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ORIGINAL ARTICLE

Colorectal surgery and surgical site infection: is a change of attitude necessary?

Manuela Elia-Guedea [1,2] · **Elena Cordoba-Diaz de Laspra** [1,2] · **Estibaliz Echazarreta-Gallego** [1,2] · **María Isabel Valero-Lazaro** [1] · **Jose Manuel Ramirez-Rodriguez** [1,2] · **Vicente Aguilella-Diago** [1,2]

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Abstract
Introduction Surgical site infection (SSI) can be as high as 30% in patients undergoing colorectal surgery and is associated with an increase in morbidity and mortality. The aim of this study is to evaluate the impact of a set of simple preventive measures that have resulted in a reduction in surgical site infection in colorectal surgery.
Applied method Prospective study with two groups of patients treated in the colorectal unit of the "Clinico Universitario Lozano Blesa" hospital in Zaragoza. One group was subject to our measures from February to May 2015. The control group was given conventional treatment within a time period of 3 months before the set of measures were implemented.
Results One hundred forty-nine patients underwent a major colorectal surgical procedure. Seventy (47%) belonged to the control group and were compared to the remaining 79 patients (53% of the total), who were subject to our treatment bundle in the period tested. Comparing the two groups revealed that our set of measures led to a general reduction in SSI (31.4 vs. 13.6%, $p = 0.010$) and in superficial site infection (17.1 vs. 2.5%, $p = 0.002$). As a consequence, the postoperative hospital stay was shortened (10.0 vs. 8.0 days, $p = 0.048$). However, it did not, the number of readmissions nor the re-operation rate. SSI was clearly related to open surgery.
Conclusions The preventive set of measures applied in colorectal surgery led to a significant reduction of the SSI and of the length of hospital stay.

Keywords Colorectal surgery · Bundle of measures · Risk factor

✉ Estibaliz Echazarreta-Gallego
esti.egallego@hotmail.com

[1] Colorectal Department, University Hospital of Zaragoza, San Juan Bosco Avenue, 15, 50009 Zaragoza, Spain

[2] Instituto de Investigaciones Sanitarias de Aragon (IIS), Zaragoza, Spain

Introduction

Surgical site infections (SSI) are still a challenge in hospitals worldwide. They represent 15–18% of all nosocomial infections and can reach 38% of postoperative infections acquired at hospital [1, 2]. SSIs require antibiotic treatments due to the mix of resistant microorganisms involved. These can lead to a longer hospitalization (average 8 days), a higher number of readmissions, and a rise in mortality and morbidity leading to a patient's perception of loss of quality of life, all of which result in an increase in health care costs [1, 3–6]. Colorectal surgery is associated with an incidence of SSIs four times higher than the one observed in other abdominal surgeries [1]. These higher rates of SSI in colorectal surgery have been mainly attributed to four factors: the type of surgery defined as clean-contaminated or contaminated [7], patients' median old age (over 65 years), the morbidity associated with colorectal surgical complications (postoperative hemorrhage, anastomotic leak, etc.), and the neoplasm being the main etiological cause of treatment. Despite the many studies performed, there is no clear consensus on the risk factors leading to SSI in major colorectal surgery, thus hindering the establishment of measures to reduce these factors.

The strategies defined to prevent surgical site infection (SSI) need to be geared towards reducing the risk of contamination and improving the patient's functional status prior to the surgical damage and to minimizing the risk of infection.

Defining a set of proven preventive measures against SSI, documenting, and following up on the results leads to improved surgical results. Keeping track of these measures with a follow-up checklist clearly reduces the rates of SSI [8]. Many colorectal surgical journals show that the packages or bundles of measures applied in daily practice can lead to an improvement in the prevention of SSIs [3, 6, 9].

The purpose of this study is to assess the impact of a simple bundle of preventive measures in the reduction of the SSI rate in colorectal surgery. The motivation for our work was to diminish our own rates of SSIs in the daily practice of our hospital unit.

Patients and methods

We performed a study comparing a prospective cohort of patients (bundle group) with a historical cohort group of patients undergoing elective colorectal surgery at a tertiary hospital from November 1, 2014 to May 31, 2015. All patients included in the study underwent elective colorectal surgery performed by a team of specialized colorectal surgeons. According to our documents, all patients followed the "Enhanced Recovery After Surgery" (ERAS) pathway. As an exception to ERAS programs—although currently under discussion—we carried out mechanical bowel preparation and oral antibiotic prophylaxis (1 g of neomycin and erythromycin 13, 14, and 23 h prior to the operation) in all patients assigned to a surgical procedure on the left colon, sigma, and rectum whenever colorectal anastomosis was going to be performed. The rest of the intraoperative ERAS criteria were applied (oxygen-therapy, glycemia control, fluid restriction, body temperature control, etc.).
Groups involved:

- Historical cohort: patients that had undergone colorectal surgery between November 1, 2014 and February 13, 2015 before the measures were implemented.
- Bundle cohort: patients operated on between February 14, 2015 and May 31, 2015, during which time the protocol was applied.

The trial was approved by the Patient Safety Group, the Mortality Commission, and the Surgical Commission of our hospital.

We first went through the main clinical practice guidelines and consulted the Infection and Antibiotic Commission of our hospital to evaluate the specific pathogens of our environment in order to better define the new measures.
We chose the following:

1. Proper antibiotic prophylaxis administration

   The antibiotics were chosen to match the specific microbial resistance of our environment. During anesthesia (routine) prophylaxis was conducted, with two intravenous grams of amoxicillin-clavulanate associated with 240 intravenous milligrams of gentamicin. We administered gentamicin due to the 17% rate of resistance of *Escherichia coli* to amoxicillin-clavulanate in our hospital environment.

   We ensured that a second dose of antibiotics (only amoxicillin-clavulanate) was applied during surgery whenever the operation took over 2 h and when there was an excessive loss of blood (more than 1000 mL) so as to ensure proper antimicrobial concentration. To prevent medication error, the anesthesiologist and his nurse were directly involved.
2. Change of location

   In order to achieve a fresher state of awareness and alertness from the whole surgical team, a change of the operating theater was recommended. The Colorectal Unit, which had been conducting the daily operations in theater number 5, was moved to a new operating theater (Operating Room 3). The change of location was geared towards securing an ongoing awareness regarding the new measures. Teams of specific anesthesiologists, nurses (instrumentalist, circulating nurse, anesthesia nurse), and assistants were defined.
3. Restriction of staff transit in the operating room

   We regulated the movement of personnel, introducing the following measures:

   - Limiting the access of medical and nursing students to the operating theater as well as that of pharmaceutical suppliers.
   - Reminding staff of the importance of the planned flow of movement within the operating room (entries and exits)—encouraging the correct use of the clean hallway (for entrances) and the dirty one (for exit), emphasizing the importance of appropriate clothing(correctly wearing masks, hats, etc.), and keeping the doors of the operating room closed during the complete surgical procedure.

4. Training sessions:

   Information and training sessions (briefing) were proposed for surgical nurses and hospital staff to help the raise awareness of the issues to all personnel involved.

   - In the operating room—the aseptic handling of wounds after the manipulation of the colon was to be strictly enforced, i.e., changing the dirty dressings, gloves, surgical tools, and thus minimalizing the risk of infection.
   - At the hospital ward—the importance of proper wound care and handling of catheters as well as their documentation was stressed.

5. Clinical sessions in colorectal unit
   All surgeons of the colorectal unit were informed about the detected problems and instructed on the measures to be implemented.

We collected and analyzed demographic, clinical, epidemiological variables, and those related to the operation and to the implementation of the new measures. We compared SSIs, as defined by the CDC criteria, for superficial, deep and organ space infection, and pre- and post-implementation of the set of measures.

Statistical analysis

Data was anonymized, and identifying fields were removed prior to analysis. The qualitative variables were compared using the chi-squared test and the Fisher exact test. The quantitative variables between two independent groups were compared using the Student *t*-test and the Mann-Whitney *U* test following normal distribution. The normality of the variables was verified with the Kolmogorov-Smirnov test. The *p* value <0.05 was defined as the level of statistical significance.

Table 1 Demographic data for both groups

Characteristics	Total (*n* = 149)	Control pre-bundle (*n* = 70) 47%	Experimental post-bundle (*n* = 79) 53%	*p*
	Median (IQR)	Median (IQR)	Median (IQR)	
Age, years	69.0 (60.5–78.0)	70.5 (59.5–79.0)	68.0 (61.0–76.0)	0.445
	Median (SD)	Median (SD)	Median (SD)	
BMI, kg/m2	27.2 (4.6)	26.3 (4.5)	28.0 (4.5)	0.032
	n (%)	*n* (%)	*n* (%)	
Male	98 (65.8)	46 (65.7)	52 (65.8)	0.989
Comorbidity	125 (83.9)	63 (90.0)	62 (78.5)	0.056
ASA score (physical status)				0.252
I–II	84 (56.4)	36 (51.4)	48 (60.8)	
III–IV	65 (43.6)	34 (48.6)	31 (39.2)	
SENIC risk factors				0.015
1	32 (21.5)	14 (20.0)	18 (22.8)	
2	69 (46.3)	29 (41.4)	40 (50.6)	
3	36 (24.2)	16 (22.9)	20 (25.3)	
4	12 (8.1)	11 (15.7)	1 (1.3)	
Previous abdominal operations	65 (43.9)	30 (43.5)	35 (44.3)	0.920
Diabetes mellitus	28 (18.8)	14 (20.0)	14 (17.7)	0.722
HTA	88 (59.1)	42 (60.0)	46 (58.2)	0.826
Chronic obstructive pulmonary disease	24 (16.1)	12 (17.1)	12 (15.2)	0.746
Ischemic heart disease	10 (6.7)	4 (5.7)	6 (7.6)	0.750
Cardiac insufficiency	6 (4.0)	4 (5.7)	2 (2.5)	0.420
Dyslipidemia	50 (33.6)	23 (32.9)	27 (34.2)	0.865
Asthma	4 (2.7)	1 (1.4)	3 (3.8)	0.623
ACxFA	15 (10.1)	9 (12.9)	6 (7.6)	0.287
Renal insufficiency	5 (3.4)	4 (5.7)	1 (1.3)	0.187
Smokers	29 (19.5)	18 (25.7)	11 (13.9)	0.070
Steroid use	6 (4.1)	4 (5.7)	2 (2.5)	0.420
Chemotherapy in last 3 months	19 (12.7)	10 (14.3)	9 (11.4)	0.597
Radiotherapy in last 3 months	16 (10.7)	6 (8.6)	10 (12.7)	0.421
Preoperative transfusion	8 (5.7)	6 (8.7)	2 (2.5)	0.146
Etiology				0.139
Neoplasia	104 (69.8)	53 (75.7)	51 (64.6)	
No neoplasia	45 (30.2)	17 (24.3)	28 (35.4)	

ACxFA cardiac arrhythmia due to atrial fibrillation, *HTA* arteria hypertension, *BMI* body mass índex, *IQR* interquartile range, *SD* standard deviation

Statistical analyses were performed using SPSS 23.0 version for Windows (SPSS, Inc., Chicago, IL).

Results

During the time period covered by our study, 149 patients were operated on at the Colorectal Unit of our hospital. We defined two groups: the first one with 70 patients (47%) that underwent a major colorectal surgical procedure prior to the application of a bundle of preventive measures and the second group with 79 patients (53%) operated on after the set of measures had been applied. A descriptive study of the main variables of both groups is shown in Tables 1 and 2.

Table 3 shows the complication rate and other variables related to the postoperative period. Hospital stay was longer for the pre-bundle group (10.0 vs. 8.0 days, $p = 0.048$), which also had a higher incidence of postoperative complications (57.1 vs. 34.2%, $p = 0.005$) and a significantly higher number of patients with SSIs (31.4 vs. 13.6%, $p = 0.010$). We observed an important reduction in surgical incisional site infection in the group which was submitted to the bundle of measures (17.1 vs. 2.5%, $p = 0.002$). No significant differences were registered for other complications, for the readmission, nor the reoperation rate between both groups of patients. Table 4 details the symptomatology of organ space complication in our study. The global result is not the sum of the different values. Postoperative complication is something dynamic in its development, and its solution depends on an early diagnosis and on the range of different possible treatments.

Table 5 shows the results of the different variables analyzed in relation to the rate of SSIs, and Table 6 reports the rate of postoperative antibiotic administration. Finally, Table 7 represents SSI in relation to the surgical procedure (open or laparoscopic approach) before and after applying the set of measures.

Discussion

The high level of SSI in our Colorectal Unit was the decisive factor in setting up a set of measures aimed at lowering the risk of infection and improving the care and safety of the patients.

We present the results obtained after introducing a simple bundle of measures and their effect in the reduction of SSI in our Colorectal Surgical Unit. Their implementation has led to a reduction in the overall level of SSI from 31.4 to 13.6% in patients surgically treated. This reduction has been particularly pronounced in superficial site infection with decreasing values of 17.1 to 2.5%.

Table 2 Characteristics related to the surgery procedure in both groups of patients

Characteristics	Total (n = 149)	Control pre-bundle (n = 70) 47%	Experimental post-bundle (n = 79) 53%	p
	Median (SD)	Median (SD)	Median (SD)	
Operative duration in minutes	144.5 (57.0)	144.0 (56.3)	145.0 (58.0)	0.915
	n (%)	n (%)	n (%)	
Preoperative sistemic Atb administration				
Amoxicillin-clavulanate	101 (67.8)	34 (48.6)		
Amoxicillin-clavulanate + Gentamicin Metronidazol + Gentamicin	40 (26.8)	33 (47.1)	67 (84.8) 7 (8.9)	*<0.001**
Others	8 (5.4)	3 (4.3)	5 (6.3)	
Preoperative oral Atb administration				*<0.001**
Neomycin + Erythromycin	34 (22.8)	4 (5.7)	30 (38.0)	
Wound class				0.160
Clean-contaminated	101 (67.8)	42 (60.0)	59 (74.7)	
Contaminated	36 (24.2)	21 (30.0)	15 (19.0)	
Infected	12 (8.1)	7 (10.0)	5 (6.3)	
Surgical approach				0.053
Open	79 (53.0)	43 (61.4)	36 (45.6)	
Laparoscopic	70 (47.0)	27 (38.6)	43 (54.4)	
Surgical procedure				0.010
Right hemicolectomy	50 (33.6)	30 (42.9)	20 (25.3)	
Left hemicolectomy	93 (62.4)	40 (57.1)	53 (67.1)	
Subtotal colectomy	6 (4.0)	0 (0.0)	6 (7.6)	

Atb antibiotic, *SD* standard deviation

*A p value <0.05 was considered

Table 3 Postsurgical complications and related variables obtained by comparing both groups

	Total (n = 149)	Control pre-bundle (n = 70)	Experimental post-bundle (n = 79)	p
	Median (IQR)	Median (IQR)	Median (IQR)	
Hospital stay, days	9.0 (6.0–13.00)	10.0 (7.0–15.0)	8.0 (6.0–11.3)	0.048
	n (%)	n (%)	n (%)	
Postoperative antibiotics	81 (54.4)	37 (52.9)	44 (55.7)	0.728
Complications <30 days	67 (45.0)	40 (57.1)	27 (34.2)	*0.005**
Clavien-Dindo				*0.014**
Minor (I–II)	46 (30.9)	29 (41.4)	17 (21.5)	
Mayor (III–IV–V)	21 (14.1)	11 (15.7)	10 (12.7)	
Global SSI	33 (22.1)	22 (31.4)	11 (13.9)	*0.010**
Superficial	14 (9.4)	12 (17.1)	2 (2.5)	*0.002**
Deep	4 (2.7)	1 (1.4)	3 (3.8)	0.623
Organ space[a]	15 (10.1)	9 (12.9)	6 (7.3)	0.287
Postoperative ileus	21 (14.1)	12 (17.1)	9 (11.4)	0.314
T >38 °C	17 (11.4)	9 (12.9)	8 (10.1)	0.601
Hemorrhage	9 (6.0)	4 (5.7)	5 (6.3)	1000
ACxFA	1 (0.7)	1 (1.4)	0 (0.0)	0.470
Cardiac insufficiency	4 (2.7)	3 (4.3)	1 (1.3)	0.342
Pulmonar insufficiency	1 (0.7)	1 (1.4)	0 (0.0)	0,470
Progressive renal insufficiency	2 (1.3)	2 (2.9)	0 (0.0)	0.219
Urinary tract infection	3 (2.0)	3 (4.3)	0 (0.0)	0.101
Other complications	11 (7.3)	7 (10.0)	4 (5.1)	0.250
Readmission <30 days	12 (8.1)	6 (8.6)	6 (7.6)	0.827
Reoperation < 30 days	20 (13.4)	10 (14.3)	10 (12.7)	0.771
Exitus	2 (1.3)	1 (1.4)	1 (1.3)	1000

ACxFA cardiac arrhythmia due to atrial fibrillation, *SD* standar desviacion, *SSI* surgical site infection, *IQR* interquartile range

*A p value < 0.05 was considered

[a] Table 4 (detailed organ space SSI complications)

Although we had a high incidence of SSI prior to the introduction of these measures, their effect has been similar to that observed in other studies such as the one described by Connolly et al. [10] who reported a decrease in SSI from 32.2 to 19.0% or Perez-Blanco's editorial [9], who achieved a reduction from 27.5 to 16.9%.These results encouraged us to affirm the necessity and interest in establishing this project and formalizing its application in our field.

On the other hand, patient's features and morbidity associated to surgical procedures have not shown any relationship to the incidence of SSIs. Factors such as diabetes mellitus, obesity (considering BMI >25), anesthetic risk according to the scale of the American Society of Anesthesiologists higher than III, or smoking had no statistical significance in either of the groups of patients studied, as opposed to other papers' findings, like those of Hennessey [1], Mallol et al. [11], Biondo [6], Owens et al. [2], or Park [12]. We have seen a significant decrease in the incidence of SSIs in patients undergoing laparoscopic surgery as Park describes in his article [12], whereas factors such as time, the length of the operation, and the use—or not—of drainages were of no relevance. Although we did not find a significant increase in SSIs in

Table 4 Detailed description of our organ space SSI complications

	Total n (%)	Control pre-bundle n (%)	Experimental post-bundle n (%)	p
Abscess	7 (4.7)	5 (7.1)	2 (2.5)	0.254
Anastomotic leakage	10 (6.7)	6 (8.6)	4 (5.1)	0.517
Local peritonitis due to anastomotic leakage	7 (4.7)	4 (5.7)	3 (3.8)	0.707

Table 5 SSI development and its relation to different variables

	Total *n* (%)	No SSI *n* (%)	SSI *n* (%)	*p*
Age				0.373
<65	55 (36.9)	45 (38.8)	10 (30.3)	
>65	94 (63.1)	71 (61.2)	23 (69.7)	
Sex				0.074
Male	98 (65.8)	7 (62.1)	26 (78.8)	
Female	51 (34.2)	44 (37.9)	7 (21.2)	
BMI				0.931
25–29.99	60 (45.8)	46 (45.1)	14 (48.3)	
>30	35 (26.7)	28 (27.5)	7 (24.1)	
ASA score				0.266
I	8 (5.4)	6 (5.2)	2 (6.1)	
II	76 (51.0)	63 (54.3)	13 (39.4)	
III	54 (36.2)	41 (35.3)	13 (39.4)	
IV	11 (7.4)	6 (5.2)	5 (15.2)	
SENIC risk factors				0.391
1	32 (21.5)	26 (22.4)	6 (18.2)	
2	69 (46.3)	55 (47.4)	14 (42.4)	
3	36 (24.2)	28 (24.1)	8 (24.2)	
4	12 (8.1)	7 (6.0)	5 (15.2)	
DM	28 (18.8)	24 (20.7)	4 (12.1)	0.266
Smokers	29 (19.5)	19 (16.4)	10 (30.3)	0.075
Immunosuppression risk	29 (19.5)	25 (21.6)	4 (12.1)	0.227
Surgical approach				0.030
Open	79 (53.0)	56 (48.3)	23 (69.7)	
Laparoscopic	70 (47.0)	60 (51.7)	10 (30.3)	
Operative duration	29 (19.5)			0.988
<180 min	104 (69.8)	81 (69.8)	23 (69.7)	
≥180 min	45 (30.2)	35 (30.2)	10 (30.3)	
Etiology				0.398
Neoplasia	104 (69.8)	79 (68.1)	25 (75.8)	
Others	45 (30.2)	37 (31.9)	8 (4.2)	
Wound class				0.846
Clean-contaminated	101 (67.8)	80 (69.0)	21 (63.6)	
Contaminated	36 (24.2)	27 (23.3)	9 (27.3)	
Infected	12 (8.1)	9 (7.8)	3 (9.1)	
Drains	131 (87.9)	101 (87.1)	30 (90.9)	0.764
Preoperative antibiotic				
Amoxicillin–clavulanate + Gentamicin	101 (67.8)	78 (67.2)	23 (69.7)	0.790
Postoperative antibotic	81 (54.4)	52 (44.8)	29 (87.9)	*<0.001**
	Median (IQR)	Median (IQR)	Median (IQR)	
Hospital stay, days	9.0 (6.0–13.00)	8.0 (6.0–11.0)	16.0 (9.25–23.25)	*<0.001**

ASA American Society of Anesthesiologists, *DM* diabetes mellitus, *BMI* body mass índex, *SSI* surgical site infection, *IQR* interquartile range

* A *p* value < 0.05 was considered

surgical procedures longer than 180 min, this factor is considered by authors such as Park [12] as one of the most important risk causes in the development of SSI, so much so that it is viewed as an independent factor altogether. We agree with other authors in considering that the most important factors in the incidence of SSIs are those associated with the patient's characteristics, bearing in mind that those related to the quality of surgical technique, such as excessive tissue trauma and/or bleeding, poor hemostasis, and spills through an accidental visceral opening, are essential to minimize the risk of SSI.

Another point to consider is the effectiveness of preoperative mechanical bowel preparation (MBP) with oral antibiotics (OA) in minimizing SSI by reducing colonic bacteria load and exposure to infectious material during bowel anastomosis. Although there is no consensus on the MBP alone, recent studies like the one published by Kim et al. [13] and Scarborough et al. [14] suggest that the combined preoperative bowel preparation (MBP + OA) is associated with a significant reduction in incisional SSI rates. As the studies described above suggest, we consider it appropriate to include routine combined bowel preparation (MBP and OA) as standard care for patients undergoing elective segmental left colorectal surgery. In our view, it should ideally be integrated into the hospital "best practice" model.

After analyzing our data, we were surprised by the high number of patients treated with antibiotics beyond the prophylactic regimen (of max. 24 h). Some cases were justified by an infectious process during the postoperative period (43.2%), but in a considerable number of cases we identified an unjustified prolonged antibiotic pattern (40.7%), although a part of this percentage includes the surgeon's discretion motivated by a technical transgression during the surgical procedure. Table 6 shows postoperative antibiotic administration. This observation led us to fortify our protocols, monitoring their enforcement and to implement a range of improvements. Thus, we created a multidisciplinary group of specialists whose aim is the optimization of antibiotics administration (Proa Group)—establishing a proper control system of antibiotic therapy, shortening the antibiotics administration to three maximum 5 days depending on the clinical response, lowering the risk of antimicrobial resistance, and currently focusing on de-escalating or short-course antimicrobial therapy for intraabdominal infection. Additionally, we started making electronic prescriptions with the computer system "Farmatools" which helps to determine the adequate dosage and duration (end date of treatment and dosage adjusted to weight and renal function) for the prescribed antimicrobial therapies.

Having said that, it is crucial to study how to influence the surgical procedure through training and specialization, but also in encouraging the team to employ the laparoscopic approach, since it can lead to a 10% reduction in SSI as in Hennessey's group study [1], and it can have statistical significance as shown by Huttner [15].

Table 6 Postoperative antibiotic administration

	Total *n* (%)
Prophylaxis (includes 24 h prolonged prophylaxis)	13 (16.04)
SSI (deep or organ-space)	25 (30.86)
Other infection: urinary tract, pneumonia	10 (12.35)
Not well specified	33 (40.74)

Table 7 SSI development and its relation with surgical approach

	Total *n* (%)	No SSI *n* (%)	SSI *n* (%)	*p*
Open approach				0.217
Pre-bundle	43 (54.4)	28 (50)	15 (65.2)	
Post-bundle	36 (45.6)	28 (50)	8 (34.8)	
Laparoscopic approach				0.027
Pre-bundle	27 (38.6)	20 (33.3)	7 (70)	
Post-bundle	43 (61.4)	40 (66.7)	3 (30)	

Our results when analyzing SSI in relation to the surgical procedure showed the reduction of SSIs reaching statistical significance in the laparoscopic subgroup as shown in Table 7. The data shows that laparoscopic surgical approach leads to a lower risk of SSI. Though it is an important factor in reducing superficial SSI, in our opinion it cannot be considered the only measure of influence. We believe that the surgical approach has had little influence on the incidence of postoperative organ/space SSI or anastomotic leakage, which instead has depended mainly on the quality of the surgical technique (minimizing tissue trauma, tension-free anastomosis, adequate hemostasis, etc.).

Having considered all the variables described, we designed a simple and inexpensive set of measures aimed at reducing SSIs. The implementation of the measures showed a decrease in hospital stay of 2 days (from 10.0 to 8.0 days). We consider this factor very important and share Owens et al.'s [2] view that it influences the processes' cost directly as well as indirectly. A longer hospitalization consumes more health resources, and it also reduces the patients' and their families' productivity due to the required family's care of the patient until he reaches complete recovery.

Similarly, the reduction of SSIs meant a reduction in the incidence of postoperative complications of our patients from 57.1 to 34.2%, leading to a further decrease in hospitalization costs. Other studies like the Born and Keenan's article [3] or Tanner's meta-analysis [16] have shown that implementing a set of measures not only reduces SSI but also lowers hospital cost.

All measures defined in the bundle are simple measures, easy to apply with no added cost to the patient (e.g. changing the surgical drapes, the gloves, and tools), thus cost-efficient. We would recommend a comprehensive analysis of the cost factor [17] to better assess this.

The success of these measures relies on informing the surgeons about the problems arising from SSI, on good teamwork, communication, and a united stance from all personnel involved in the surgical procedure. Several publications have proven that making surgeons aware of the results of their operations can significantly reduce SSI rates [18]. We therefore consider it mandatory to hold regular briefing sessions and routine communication meetings geared towards encouraging a united attitude from all employees. We found it quite remarkable that all patients subject to our set of measures received a second antibiotic dose 2 h after beginning of the operation. Further studies analyzing the different measures individually would be advantageous to find out which ones have the greatest impact in preventing the occurrence of SSIs.

We cannot ignore that there are other studies whose authors have not observed a reduction in SSI rates after applying similar measures, like Mallol [11] or Ghuman [17] who recorded a SSI rate of 25.2% in the pre-protocol group and of 26.6% in the post-protocol group ($p = 0.820$), or Tanner [16] who described an incidence of SSI in the pre-and post-protocol group of 24.0 and 28.0%, respectively. However, they all agree that these measures are necessary, easy to apply, and that they undoubtedly contribute to improve the safety of surgical patients. Regardless of the measures contained in each of the studies discussed above, including ours, (e.g. keeping a strict control of body temperature, blood loss, the glycemia parameters, an adequate oxygenation, proper water balance, etc.), we stressed the importance of maintaining everybody's awareness focused on a common goal in order to reduce SSIs through active teamwork.

Our study has several limitations. First of all, all patients were undergoing elective colorectal surgery, all of them in one single hospital. It would be interesting to see whether the implementation of this set of measures could be useful and transferable to other situations such as emergency surgery, different hospitals, or other health communities.

We believe that our results prove the value of the measures implemented as a tool for quality improvement in the care of patients undergoing colorectal surgery.

Although each single measure could improve the rate of SSIs to a different degree, we deem it essential to underscore how crucial it is that the entire team be actively involved in implementing the new measures, as well as maintaining the staff's engagement and avoiding disaffection or laxity among the personnel involved in the process. Continuous encouragement and systematically promoting a high sense of alertness of all those involved is probably the best recipe for optimum results.

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