Impact of sequential implementation of multimodal perioperative care pathways on colorectal surgical outcomes

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Background: Standardized care protocols offer the potential to reduce postoperative complication rates. The purpose of this study was to determine whether there was an additive benefit associated with the sequential implementation of the evidence-based Surgical Site Infection Bundle (SSIB) and Enhanced Recovery After Surgery (ERAS) protocols for patients undergoing colorectal surgery in a community hospital.

Methods: Patients at a single institution who underwent elective colorectal surgery between Apr. 1, 2011, and Dec. 31, 2015 were identified by means of American College of Surgeons National Surgical Quality Improvement Program data. Patients were stratified into 3 groups according to the protocol implementation dates: pre-SSIB/pre-ERAS (control), post-SSIB/pre-ERAS and post-SSIB/post-ERAS. Primary outcomes assessed were length of stay and wound complication rates. We used inverse proportional weighting to control for possible differences between the groups.

Results: There were 368 patients included, 94 in the control group, 95 in the post-SSIB/pre-ERAS group and 179 in the post-SSIB/post-ERAS group. In the adjusted analyses, mean length of stay (control group 7.6 d, post-SSIB/post-ERAS group 5.5 d, p = 0.04) and overall wound complication rates (14.7% and 6.5%, respectively, p = 0.049) were reduced after sequential implementation of the protocols.

Conclusion: Sequential implementation of quality-improvement initiatives yielded additive benefit for patients undergoing colorectal surgery in a community hospital, with a decrease in length of stay and wound complication rates. The amount of improvement attributable to either initiative is difficult to define as they were implemented sequentially. The improved outcomes were realized after the introduction of the ERAS protocol in adjusted analyses.

Contexte : Les protocoles de soins standardisés offrent la possibilité de réduire les taux de complications postopératoires. Le but de cette étude était de déterminer s'il y a un avantage additif associé à l'application séquentielle des protocoles fondés sur des données probantes SSIB (*Surgical Site Infection Bundle*) et ERAS (*Enhanced Recovery After Surgery*) chez des patients soumis à une chirurgie colorectale dans un hôpital communautaire.

Méthodes : Les patients d'un seul établissement ayant subi une chirurgie colorectale non urgente entre le 1er avril 2011 et le 31 décembre 2015 ont été recensés à partir des données du Programme national d'amélioration de la qualité chirurgicale de l'American College of Surgeons. Les patients ont été stratifiés en 3 groupes selon les dates d'application des protocoles : pré-SSIB/pré-ERAS (témoin), post-SSIB/pré-ERAS et post-SSIB/post-ERAS. Les paramètres principaux évalués étaient la durée du séjour hospitalier et les taux de complications de plaies. Nous avons utilisé une pondération proportionnelle inverse pour tenir compte des possibles différences entre les groupes.

Résultats : Nous avons inclus 368 patients, 94 dans le groupe témoin, 95 dans le groupe post-SSIB/pré-ERAS et 179 dans le groupe post-SSIB/post-ERAS. Dans les analyses ajustées, la durée moyenne des séjours (groupe témoin 7,6 j, groupe post-SSIB/post-ERAS 5,5 j, p = 0,04) et les taux globaux de complications de plaies (14,7 % et 6,5 % respectivement, p = 0,049) ont diminué après l'application séquentielle des protocoles.

Conclusion: L'application séquentielle des initiatives d'amélioration de la qualité a donné lieu à des bienfaits additifs chez les patients soumis à une chirurgie colorectale dans un hôpital communautaire, avec abrègement du séjour hospitalier et diminution du taux de complications de plaies. Le degré d'amélioration attribuable à chacune des initiatives est difficile à préciser puisqu'elles ont été appliquées séquentiellement. L'amélioration des paramètres a été obtenue après l'introduction du protocole ERAS dans des analyses ajustées.

Surgery for resection of the colon or rectum is traditionally associated with a high risk of complications.[1] Historically, patients undergoing colorectal resection could expect a 20%–25% risk of complications along with the prospect of a postoperative hospital stay of 7–10 days.[2] Recognizing an opportunity for improved care, many institutions have introduced standardized care protocols to decrease postoperative complication rates, reduce length of stay and provide cost-effective care without compromising patient safety. Two such protocols are the Enhanced Recovery After Surgery (ERAS) and the Surgical Site Infection Bundle (SSIB). These protocols show promising results in reducing morbidity and length of stay after colorectal procedures.[3–5]

The ERAS pathway is an evidence-based initiative developed to promote rapid recovery and decrease postoperative complication rates. This multimodal intervention was first introduced by Kehlet,[6] in 1990, and is now recognized as the gold standard for perioperative care management in patients undergoing colonic or rectal surgery.[7] The ERAS pathway aims to optimize recovery by modifying physiological and psychological responses to major surgery.[8] Studies evaluating patient outcomes after implementation of ERAS have shown reduced complication rates and length of stay, improvements in cardiopulmonary function, earlier mobilization and return of bowel function, and overall reduction of cost to the health care system.[9–11] The SSIB is a perioperative quality-improvement initiative that focuses specifically on preventing postoperative wound infections. Surgical site infections are hospital-acquired surgical complications associated with substantial morbidity. They are the most common nosocomial infections in surgical patients.[12] The reported infection rate following colorectal resection is varied but is highest among abdominal surgical procedures.[13] The SSIB consists of evidence-based processes of care to reduce surgical wound infection rates. Prevention of surgical site infections is an important step to reduce rates of morbidity and mortality and costs.[14–16]

Several systematic reviews have shown that ERAS and SSIB pathways can decrease length of stay and rates of perioperative morbidity and surgical site infection.[3–5,7,10] To our knowledge, only 1 study has presented the combined effects of both evidence-based pathways in a single institution,[3] and only 2 studies evaluating standardized care pathways have been conducted in smaller community centres.[17,18] The purpose of the present study was to examine whether an additive benefit exists with the combination of ERAS and SSIB initiatives and to report the results from a community hospital.

Methods

Study population and data collection

This was a retrospective cohort study approved by the Interior Health Research Ethics Board. The study was completed at Royal Inland Hospital, a tertiary referral community hospital with 245 acute care beds located in Kamloops, British Columbia. The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) was introduced at our hospital in 2011. We used NSQIP data to identify all patients who underwent colorectal procedures at our site from Apr. 1, 2011, through Dec. 31, 2015. The NSQIP methodology was applied by 2 surgical-clinical reviewers to rigorously collect demographic information, clinical variables and 30-day outcomes for all patients who underwent colorectal resection during the study period. Custom fields were created within the NSQIP workstation to track compliance rates for the perioperative processes within both the ERAS and the SSIB protocol.

The NSQIP system of data sampling has been validated[19] and allows for comparison of risk-adjusted surgical outcomes among all participating hospitals. We used a procedure-targeted NSQIP module to ensure that all relevant cases were captured. Inclusion criteria were based on predefined NSQIP Current Procedural Terminology codes for colorectal resection. Procedures were elective, open or laparoscopic, and included abdominoperineal resection, partial colectomy, total abdominal colectomy with or without proctectomy, proctectomy and low anterior resection. Patients under the age of 18 years were excluded as per NSQIP guidelines. In addition, patients who had emergency colorectal procedures were excluded, as the perioperative care pathways could not be applied in the same way to this patient population owing to the expediency of care required. No patients were lost to follow-up. Processes within the quality-improvement initiatives were applied to all eligible patients, at reported compliance rates, as per their cohort, and follow-up data were obtained for all these patients as per the NSQIP protocol.

Perioperative quality-improvement pathways

The SSIB and ERAS interventions were a multidisciplinary effort that required the participation and compliance of surgeons, operating room nurses, anesthesiologists, ward nurses, enterostomal therapists, clinical practice educators, patient care coordinators and other allied health care professionals. Implementation of the perioperative care pathways was a team effort coordinated by a team of up to 15 front-line providers. The SSIB and ERAS elements were selected based on established, evidence-based, best-practice guidelines as reviewed by the local team.[20–27] Our site participated in Health Authority and provincial ERAS collaboratives, and this also influenced pathway design. Compliance with the components of the perioperative quality-improvement programs was tracked and reported quarterly. The target compliance for each component throughout all study periods was set at 80% for our site.

We categorized patients into 1 of 3 groups based on the implementation dates of the SSIB and ERAS interventions as follows: pre-ERAS/pre-SSIB (control group) (Apr. 1, 2011, to June 16, 2013), pre-ERAS/post-SSIB (June 17, 2013, to May 20, 2014) and post-ERAS/post-SSIB (May 21, 2014, to Dec. 31, 2015).

Outcome measures

The primary outcome measures included hospital length of stay and wound complications. Secondary outcome measures included death within 30 days, readmission within 30 days, unplanned return to the operating room and various complications captured in the NSQIP database.

Statistical analysis

We compared baseline demographic characteristics, patient characteristics and 30-day postoperative outcome variables between groups using the nonparametric Kruskal–Wallis test for continuous variables (age, body mass index) since the data did not follow a normal distribution, and the χ^2 or Fisher exact test, as appropriate, for categorical variables. We used a propensity score approach to account for baseline differences between groups owing to the nonrandomized design of the study. The propensity score model was developed through a careful approach selecting variables thought to be related to the outcomes. Covariates included age, body mass index, sex, American Society of Anesthesiologists classification, wound classification, laparoscopic procedure, diabetes status and smoking status. We examined the balance of the propensity score across treatment and comparison groups in quintiles using *t* tests and reported standardized differences remaining in the baseline covariates after reweighting, along with adjusted covariate values. To estimate the average treatment effect of the SSIB and ERAS interventions, we used inverse proportional weighting with weighted comparisons between pre-ERAS/pre-SSIB v. post-ERAS/pre-SSIB, post-ERAS/pre-SSIB v. post-ERAS/post-SSIB, and pre-ERAS/pre-SSIB v. post-ERAS/post-SSIB. The level of significance for all statistical tests was set at $p < 0.05$. All analyses were conducted in Stata/SE version 15 (StataCorp).

Results

Patient characteristics

There were 368 patients in this study, 94 in the control group, 95 in the post-SSIB/pre-ERAS group and 179 in the post-SSIB/post-ERAS group. The cohorts were balanced for sex, body mass index, American Society of Anesthesiologists classification, diabetes, chronic obstructive pulmonary disease, smoking status, functional status and preoperative chemotherapy (Table 1). However, statistically significant differences were observed for median age (control group 73 yr, post-SSIB/pre-ERAS group 68 yr, post-SSIB/post-ERAS group 70 yr, p = 0.049), laparoscopic procedure (80.9%, 91.6% and 93.3%, respectively, p = 0.007) and clean/contaminated wound classification (67.0%, 84.2% and 84.4%, respectively, p = 0.008).

After application of inverse proportional weighting, all baseline patient characteristics used in the propensity score model were balanced in all groups (Table 2).

Postoperative outcomes

Significant decreases were observed in the unadjusted values for mean length of stay (control group 9.0 d, post-SSIB/pre-ERAS group 6.4 d and post-SSIB/post-ERAS group 5.2 d, p = 0.01) and median length of stay (5 d, 3 d and 3 d, respectively, p < 0.001). There were also significant decreases in the overall rates of wound infection (16.0%, 9.5% and 5.0%, respectively, p = 0.01), superficial surgical site infection (8.5%, 4.2% and 0.6%, respectively, p = 0.001) and urinary tract infection (4.3%, 0.0% and 0.6%, respectively, p = 0.02) (Table 3).

After application of inverse proportional weighting, decreases in length of stay and rates of wound complications including superficial and organ space infections and urinary tract infections were observed after implementation of the SSIB pathway; however, only the change in the urinary tract infection rate was statistically significant (p = 0.04) (Table 4). Introduction of the ERAS pathway continued to demonstrate similar clinically relevant trends, without statistical significance. Comparison between the control group and the post-SSIB/post-ERAS group showed significant decreases in mean length of stay (7.6 d v. 5.5 d, p = 0.04) and the rate of overall wound complications (14.7% v. 6.5%, p = 0.049) and superficial surgical site infections (8.2% v. 1.8%, p = 0.047). Although not statistically significant, a trend of decreasing organ space surgical site infection was also observed (7.3% v. 4.7%, p = 0.4).

Perioperative pathway compliance

Target rates of compliance of at least 80% were achieved for 9 of the 18 components of the SSIB, although analysis of trends over time illustrated consistent improvement in compliance. Target rates of compliance were achieved for 11 of the 18 ERAS components (Table 5).

Discussion

Evidence-based quality-improvement pathways were implemented sequentially in a community hospital to evaluate the impact on outcomes in patients undergoing colorectal surgery. When introduced effectively, these types of quality-improvement initiatives can lead to improvements in patient outcomes.[3–5,7,10] In the unadjusted analyses, the sequential implementation of the ERAS and SSIB initiatives had a significant cumulative impact on overall length of stay and wound complication rates. These findings are consistent with those of the only other study we are aware of in which similar objectives were investigated.[3]

In the adjusted analyses, the implementation of SSIB resulted in marginal, nonsignificant reductions in a number of outcomes, including length of stay, superficial surgical site infections, organ space surgical site infections and urinary tract infections. Subsequent implementation of ERAS appears to have supplemented the improvements in the same outcomes shown in the SSIB-alone cohort, with the added benefit of reduced rates of septic shock. Comparison of the pre- and postintervention groups showed that patient length of stay was significantly reduced, and overall wound complication rates were significantly lower. Subgroup analysis showed that the lower wound complication rates were mainly due to reduction of the rates of superficial surgical site infections. Although there was a trend only toward lower urinary tract infection rates, the control group had low rates of this complication, which may have been secondary to previous quality-improvement efforts at our site to address this specific outcome. Similarly, there were no cases of postoperative deep venous thrombosis or pulmonary embolism, and high levels of adherence to

Table 1. Characteristics of patients who underwent colorectal procedures stratified by implementation date of the Surgical Site Infection Bundle and Enhanced Recovery After Surgery care pathways

Characteristic	Group; no. (%) of patients* Pre-SSIB/pre-ERAS n = 94	Post-SSIB/pre-ERAS n = 95	Post-SSIB/post-ERAS n = 179	p value
Age, yr, median (Q1, Q3)	73 (64, 80)	68 (60, 75)	70 (61, 77)	0.049
Body mass index, median (Q1, Q3)†	28 (24, 31)	27 (24, 31)	27 (24, 31)	0.9
Age, yr, mean ± SD	71.2 ± 11.7)	66.8 ± 12.7	68.7 ± 11.9	0.04
Sex				0.6
Male	38 (40.4)	42 (44.2)	83 (46.4)	
Female	56 (59.6)	53 (55.8)	96 (53.6)	
American Society of Anesthesiologists class				0.09
1–2	33 (35.1)	46 (48.4)	86 (48.0)	
3–4	61 (64.9)	49 (51.6)	93 (52.0)	
Wound classification				0.008
Clean/contaminated	63 (67.0)	80 (84.2)	151 (84.4)	
Contaminated	19 (20.2)	10 (10.5)	20 (11.2)	
Dirty/infected	12 (12.8)	5 (5.3)	8 (4.5)	
Laparoscopic procedure				0.007
Yes	76 (80.8)	87 (91.6)	167 (93.3)	
No	18 (19.1)	8 (8.4)	12 (6.7)	
Diabetes				0.4
Yes	12 (12.8)	9 (9.5)	28 (15.6)	
No	82 (87.2)	86 (90.5)	151 (84.4)	
Chronic obstructive pulmonary disease				0.7
Yes	8 (8.5)	6 (6.3)	17 (9.5)	
No	86 (91.5)	89 (93.7)	162 (90.5)	
Smoker				0.4
Yes	22 (23.4)	15 (15.8)	40 (22.3)	
No	72 (76.6)	80 (84.2)	139 (77.6)	
Functional status				0.06
Independent	93 (98.9)	89 (93.7)	176 (98.3)	
Partially/totally dependent	1 (1.1)	6 (6.3)	3 (1.7)	
Chemotherapy				0.6
Yes	6 (6.4)	4 (4.2)	8 (4.5)	
No	88 (93.6)	89 (93.7)	156 (87.2)	
Missing	0 (0.0)	2 (2.1)	15 (8.4)	

Q1 = quartile 1 (lowest); Q3 = quartile 3; SD = standard deviation.
*Except where noted otherwise.
†Data missing for 7 patients.

Table 2. Cohort characteristics after inverse proportional weighting

	% of patients*				% of patients*				% of patients*			
Characteristic	Pre-SSIB/ pre-ERAS	Post-SSIB/ pre-ERAS	Std. Δ, %†	*p* value	Post-SSIB/ pre-ERAS	Post-SSIB/ post- ERAS	Std. Δ, %†	*p* value	Pre-SSIB/ pre-ERAS	Post-SSIB/ post-ERAS	Std. Δ, %†	*p* value
Age, yr, mean ± SD	69.5 ± 1.4	71.2 ± 1.3	6.0	0.7	68.5 ± 1.2	67.9 ± 1.0	1.3	0.9	70.0 ± 1.3	70.6 ± 1.0	6.4	0.6
Body mass index, mean ± SD	27.9 ± 0.7	28.1 ± 0.7	2.4	0.9	28.2 ± 0.6	28.0 ± 0.4	0.4	1.0	28.2 ± 0.7	28.0 ± 0.4	7.2	0.6
Sex			0.2	1.0			5.8	0.8			1.4	0.9
Male	43.3	43.2			44.3	45.5			44.2	43.4		
Female	56.7	56.8			55.7	54.5			55.8	56.6		
American Society of Anesthesiologists class			10.7	1.0			0.8	1.0			4.8	0.7
1–2	40.5	40.0			48.5	48.5			43.7	41.0		
3–4	59.5	59.9			51.5	51.5			56.3	59.0		
Wound classification			15.5	0.9			0.9	1.0			14.7	0.9
Clean/ contaminated	77.0	75.2			84.8	84.7			77.6	76.3		
Contaminated	14.8	14.5			11.0	11.0			14.9	14.7		
Dirty/infected	8.2	10.3			4.2	4.3			7.5	9.0		
Laparoscopic procedure			9.7	0.8			0.7	0.9			11.2	0.7
Yes	87.1	85.4			93.0	92.7			89.2	87.4		
No	12.9	14.6			7.0	7.3			10.8	12.6		
Diabetes			3.0	0.9			3.3	0.8			1.9	0.8
Yes	10.6	10.1			14.8	13.6			14.4	13.3		
No	89.4	89.9			85.2	86.4			85.6	86.7		
Chronic obstructive pulmonary disease			0.3	1.0			9.2	0.5			10.9	0.2
Yes	7.1	7.2			7.1	9.4			7.1	11.7		
No	92.9	92.8			92.9	90.6			92.9	88.3		
Functional status			10.8	0.6			14.6	0.2			3.1	0.8
Independent	99.0	97.6			96.5	98.8			99.1	98.8		
Partially/totally dependent	1.0	1.2			3.5	1.2			0.9	1.2		
Chemotherapy			2.4	0.9			4.7	0.1			4.0	0.8
Yes	5.5	4.9			4.0	5.0			6.2	5.4		
No	94.5	95.1			96.0	95.0			93.8	94.6		

ERAS = Enhanced Recovery After Surgery; SD = standard deviation; SSIB = Surgical Site Infection Bundle; std. Δ = standard difference.
*Except where noted otherwise.
†Values less than 20% indicate negligible differences between groups for a particular covariate.

prophylaxis, which may have been due to preexisting initiatives to improve compliance with the introduction of order sets for venous thromboembolism prevention. Prolonged postoperative deep vein thrombosis prophylaxis was not routinely used for any of the patient groups.

Based on the adjusted outcomes, it appears that the addition of a second standardized protocol, ERAS, provided the most benefit to patients undergoing colorectal surgery. However, there was no cohort in which ERAS was the only quality-improvement initiative implemented. In the only other study that investigated the same initiatives implemented sequentially, ERAS was introduced before SSIB.[3] Results in that study mirror the trend observed in the current study of larger improvements after the introduction of a second quality-improvement initiative. It may be that sustained evidence-based quality-improvement efforts, rather than multiple protocols, lead to greater improvements in patient outcomes. However, our study cannot comment on the effectiveness of either protocol separately.

Although both standardized quality-improvement initiatives in the present study largely relied on existing quality-improvement infrastructure within our hospital, we recognize that the opportunity cost of implementing these protocols is potentially high. Implementing each protocol consumes finite resources. Future research may help teams decide which quality-improvement initiative to choose to implement to most improve outcomes.

Establishing sustainable quality-improvement projects can be challenging. These multicomponent programs are complex initiatives, and the development of strategies by key stakeholders to address the challenges with each pathway component is crucial. Our community site was able to achieve sustainability by hosting frequent meetings with key stakeholders to reinforce program objectives and

Table 3. Thirty-day postoperative outcomes

Outcome	Group; no. (%) of patients*			p value
	Pre-SSIB/pre-ERAS	Post-SSIB/pre-ERAS	Post-SSIB/post-ERAS	
Length of stay, d				
Median (Q1, Q3)	5 (4, 8)	3 (3, 7)	3 (2, 5)	< 0.001
Mean ± SD	9.0 ± 9.4	6.4 ± 9.1	5.2 ± 5.2	0.01
Death	3 (3.2)	1 (1.0)	3 (1.7)	0.5
Readmission	9 (9.6)	6 (6.3)	16 (8.9)	0.7
Unplanned reoperation	7 (7.4)	10 (10.5)	10 (5.6)	0.3
Wound infection	16 (17.0)	9 (9.5)	9 (5.0)	0.01
Superficial surgical site infection	8 (8.5)	4 (4.2)	1 (0.6)	0.001
Organ space surgical site infection	8 (8.5)	5 (5.3)	8 (4.5)	0.4
Wound disruption	1 (1.1)	1 (1.0)	2 (1.1)	1.0
Pneumonia	1 (1.1)	2 (2.1)	5 (2.8)	0.9
Unplanned intubation	2 (2.1)	1 (1.0)	6 (3.4)	0.5
Urinary tract infection	4 (4.2)	0 (0.0)	1 (0.6)	0.02
Stroke/ cerebrovascular accident	0 (0.0)	0 (0.0)	1 (0.6)	1.0
Cardiac arrest	0 (0.0)	0 (0.0)	3 (1.7)	0.4
Myocardial infarction	2 (2.1)	0 (0.0)	4 (2.2)	0.4
Blood transfusion	12 (12.8)	9 (9.5)	15 (8.4)	0.5
Sepsis	1 (1.1)	2 (2.1)	2 (1.1)	0.8
Septic shock	3 (3.2)	3 (3.2)	3 (1.7)	0.6

ERAS = Enhanced Recovery After Surgery; Q1 = quartile 1 (lowest); Q3 = quartile 3; SD = standard deviation; SSIB = Surgical Site Infection Bundle.

*Except where noted otherwise.

Table 4. Thirty-day postoperative outcomes after inverse proportional weighting

Outcome	% of patients*			% of patients*			% of patients*		
	Pre-SSIB/ pre-ERAS	Post-SSIB/ pre-ERAS	p value	Post-SSIB/ pre-ERAS	Post-SSIB/ post-ERAS	p value	Pre-SSIB/ pre-ERAS	Post-SSIB/ post-ERAS	p value
Length of stay, d, mean	7.9	6.4	0.3	6.1	5.2	0.3	7.6	5.5	0.04
Death	2.6	2.2	0.9	1.2	1.7	0.7	2.2	1.7	0.8
Readmission	9.4	6.8	0.5	5.8	8.8	0.3	9.8	9.3	0.9
Unplanned reoperation	6.2	10.9	0.2	9.7	5.5	0.2	5.7	5.7	1.0
Wound infection	14.2	11.4	0.6	8.9	5.1	0.2	14.7	6.5	0.049
Superficial surgical site infection	7.7	5.4	0.6	3.9	0.7	0.1	8.2	1.8	0.047
Organ space surgical site infection	7.4	6.1	0.7	4.9	4.4	0.8	7.3	4.7	0.4
Wound disruption	1.0	1.4	0.8	1.3	1.1	0.9	1.3	1.2	0.9
Pneumonia	0.8	4.4	0.2	2.6	2.8	0.9	0.9	3.4	0.1
Unplanned intubation	1.8	1.3	0.8	1.4	3.4	0.3	1.7	3.8	0.3
Urinary tract infection	3.3	0.0	0.04	0.0	0.0	1.0	3.0	0.5	0.1
Stroke/cerebrovascular accident	0.0	0.0	1.0	0.0	0.6	1.0	0.0	0.5	1.0
Cardiac arrest	0.0	0.0	1.0	0.0	1.6	1.0	0.0	1.7	1.0
Myocardial infarction	1.8	0.0	0.2	0.0	2.3	1.0	1.9	2.5	0.8
Blood transfusion	12.2	9.8	0.6	8.4	7.7	0.8	12.0	9.7	0.6
Sepsis	0.9	1.4	0.7	1.5	1.1	0.8	0.9	1.1	0.9
Septic shock	2.7	4.1	0.6	3.2	1.6	0.4	2.4	1.9	0.8

ERAS = Enhanced Recovery After Surgery; SSIB = Surgical Site Infection Bundle.

Table 5. Compliance with components of the perioperative care pathways

Pathway; component	Compliance rate, % Post-SSIB	Compliance rate, % Post-SSIB/ post-ERAS
Surgical Site Infection Bundle		
Preoperative		
Scrub	91	86
Appropriate hair removal	NR	NR
Appropriate antibiotic timing	47	92
Appropriate antibiotic	83	96
Blood glucose measurement	27	87
Bowel preparation	39	78
Intraoperative		
Isolation technique	76	86
Wound barrier	86	88
Antimicrobial sutures	86	88
Antibiotic redosing if case > 4 h	56	62
Temperature measurement	NR	NR
Warming	83	96
Blood glucose measurement	1	2
Postoperative		
Normothermia attained in postanesthesia recovery	93	80
High-flow oxygen for 1 h	2	66
Blood glucose measurement	23	76
Standardized wound care orders	45	NR
Dressing removed on postoperative day 2	37	NR
Enhanced Recovery After Surgery		
Preoperative		
Preadmission counselling	—	97
Both doses of carbohydrate drink administered	—	85
Venous thromboembolism prophylaxis	—	90
Prophylactic antibiotic 0–60 min before incision	—	93
Oral antibiotic therapy	—	80
Intraoperative		
Goal-directed fluid therapy	—	79
Multimodal pain management	—	79
Normothermia attained in postanesthesia recovery	—	93
Multimodal antiemetic therapy	—	80
No abdominal or pelvic drains	—	87
Postoperative		
Chewing gum by postoperative day 0 or 1	—	78
Clear fluids started by postoperative day 0 or 1	—	77
Intravenous fluid administration discontinued by postoperative day 0 or 1	—	13
Prophylactic antiemetic for 24 h	—	93
Mobilization by postoperative day 0 or 1	—	87
Mobilization 2 times per day by postoperative day 2	—	80
Eating solid food by postoperative day 2	—	38
Foley catheter removed by postoperative day 2	—	74

ERAS = Enhanced Recovery After Surgery; NR = not reported (reviewers were unable to collect compliance for these variables); SSIB = Surgical Site Infection Bundle.

identify areas for improvement. Information was disseminated by widely sharing quarterly reports, displaying posters in visible areas to motivate front-line providers and providing direct, real-time feedback to these providers. Appropriate system changes at each stage of the perioperative journey were introduced to improve compliance and knowledge translation. Finally, the patient must not be forgotten as a vital stakeholder. Engaging patients in their own care leads to greater effectiveness of project implementation. Our site developed initiatives including patient booklets and Web sites to help patients contribute to the sustainability and success of the quality-improvement initiative.

Limitations

There are several limitations to our study. Although the data were collected prospectively, the retrospective nature of the analysis may have introduced biases and may have led to the inability to collect missing data. The adjusted analyses, in which patient characteristics from the NSQIP database were used, attempted to account for differences in patient characteristics between the cohorts, as was found for wound classification and laparoscopic procedure. We did not expect inherent differences in these characteristics between these successive cohorts. The differences may have been due to the quality-improvement initiatives themselves. With the introduction of SSIB, there was a focus on several variables that may have affected wound classification, including use of a wound protector, isolation technique, efforts to minimize spillage during creation of the anastomosis, standardized use of bowel preparation with oral antibiotic therapy and education to help nurses/surgeons properly determine wound class. Similarly, increasing rates of laparoscopic surgery between the successive cohorts is in keeping with compliance with the 2 protocols' processes. The adjusted outcomes may therefore underestimate the effectiveness of the interventions, and the unadjusted outcomes may be a more useful measure of their effectiveness. However, we acknowledge that there may have been unmeasured confounding variables or other real differences between the cohorts that may have affected our results. Delivery of multicomponent quality-improvement programs has a learning curve. Therefore, sequentially introducing different programs may have led to better compliance with the second intervention as the stakeholders had an implementation strategy developed and the staff were accustomed to delivering complex care plans. Also, as greater attention is paid to relevant processes, documentation may become more accurate over time. This could cause the appearance of differences between cohorts that are not real. Finally, the sample size may have been too small for improvements in some outcomes to reach statistical significance.

Conclusion

Our findings show that sequential implementation of perioperative care pathways in colorectal surgery can lead to a cumulative improvement in patient outcomes. The absolute benefit attributable to either protocol separately is difficult to define. Unadjusted outcomes improved with sequential implementation of the quality-improvement protocols. Significant improvement in the adjusted primary outcomes of length of stay and wound complication rates was realized after implementation of ERAS. Our results show that community hospitals are able to effectively and successfully implement multiple complex perioperative quality-improvement pathways, with results comparable to those in large academic centres. Integrating these pathways can be resource and time intensive but can lead to substantial benefit for patients in terms of shorter length of stay and decreased morbidity rates.

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