incisional SSIs following elective colorectal resection are more frequent than is generally reported in the literature, that they can be predicated by measurable perioperative factors, and that they carry substantial morbidity and cost.

Methods: Over a 2-year period at a university hospital, data on all elective colorectal resections performed by a single surgeon were retrospectively collected. The outcome of interest was a diagnosis of incisional SSI as defined by the Center of Disease Control and Prevention. Variables associated with infection, as identified in the literature or by experts, were collected and analyzed for their association with incisional SSI development in this patient cohort. Multivariate analysis by stepwise logistic regression was then performed on those variables associated with incisional SSI by univariate analysis to determine their prognostic significance. The incidence of SSI in this study was compared with the rates of incisional SSI in this patient population reported in the literature, predicted by a nationally based system monitoring nosocomial infection, and described in a prospectively acquired intradepartmental surgical infection data base at our institution.

Results: One hundred seventy-six patients undergoing elective colorectal resection were identified for evaluation. The mean patient age was 62 ± 1.2 years, and 54% were men. Preoperative diagnoses included colorectal cancer (57%), inflammatory bowel disease (20%), diverticulitis (10%), and benign polyp disease (5%). SSIs were identified in 45 patients (26%). Twenty-two (49%) SSIs were detected in the outpatient setting following discharge. Of all preoperative and perioperative variables measured, increasing patient body mass index and intraoperative hypotension independently predicted incisional SSI. Although we could not measure statistically increased length of hospital stay associated with SSI, a representative population of patients with SSI accumulated a mean of $6200/patient of home health expenses related to wound care. Our rates of SSI were substantially higher than that reported generally in the literature, predicted by the National Nosocomial Infection System, or described by our own institutional surgical infection data base.

Conclusions: The incidence of incisional SSI in patients undergoing elective colorectal resection in our cohort was substantially higher than generally reported in the literature, the NNIS or predicted by an institutional surgical infection complication registry. Although some of these differences may be attributable to patient population differences, we believe these discrepancies highlight the potential limitations of systematic outcomes measurement tools which are independent of the primary clinical care team. Accurate surgical complication documentation by the primary clinical team is critical to identify the true frequency and etiology of surgical complications such as incisional SSI, to rationally approach their reduction and decrease their associated costs to patients and the health care system.

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Surgical site infections (SSI) are the third most common hospital-acquired infection and account for 14% to 16% of all such infections.[1] For surgical patients, though, SSI are the most common hospital-acquired infection.[2,3] Several reports have described the substantial cost of these infections in terms of attributable mortality,[3] increased morbidity measured as increased postoperative hospital length of stay, and increased hospital costs.[4–7] SSI in patients undergoing colorectal resection have been specifically studied, with similar general findings.[6,7] However, there has been wide discrepancy in the reported incidence of incisional SSI following colorectal surgery, ranging from 3 to 30%.[8–15] Additionally, there has been no clear consensus on the risk factors contributing to SSI following colorectal surgery, which has limited the data's value to surgeons involved in quality improvement programs hoping to address specific variables that could reduce this risk.

In the last decade, there has been growing interest in developing accurate and efficient systems to better measure outcomes following surgical intervention. This trend has been stimulated by a general recognition of the inadequacy of

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traditional measures that have attempted to address these issues (such as in hospital quality improvement programs) and a dramatic increase in interest on the part of the public and the insurance industry to have access to such accurate information. The existence of such data is the cornerstone of the trend of evidence-based decision making regarding the choice of surgical treatments and the selection of the physician or institution best able to provide these services. Several nation-wide systems are now being developed to address the need for accurate and comprehensive data regarding surgical outcomes and complications. One such example is the effort on the part of the American College of Surgeons to develop and implement the National Surgical Quality Improvement Project. In the specific area of hospital-acquired infections, the Center for Disease Control and Prevention's (CDC) National Nosocomial Infection Surveillance (NNIS) system serves in part to provide a comprehensive monitoring system that reports trends in SSI. The purpose of this nationwide surveillance is to establish benchmarks for interhospital and intrahospital comparisons. Additionally, measuring SSI rates as an indicator of quality is a particular emphasis by the Joint Commission of Accreditation of Healthcare Organizations.[16] In an attempt to improve meaningful interhospital and intrahospital SSI rate comparisons, the NNIS developed a basic SSI risk index that is operation specific (and further adjusted for laparoscopy in certain operative categories) and composed of the following: an American Society of Anesthesiologists (ASA) score of 3, 4, or 5; wound classification; and operative duration.[5] The NNIS criteria are considered an improvement for discriminating and predicting SSI risk compared with the prior risk stratification methods developed following the Study on the Efficacy of Nosocomial Infection Control project.[17] However, Vandenbrouke-Grauls and Schultsz have criticized this risk adjustment strategy as overly simplistic and stated a need to identify more procedure-specific risk factors to derive risk adjustment.[18] Another potentially important limitation of the NNIS data reports is the varied degree of postdischarge surveillance each of its contributing hospitals commits to and the methods they use to complete this task. As the push for streamlined care with shorter postoperative hospitalizations continues, the number of postdischarge SSI diagnosed continue to rise,[19] and several studies have already reported large proportions of SSI that are detected postdischarge.[20–23]

Because of the potential impact of SSI on our patients undergoing elective colorectal surgery, the inconsistencies in the surgical literature regarding the true incidence of SSI in these patients, the lack of consensus regarding the risk factors for SSI, and the growing demand for accurate and efficiently collected surgical outcome data, we undertook this study of incisional SSI in patients at our institution undergoing elective colorectal resection. Our specific objectives were to (1) determine our rate of incisional SSI, (2) identify risk factors for incisional SSI development in this population, (3) estimate the financial impact of these infections, and (4) to assess our methods of complication monitoring in an attempt to improve our accuracy and efficiency in systematically measuring our surgical outcomes.

METHODS

Subjects

This study was conducted at the University of Virginia and approved by the Human Investigation Committee. Patients who underwent elective colorectal resection, total or partial, performed by 1 surgeon (EFF) from February 2000 to January 2002 were identified for inclusion in the study. Cases did not include patients who underwent simple colostomy closure with associated wedge or segmental resection. Patients' hospital records, clinic charts (which included correspondences with referral physicians and home health agencies regarding patients' care), operating room records, and information on the University of Virginia Health System's Clinical Archive System were reviewed for initial data collection.

Measures

Demographic and clinical variables were recorded at time of chart review. Specific intake variables for each patient included: age, gender, height, weight, diagnosis, history of diabetes, preoperative albumin level, preoperative steroid use, history of laparotomy, mechanical bowel preparation the day before surgery, nonabsorbable antibiotic bowel preparation, ASA score as determined by the anesthesiology team during their preoperative assessment, perioperative antibiotics (including type, when given in relation to making the initial skin incision, intraoperative redosing, and continuation for 24 hours of coverage), type of preoperative skin preparation, procedure performed, length of operation, wound classification, intraoperative hypothermia, postoperative hypothermia, intraoperative hypotension, need for perioperative transfusions, use and type of ostomy, and type of wound closure. Outcomes variables included development and date of an incisional SSI, type of treatment chosen for the infection, death, length of postoperative stay, and home health costs.

As per protocol, all elective procedures had combination mechanical bowel preparation with oral laxatives and nonabsorbable antibiotic preparation. Each patient was routinely shaven with electric clippers once in the operative suite just prior to surgical site preparation. For site preparation, povidone-iodine (betadine) scrub was used almost exclusively. Two cases used 2% chlorhexidine gluconate scrub.

One home health group of the four main regional groups that we contacted was willing to share cost information. An attempt to identify wound specific costs was made

for each patient determined to have incisional SSI and treated by this company. An estimation of the postdischarge expenditure related to incisional SSI was made.

Dependent Variable

The primary outcome of interest was a diagnosis of incisional SSI (superficial or deep incisional) as defined by the CDC.[24] Briefly, superficial incisional SSI occur within 30 days of the operation and only involve the skin and subcutaneous tissue and 1 of the following: (1) purulent drainage, (2) organisms isolated from an aseptically obtained culture of incisional fluid or tissue, (3) signs or symptoms of infection which include: pain or tenderness, localized swelling, erythema, or heat, and the wound is opened, or (4) diagnosis of superficial incisional SSI by a surgeon or attending physician. Deep incisional SSIs occur when the incisional wound involves the muscle and fascial layers but not the organ space. Additionally, one of the following must accompany deep soft tissue involvement: (1) purulent drainage from the deep incision; (2) the incision dehisces spontaneously or is deliberately opened by a surgeon in the presence of signs or symptoms of infection; or (3) diagnosis of deep incision is made by a surgeon. A single modification to the definition was made for patients diagnosed in the postdischarge setting, for whom we extended the diagnosis period to 90 days from the date of surgery. The modification allowed for improved capture of incisional SSI in the postdischarge time period. Also, because of the high likelihood of misclassification between deep and superficial by chart review, we choose to evaluate both superficial and deep incisional SSI under the umbrella term of incisional SSI. One surgeon reviewer (EFF) adjudicated each case to determine if an incisional SSI occurred.

Independent Variables

Patient age was evaluated as a continuous variable. Height and weight were used to calculate body mass index (BMI) in kg/m^2. Nine patients did not have heights recorded and were therefore assigned a height according to the average height as listed in the CDC's National Health and Nutritional Examination Survey (NHANES)–164 cm for women and 177 cm for men.[25] BMI was evaluated as a continuous and categorical ($\leq$24, 25 to 29, $\geq$30, as presented in the NHANES[25]) variable. Preoperative albumin was dichotomized, and normal was considered $\geq$3.5 g/dL. Preoperative serum albumin is not a routine clinical laboratory test for our patients and is only obtained if there is any clinical suspicion of malnutrition. Therefore, patients without a preoperative serum albumin performed within 30 days prior to the surgery were considered normal (n = 62). ASA score was dichotomized into $\leq$2 or >2, which reflects the NNIS distinction of ASA scores >2. Perioperative antibiotics were also categorized as appropriate or inappropriate. Determination of appropriateness was based on dosing time with respect to the incision (inappropriate if not given prior to the incision), spectrum of activity (inappropriate if the antibiotic(s) did not cover Gram-negative bacilli or anaerobes), and the necessity of redosing (dependent on the half-life of the antibiotic(s) given and the length of the case), as set by the CDC.[3] Length of operation was categorized into 4 variables for analysis (<2 hours, 2 to 3 hours, 3 to 4 hours, and >4 hours). The use of transfusion of cellular or plasma products was evaluated as a single category. Similarly, ileostomy and colostomy creation were considered as 1 variable (ostomy: yes/no). Wound classification was dichotomized as clean-contaminated = 0 and contaminated or dirty = 1. All other variables were already dichotomized and are presented in the results.

Statistical Analyses

Following data collection, the rate of SSI in the study population and the percent diagnosed in the postdischarge period was determined. Bivariate comparisons of those patients with or without incisional SSI were unpaired, and all tests of significance were two-tailed. Comparative analysis of categorical variables was performed using a χ^2 testing with Yate's continuity correction. Continuous variables were analyzed using Student's t tests for normally distributed variables; otherwise, the Mann-Whitney U test was employed.

A multivariable analysis, in which development of incisional SSI was the dependent outcome variable, was performed by logistic regression employing a Wald statistic backward stepwise selection. Independent variables with a P value ≤ 0.2 for an association with development of SSI by bivariate statistics were included in the multivariable analysis as was determined prior to the analysis. The model was evaluated for modifying effects. Calibration and discrimination of model performance were assessed by the Hosmer-Lemeshow goodness of fit test and area under the ROC curve, respectively.

Values are expressed as medians with interquartile ranges (IQR) for continuous variables or as a percentage of the group of origin for categorical variables. The results of the logistic regression are reported as odds ratios (OR) with 95% confidence intervals (CI). All P values are two-tailed, and $P \leq 0.05$ was considered to indicate statistical significance. All statistical analysis in this study was performed using SPSS software (version 11.0, SPSS Inc., Chicago, IL).

RESULTS

During the 2-year period under review, 176 patients were identified who underwent elective colorectal resection performed by EFF. The mean patient age was 62 years (IQR, 48 to 72), and 54% of the group (95) was male. Of the patients having the procedure performed, 101 (57.4%) had cancer, 35 (19.9%) had inflammatory bowel disease, 17 (9.7%) had diverticular disease, and 23 (13.1%) had another diagnosis necessitating resection. The most common type of

procedure performed was low anterior resection 65 (36.9%) followed by right-sided colectomy 36 (20.5%), total colectomy or total proctocolectomy 34 (19.3%), and abdominoperineal resection 19 (10.8%). The remaining 22 (12.5%) received some other partial colectomy. Seventy-one (40.3%) patients also had a stoma created at the time of the case (either ileostomy or colostomy).

For this patient cohort, 45 (25.6%) were diagnosed with incisional SSI. Of the infected patients, 23 (51%) were inpatients at diagnosis, and 22 (49%) were diagnosed postdischarge in the outpatient setting. Five patients were diagnosed after the CDC-designated 30-day period used to define SSI, and these occurred at postoperative days 37, 43, 48, 65, and 73. The other 40 patients were diagnosed within 30 postoperative days. The median time to diagnosis was 9 days (IQR, 5 to 19 days).

Bivariate Analysis

In the bivariate analysis, patients were divided into those with or without incisional SSI and compared. Patients who developed incisional SSI were more likely to have a higher BMI and have a higher ASA score given preoperatively. However, there was no difference in age or gender distribution. Also, neither diagnosis, preoperative albumin level <3.5 g/dL, preoperative steroid use, nor prior laparotomy had any significant associations with development of incisional SSI. Table 1 summarizes the comparisons of the patient characteristics.

When evaluating the perioperative and operative characteristics, only prolonged length of operation was significantly associated with the development of an incisional SSI. However, there was a trend toward developing an incisional SSI if the patient developed intraoperative hypotension during the case. None of the other factors recorded were statistically associated with the development of incisional SSI. Table 2 summarizes the comparisons of perioperative/operative characteristics.

Multivariable Analysis

Following the bivariate analysis, the variables BMI, ASA score >2, length of operation, and intraoperative hypotension variables were selected for stepwise logistic regression analysis as their *P* values for association with incisional SSI development were <0.2, the predetermined cutoff for inclusion. For our population, BMI and intraoperative hypotension were independently predictive of developing an incisional SSI. Table 3 summarizes the results from the multivariate analysis.

Cost Estimation

Of the 45 infected patients, 44.4% (20) required home health assistance with wound management. We received home health cost data on 12 of these 20 patients. The cost per patient ranged from $912.57 to $24,108.00 with the mean cost at $6200. Applying this average to the whole group requiring home health, we estimate that the cohort expended $124,000 as a result of their infections. We acknowledge this is a very rough estimate, but the cost is clearly significant.

TABLE 1. Patient Characteristics

Characteristic	Incisional SSI	No SSI	*P* value
Number	45	131	
Age (median yr and IQR)	62 (47–70)	61 (49–72)	0.671
Body mass index (kg/m^2)			0.024
≤24	31.1% (14)	51.9% (68)	
25–29	37.8% (17)	27.5% (36)	
≥30	31.1% (14)	20.6% (27)	
Gender			0.942
Male	55.6% (25)	53.4% (70)	
Female	44.4% (20)	46.6% (61)	
Comorbidities			
Diabetes	11.1% (5)	13.7% (18)	0.848
Preoperative albumin <3.5 (g%)	2.2% (1)	9.2% (12)	0.228
Preoperative steroid use	15.6% (7)	13.7% (18)	0.957
Prior laparotomy	31.1% (14)	28.2% (37)	0.861
Diagnosis			
Cancer	48.9% (22)	60.3% (79)	0.245
IBD	24.4% (11)	18.3% (24)	0.502
Diverticular disease	13.4% (6)	8.4% (11)	0.500
Other	13.4% (6)	13.0% (17)	0.910
ASA score >2	35.6% (16)	19.1% (25)	0.040

IQR, interquartile range; IBD, inflammatory bowel disease; ASA, American Society of Anesthesiologists.

DISCUSSION

Our rate of incisional SSI for elective colorectal resections (25.6%) is higher than predicted by general review of the literature. Although there is a wide range of frequencies reported, from 3% to 30%,[8–15] the average rates for wound infections reported is roughly 10%. Our rate is also greater than that suggested by the 2001 NNIS report,[26] which demonstrated median rates of 3.57% for cases with a 0 risk factors to 12.88% for cases with 3 risk factors. Finally, this rate is higher than that recorded by an independent internal review of postsurgical infections by our own department, prospectively detected and recorded by one of our coauthors (RGS), a general surgeon with a special interest in surgical infection. There are a number of potential explanations for these discrepancies. First, our population of patients may be different than those generally reported in the surgical literature. The present cohort represents a tertiary referral practice of a board-certified colon and rectal surgeon. The number of operations involving more than an abdominal segmental re-

TABLE 2. Perioperative/Operative Characteristics

Characteristic	Incisional SSI	No SSI	*P* value
Number	45	131	
Appropriate perioperative antibiotics	68.9% (31)	65.6% (86)	0.830
Procedure type			
Right sided colectomy	13.3% (6)	22.9% (30)	0.247
Low anterior resection	40.0% (18)	35.9% (47)	0.753
Abdominoperineal resection	13.3% (6)	9.9% (13)	0.721
Total colectomy or proctocolectomy	20.0% (9)	19.1% (25)	1.000
Other partial colectomy	13.3% (6)	12.2% (16)	1.000
Length of operation			0.031
<2 hours	20.0% (9)	31.3% (41)	
2–3 hours	26.7% (12)	34.4% (45)	
3–4 hours	33.3% (15)	22.1% (29)	
>4 hours	20.0% (9)	12.2% (16)	
Temperature <36°C	33.3% (15)	36.6% (48)	0.827
Intraoperative hypotension (SBP <90)	26.7% (12)	14.5% (19)	0.105
Perioperative transfusion	20.0% (9)	17.6% (23)	0.706
Ostomy created	46.7% (21)	36.6% (48)	0.312
Primary wound closure	93.3% (42)	92.4% (121)	1.000
Contaminated or dirty wound	4.4% (2)	3.8% (5)	1.000

SBP, systolic blood pressure.

section 118 (67%), the number of low anterior resections 65 (36.9%), and the number of stomas created 71 (40.3%) are all indicative of a complex subspecialty practice that may be different than the cohorts described in other studies. Our population had high percentages of patients with inflammatory bowel disease (19.9%) and colorectal cancer (57.4%), also perhaps different than the normal distribution of a less specialized program. Finally, 94 (54%) of 176 of our patients had a BMI ≥ 25, and 41 (23%) of 176 had a BMI ≥ 30, indicating a high rate of obesity (one of our variables predicting higher SSI) in this population, which may not be representative of populations such as that of Tang et al,[15] a study from the Far East.

We do, however, believe that this high SSI rate is not entirely explained by these potential population differences. Our data suggest that methodology of complication measurement may also be an important contributing factor. Twenty–two (49%) of our wound infections were diagnosed after discharge, highlighting the substantial inadequacy of surveillance systems that are primarily inpatient based. Our own intradepartmental, prospectively acquired postsurgical database predicted an incisional SSI rate in this patient population of 11.9%, essentially one half of the infections we report. This system is strictly inpatient-based, and in careful review of our data, simply missed the half of the SSI diagnosed in the outpatient setting. We, therefore, support the concern with the NNIS data or with any surveillance system for SSI that does not have consistently strong methods for complication detection following discharge. Our experience also subjectively supports the importance of direct involvement of the primary care team in the diagnosis and calculation of complications such as SSI. We found at times extremely poor or scattered documentation of incisional SSI in the patient record, and we frequently made the diagnosis of incisional SSI on the basis of events not clearly documented in the patient record, such as poorly documented clinic encounters, follow-up phone calls from referring physicians, and discussions with home health agencies. These factors may easily lead to underreporting of complications by systems solely acquiring data from formal charting by personnel not directly involved in the patient's care. We feel that these potential patient population differences and differences in our SSI detection methodology may explain the discrepancies between our reported and expected rates of incisional SSI.

A further objective of this study was to identify potential risk factors that independently predict development of incisional SSI. By multivariate analysis, we identified increasing BMI and intraoperative hypotension as 2 such factors. The association of obesity with developing SSI is well documented.[27–29] A recent study from the Memorial Sloan Kettering Cancer Center also identified obesity as a risk factor for SSI development in patients undergoing colorectal resections.[30] The growing epidemic of obesity in this country may be responsible for increasing the overall morbidity of elective colorectal resection, due to increasing rates of SSI in this group of patients. Unfortunately, this is a factor that is relatively resistant on an individual basis to overcome in the perioperative period. Potentially leaving wounds open in patients with higher BMI's would reduce the infection rate, but the resultant costs from dressing changes and prolonged

TABLE 3. Multivariable Analysis (Cases = 176; Outcomes = 45)

Independent Predictors	OR	CI	*P* value
BMI (kg/m^2)			
≤24	1.0	ref	
25–29	2.5	1.1–5.7	0.032
≥30	3.0	1.2–7.2	0.018
Intraoperative hypotension (yes/no)	2.6	1.1–5.7	0.030
Hosmer-Lemeshow goodness of fit test = 0.719			
Area under the ROC curve = 0.7			

BMI, body mass index.

hospital stays as patients and families are taught to dress wounds would be prohibitive.

In our multivariable analysis, we also identified intraoperative hypotension as an operative factor that predicts incisional SSI development. The data does not delineate the pathophysiology of this relationship, but one could theorize the contribution of poor wound tissue perfusion related to hypotension. Additionally, intraoperative hypotension may also be a surrogate marker for other factors, such as size or complexity of surgery that were not otherwise identified in the variables studied. Nonetheless, the data suggest the importance in the maintenance of intraoperative normotension in the reduction of SSI, and they identify this variables importance for further investigation.

Our data suggest that the development of incisional SSI was costly. Unlike other studies,[7] we could detect no additional length of stay related to incisional SSI. This is probably due the extensive growth and availability of the home health care resources over the last decade as well as the strong institutional pressures regarding early discharge of most surgical patients. These data clearly highlight the transfer of the substantial medical expenditures related to the formation of an incisional SSI from the inpatient to outpatient setting.

There are several important study limitations that require further discussion. First, all diagnoses of incisional SSI were recorded retrospectively. Therefore, diagnosis was made by interpretation rather than by direct examination. This greatly enhances the possibility of the misdiagnosis of SSI when compared with a prospective review, and the possibility of inaccuracies and incompleteness of all variable data points. Second, variability in infection detection by chart review could not be assessed because only 1 surgeon adjudicated all the cases, and discernable differences in surgeons' tendencies to make a diagnosis of SSI has been reported.[31] However, by having only 1 reviewer, there was likely greater consistency in case-to-case interpretation of the presented data. Third, there are other known predictors or plausible factors associated with SSI that were not evaluated, including cardiac disease, smoking history,[32] >10% weight loss,[33,34] pre/postoperative anemia,[34] or glucose control.[35] Despite these limitations, we believe the present study accurately portrays the rate of incisional SSI in this patient population.

CONCLUSIONS

This study reports a higher than expected rate of SSI following elective colorectal resection, due perhaps to differences in patient populations as well as discrepancies in methodology of complication surveillance. We believe the accuracy and efficiency of any surgical outcomes program depend on the active participation of the primary care team in a prospectively acquired data acquisition system that collects data from both the inpatient and outpatient settings.

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Discussions

DR. R. PHILLIP BURNS (Chattanooga, Tennessee): I think it is obvious that this paper shows that the Southern has in its new member Dr. Foley a surgeon with considerable intestinal fortitude. It also attests to the friendship and respect he must share with Drs. Sawyer, Smith et al in that he allowed his colleagues to publish his complications, and I think we are all benefited by that.

This is an interesting retrospective review of Dr. Foley's experience in an elective setting that reflects a tertiary referral type practice, as evidenced by the relatively large percentage of cases that involve low pelvic dissections and anastomoses. The results reinforce the personal impression that SSI has always been under reported. While some of these infections were relatively minor, it also confirms that in this era of early discharge post-op, many complications will and must be discovered in the outpatient setting where many surgeons prefer to abbreviate the length of time spent in direct patient contact and evaluation in the interest of efficiency and cost control. As expected, the cost of care for these infections shifted to the outpatient setting, and the projections for resultant costs in the text of the paper are enlightening.

The larger contribution of this paper is, of course, the exposure of inaccurate measurement tools for true outcomes assessment that exists today as reflected by the reported 25% surgical site infection compared to a 10% to 12% standard used in most papers and studies. As a result of this observation, which shows underreporting, does it invalidate previous studies that have evaluated the effectiveness of issues such as bowel prep, systemic antibiotic use, prophylactic antibiotic use, and different surgical techniques in colon surgery? Did the extension of the usual postoperative study period from 30 to 90 days change anything and should this be the new standard for future studies?

Not surprisingly, obesity proved to be a significant risk factor for surgical site infection in this study group. Do you have any technical considerations for closure, such as leaving the subcutaneous tissue open, that might help lower this rate? I suspect that doing so, or at most doing a loose closure of the subcutaneous tissue, may be more economically feasible than suggested in your manuscript.

Finally, you indicate that all patients had an antibiotic bowel prep but rates of appropriate systemic antibiotic administration was low. I assume this is secondary to relaxation or absence of protocol? Is this the case? I enjoyed this paper very much and congratulate you on membership in the Southern.

DR. THOMAS R. GADACZ (Augusta, Georgia): The authors attribute the observed higher infection rate to 2 major factors. The first is a difference in the patient group, mainly more complex operations, an ostomy in 40% of the patients, and a high incidence of obesity. The second factor is the completeness in recording the infection rate.

Of all the factors analyzed, obesity and intraoperative hypotension were associated with a higher wound infection rate. This paper has a real pragmatic message. Our methods of measuring SSI seem to be inaccurate in detecting the real effect of colorectal operations on long-term outcomes and costs. Some of our current standard measurements and assessments may be inadequate in these risk adjusted rates, and perhaps factors such as obesity—no pun intended—should be weight adjusted as a risk factor.

I have 3 questions. The purpose of this paper was to reflect the SSI in your patients. If you exclude certain risk factors such as a high BMI or colorectal operations with ostomies, would your numbers be more in keeping with the expected 10% to 12% infection rate for a clean contaminated wound?

Second, do you plan to analyze your data for other emerging risk factors such as postoperative glucose control?

Third, what would you propose as a new methodology to measure the real effects of colorectal operations on outcomes and costs?

I wish to thank the authors for a copy of the manuscript in advance and also congratulate Dr. Foley on his membership, and I want to thank the organization for the privilege of discussing this paper.

Dr. Hiram C. Polk, Jr. (Louisville, Kentucky): I wanted to bring the audience's attention to several points that Dr. Burns has touched upon. If you are going to do relatively long operations, as long as were described in the infected groups, three and a half hours or so, you are going to want to use a different drug that persists in the wound for a longer time. I don't think many people would think Cefoxitin is a drug that accomplishes that goal. You surely could supplement that with some topical drugs at the time of closure, which might add to that.

Secondly, rather than depend on a primary care team, most surgeons see their patients towards the end of the 30th or 40th day after operation. That is the time that our data indicate you get the most accurate information. It saves a lot of phone calls and the surgeon's opinion about a wound turns out to be fairly accurate.

Finally, I do think that the home health issue here can be overdone and it is a dangerous alternative to having the patient come back to your office and look after these sort of things. This is a revealing kind of paper that makes all of us look inward.

Dr. John M. Kellum (Richmond, Virginia): I too want to congratulate Dr. Foley and his co-authors at our sister institution for this excellent paper. I like this paper because it is so brutally honest. I wanted to concentrate a little on the bowel prep. You said that all of the patients had a bowel prep. I wondered if you felt that the practice of insurance companies not covering preoperative days for the bowel prep may have resulted in the higher rate of infection. I notice in my own practice that patients frequently don't cooperate at home with bowel preps and when patients are allowed to come into the hospital, the residents try to administer the bowel prep and the antibiotics at the same time so that the pills just get flushed out, unabsorbed.

Secondly, according to the New Times this past Saturday, the incidence of obesity in the general population is now 31%, which is about a 100% increase in the last 25 years. Given that fact, are you treating obese patients any differently in terms of your wound care and wound closure? Could you describe your wound closure?

Dr. Richard J. Howard (Gainesville, Florida): I enjoyed this paper, and certainly we all admire Dr. Foley's honesty. I would like to ask him a couple questions about gathering data.

There have been a few very large studies, starting with the America College of Surgeons National Research Council—large scale, I think there were 15,000 patients reported in that in 1964—and the CDC has run the National Nosocomial Infection Survey, which has reported a couple hundred thousand patients. The third one was one done by a surgeon at the Minneapolis VA, James Lee, and his research nurse Mary Olson, and I think that is probably one of the best studies because it was done prospectively. Mary Olson went around and looked at wounds, took off the dressing and looked at wounds of patients in the hospital, and then went to the clinics afterwards since all the patients came back to the VA hospital. And, of course, that is a special situation.

Even that is not being done anymore because it was so expensive for the VA to fund a nurse half time to do only that. But it has been said by all of those very large studies that in order to really get good data about complications—in this case wound infections, but it applies the same for all complications—you have to have data gathered prospectively and by an independent observer, because surgeons like to minimize the number of wound infections we have.

So I would like to ask the author whether he thinks that there might even be more wound infections had the data been gathered prospectively and whether any difference might have been brought to light if an independent observer were watching his wounds?

Dr. Galen V. Poole (Jackson, Mississippi): This was a very fine presentation. I would venture to guess that a number of papers have been withdrawn by authors from consideration at similar presentations because of rather disappointing results. You are to be congratulated on giving this presentation today. I do have a question with regard to some of the predictors of postoperative infection, primarily the presence of hypotension. Was this really a surrogate for intraoperative blood loss or transfusions, or some other factor that may not have been evaluated?

Dr. Raleigh R. White, iv (Temple, Texas): I really enjoyed Dr. Foley's paper. As a plastic surgeon, I found it very pertinent for me that he focused on the soft tissues as an infection site.

The questions that came to my mind involve the soft tissue wound after a fascial closure. I wondered if there was any information, perhaps in the manuscript, about what Dr. Polk alluded to as irrigation of the subcutaneous tissues, and even to the type of suture removed? That might vary from surgeon to surgeon in that process.

And then finally, I wondered about the bacteria that were actually identified from these wound infections. Were they primarily enteric bacteria or cutaneous?

Dr. Basil A. Pruitt, Jr. (San Antonio, Texas): I wonder whether obesity is simply a surrogate for glucose intolerance, which is a normal response to injury, and whether you

plan to monitor and control glucose levels in the next 106 patients.

Secondly, it is a little surprising that length of operation was important and transfusions were not, since I think those would parallel one another. And I wonder whether that simply reflects a type 2 error, or whether you have some other explanation why transfusion, which is known to be immunosuppressive, did not exert an effect in your patients?

DR. EUGENE F. FOLEY (Charlottesville, Virginia): Thank you very much for all those comments. I guess it is a testimony to the fact that we are all very interested in the things we don't do well perhaps even more than the things we do well.

To talk about some specific things: For the patients in the cohort as a whole, and we didn't make any differentiation between normal weight patients and obese patients, we closed the fascia with a running absorbable monofilament, did nothing with the subcutaneous tissue, closed the skin with skin clips. I think based on these findings we are certainly a lot more worried about the patients particularly in the obese category, the over 30 BMI—indeed that we should think about doing something different as far as those closures are concerned. Perhaps even closing the skin loosely and leaving points of egress, because I think to a large degree it is related to having a large closed space where fluid can accumulate.

Let me talk about some of the other specific questions that people had.

It may easily be that some of the variables that we saw related—or at least we had concern that some of the variables that we saw that related to SSI were, in fact, surrogates of other things. For instance, intraoperative hypotension certainly could be a surrogate for longer operation, more complex operation, as was pointed out, the need for transfusion. We looked at each of those variables independently, however, and did not see a significant difference in any of the variables when we looked at them either by variate or multivariate analysis other than the hypotension. So at least by our ability to measure things statistically we did not think that intraoperative hypotension was simply marking the presence of one of the other factors at least we measured.

Now, it may have been marking a factor that we didn't think of measuring, which may have gone along with the fact that it was a marker for just having a bigger operation. There has been lots of interest in blood glucose or blood sugar control in postoperative infection. In fact, at our institution we have been very interested in aggressively treating patients' blood sugars in the postoperative period to try to reduce the chances of having wound infections. We did not particularly measure postoperative recordings of blood pressure, so it may be that obesity was, in fact, a marker for having postoperative hyperglycemia, which has been shown in other studies to be a risk factor in the development of SSI. However, we did not see diabetes independent of obesity as being a predictor for SSI.

Finally, there are a number of other specific questions that came out of our findings related to the general changes in the way we provide health care. And I think the answer is yes. It goes from the preoperative arena where you wonder about the adequacy of bowel preps and the compliance of bowel preps done in the outpatient setting, which is different than it was done 10 or 15 years ago. And also it clearly goes as far as making it much more difficult, in my opinion, to count particularly the long-term complications. Because I think the real place that our institutional database fell down, and I think a lot of these others do, is the counting of complications that occur after discharge. And when we are sending patients home earlier and earlier, I think the likelihood that we will underreport complications in that period of time following surgery is going to go up.