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An Examination of Additional Medical Costs Due to Postoperative Infections in Colorectal Surgical Patients Using Administrative Profiling Data

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We performed a retrospective study using 161 colorectal surgical patients to explore the additional medical costs due to postoperative infections. Patients were divided into two groups based on antimicrobial drug use duration: the control group included 112 patients with standard antimicrobial prophylaxis use, and the case group included 49 patients with additional antimicrobial drug use (indicating postoperative infection). The case group had additional medical costs of US$7,993 (95% CI: 5,481-10,506) and hospital stay of 24.8 days (95% CI: 17.5-32.2). Factors significantly associated with postoperative infections were preoperative physical status scores of 3 or higher (OR: 3.447, 95%CI: 1.127-10.546), preoperative ileus (OR 6.618, 95%CI: 2.491-17.579), hypertension (OR: 2.140, 95%CI: 1.082-4.232), contaminated surgery (OR: 11.784, 95%CI: 3.151-44.066), open surgery (OR: 2.111, 95%CI: 1.065-4.187), and operative duration exceeding 400 minutes (OR: 2.465, 95%CI: 1.111-5.471). These findings suggest that hospital administrators should take appropriate measures to prevent postoperative infections in surgical inpatients.

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INTRODUCTION

Since 2002, Japan's national universities have been obligated to operate as independent administrative corporations as part of administrative reform. The affiliated national university hospitals are also deeply influenced by this transformation, and have been required to improve their efficiency from a health care economics standpoint. As a result, it has become important for hospital administrators to elucidate the additional medical costs (AMC) associated with postoperative infections in order to improve patient outcomes and reduce unnecessary costs.

Although cost-effectiveness analyses in the field of infection control can raise controversies, the results of these analyses can help to inform the decision-making process when developing and implementing infection control measures. However, there is a lack of cost-of-illness studies, which are integral components of cost-effectiveness analyses, conducted in Japan [1-3].

Numerous studies have been conducted on postoperative infections in colorectal surgical patients in the United States and the United Kingdom [4-

8]. When postoperative infectious diseases such as surgical site infections (SSIs) occur, patients are subjected to heavier physical, spiritual, and economic burdens. SSIs have been shown to increase the length of hospital stay (LOS) by 6-14 days and hospitalization charges by approximately US$2,600-18,000. In contrast, few studies have addressed the costs associated with these infections in Japan. Ogino *et al*. reported that the average LOS was prolonged by six days and post-surgical costs were increased by US$1,400 per patient for SSI cases relative to non-SSI cases [9]. Kashimura *et al*. reported that the average LOS for SSI cases after colorectal surgery was prolonged by 17.8 days, and the average medical costs were increased by US$5,938 [10].

The use of antimicrobial prophylaxis (AMP) has been shown to be effective in reducing the rate of postoperative wound infections for a number of different operative procedures [11, 12]. Such infections account for substantial morbidity and mortality within hospitals, as well as incur higher hospitalization charges [13, 14]. A survey conducted in 1994 by the Japanese Society of Gastroenterological Surgery on its member hospitals demonstrated the prevalence of excessive prophylaxis durations, with the recommended pre-incisional antibiotic administration performed by only one-third of the hospitals surveyed [15]. In 2008, the Guidelines Committee for Clinical Studies on Prophylactic Antimicrobial Drugs for Postoperative Infections and the Japanese Society of Chemotherapy published guidelines that allowed for AMP to be continued for up to 4 days after an operation, while simultaneously demonstrating how to conduct a clinical research on AMP [16].

In this study, we conducted an analysis of surgical patients with colorectal malignancies at a Japanese university hospital to verify if surgeons used AMP drugs in concordance with current guidelines, and analyzed administrative claims data to explore the relationships between AMC, AMP agent use, and factors associated with postoperative infections.

METHODS

This study was approved by the Institutional Review Board of the Faculty of Medicine, Shimane University.

Shimane University Hospital

Shimane University Hospital (SUH) is affiliated with the Faculty of Medicine, Shimane University and a tertiary care referral center in Shimane Prefecture, Japan. SUH contains 600 beds (including 40 psychiatric care beds), and serves approximately 10,000 inpatients per year, 1,500 outpatients per day, and 183,000 patient-days with an average LOS duration of approximately 18.0 days between 2007 and 2009.

Study subjects

We obtained data from 220 surgical patients with colorectal malignancies who had been admitted to SUH between FY2007 and FY2009. We excluded 59 patients who had undergone chemotherapy treatments at the Department of Digestive and General Surgery in SUH, leaving a final sample of 161 patients for analysis.

This study was then conducted according to the following process.

1) We classified the 161 patients into two groups based on postoperative infection status: the case group and the control group. Patients in the case group were identified as those who were treated with AMP for durations beginning on the day of surgery that extended beyond the third postoperative day and/or those who were re-administered with antimicrobials once again after the initial AMP duration; these patients were determined to have postoperative infections. Patients in the control group were those who were given AMP from the day of surgery until or before the third postoperative day. By employing these criteria, we identified 49 case patients and 112 control patients.

When taking surgical sites and procedures into account, target patients were further classified into the following four groups: laparoscopic colectomy (LC), open colectomy (OC), laparoscopic proctectomy (LP; including rectal resection and amputation using laparoscopy), and open proctectomy (OP; including open rectal resection and amputation). The control group included 63 LC, 27 OC, 12 LP, and 10 OP patients; the case group included 13 LC, 21 OC, 11 LP, and 4 OP patients.

2) Using the hospital's electronic health record system, we investigated the clinical services ordered for

the patients in the case and control groups; these services included laboratory examination services, surgery/procedure services, injection services, and diagnostic imaging services.

3) To identify the clinical services actually provided to the patients, we compared medical fees for each clinical service collected from administrative claims data with the aforementioned electronic health record data.

4) Total medical fees for each patient were calculated by the combination of clinical service items that were actually provided.

Definition of variables

The clinical indicators used in this study included age, gender, total LOS, pre- and postoperative LOS, preoperative physical status, comorbidities, preoperative ileus, surgical site, surgical procedure, operative duration, wound classification (clean-contaminated/contaminated), and elective/emergency operation.

To evaluate each patient's preoperative physical status, we used the American Society of Anesthesiologists Physical Status classification system (ASA-PS) [17]. The ASA-PS score ranges from 1 to 5, with higher numbers indicating more serious conditions. Patient comorbidity status was analyzed using the following three diseases: diabetes mellitus, hypertension, and hyperlipidemia. A designation of Comorbidity 1 indicates that a patient had one of these three diseases, Comorbidity 2 indicates that a patient had two of these three diseases, and Comorbidity 3 indicates that a patient had all three diseases. The presence of preoperative ileus revealed that a patient had a gastrointestinal obstruction.

Each surgical operation was evaluated using surgical site (colon and rectum), surgical procedure (laparoscopic surgery and open surgery), and operative duration (minutes). Operative duration was analyzed using two categories: Category 1 represented a short operative duration of less than or equal to 400 minutes and Category 2 represented a longer duration that exceeded 400 minutes. Furthermore, we determined if a performed surgery was clean-contaminated or contaminated, and whether it was an elective or emergency operation.

Economic indicators included total health care costs (THC) and AMC by clinical services. These costs were computed using medical fees, which are generally calculated by summing the charges billed during each hospitalization on a fee-for-service (FFS) basis according to the social insurance medical fee schedule under the nationally uniform universal health insurance system. Health care costs included those for major clinical service items, such as administrative fees, medication fees, injection fees, treatment fees, surgery/procedure fees, laboratory examination fees, diagnostic imaging fees, and admission fees. Furthermore, Japanese medical institutions have to choose between the conventional FFS payment system and the newer Diagnosis Procedure Combination (DPC) prospective payment system, which is similar in concept to the Diagnosis-Related Groups Prospective Payment System (DRG-PPS). DPC-compliant hospitals currently include approximately 80 university hospitals in Japan, including SUH.

In addition to calculating THC utilizing the DPC system, we also made calculations based on the conventional FFS payment system for the purpose of providing context. In the Japanese health care setting, each hospital compiles monthly lists of hospitalization costs on a day-to-day basis categorized by clinical services. In our investigation, we checked these lists and identified the health care costs unrelated to the primary disease. Costs are presented as US dollars, where US$1 = 100 Japanese Yen.

Statistical methods

We used the software package SPSS (version 21.0 for Windows, IBM Inc. Chicago, IL) for all statistical analyses. Continuous variables were analyzed using the Mann-Whitney test, and discrete variables were analyzed using the chi-squared test. The associations between the case group and the independent variables were described using odds ratios (ORs) and 95% confidence intervals (CIs) calculated from logistic regression analysis. Age, gender, comorbidities, ASA-PS, preoperative ileus, surgical site, surgical procedure, operative duration, clean-contaminated/contaminated wound classification, and elective/emergency operation were included in the logistic regression model as independent variables for the case group. All reported p-values were two-tailed, and the level of significance was set at $p < 0.05$.

RESULTS

Patient characteristics

Table 1 presents the numbers of patients in the case and control groups by surgical sites and procedures. Of the 76 LC patients, 63 were from the control group and 13 from the case group; of the 48 OC patients, 27 were from the control group and 21 from the case group; of the 23 LP patients, 12 were from the control group and 11 from the case group; of the 14 OP patients, 10 were from the control group and 4 from the case group.

Table 1 also presents the means and standard deviations (SD) of age and the gender ratios of the patients. There were no significant differences between the case and control groups for surgical

Table 1. Patient Characteristics

	Control group	Case group	*p*-value
Number of patients (n=161)	112	49	
LC (n=76)	63	13	<0.001
OC (n=48)	27	21	0.018
LP (n=23)	12	11	<0.001
OP (n=14)	10	4	<0.001
Mean age (years, mean±SD)	69.1 ± 10.8	71.4 ± 9.8	0.206
LC (n=76)	70.4 ± 10.1	71.8 ± 8.4	0.633
OC (n=48)	69.3 ± 12.9	72.8 ± 12.3	0.356
LP (n=23)	62.2 ± 9.4	69.1 ± 6.4	0.053
OP (n=14)	68.6 ± 8.5	69.0 ± 7.1	0.935
Gender (male/ female)	55/57	31/18	0.098
LC (n=76)	31/32	9/4	0.188
OC (n=48)	13/14	11/10	0.771
LP (n=23)	7/5	9/2	0.221
OP (n=14)	4/6	2/2	0.733
Comorbidity (+/-)	46/66	13/36	0.078
LC (n=76)	26/37	6/7	0.745
OC (n=48)	11/16	4/17	0.108
LP (n=23)	5/7	3/8	0.469
OP (n=14)	4/6	0/4	-
ASA-PS			
ASA-PS = 1,2:3,4			
LC (n=76)	62/1	10/3	0.102
OC (n=48)	23/4	16/5	0.428
LP (n=23)	11/1	11/0	0.328
OP (n=14)	10/9	4/4	-
Operative duration (min: mean±SD)			
LC (n=76)	303 ± 80 (63)	298 ± 78 (13)	0.843
OC (n=48)	227 ± 71 (27)	244 ± 111 (21)	0.508
LP (n=23)	442 ± 69 (12)	448 ± 174 (11)	0.914
OP (n=14)	363 ± 99 (12)	482 ± 152 (4)	0.108
Elective/emergency	107 / 5	36 / 13	<0.001
Preoperative ileus (+/-)	105 / 7	34 / 15	<0.001

LC: laparoscopic colectomy; OC: open colectomy
LP: laparoscopic proctectomy, rectal resection and amputation using laparoscopy
OP: open proctectomy, rectal resection and amputation

sites and procedures in the mean age and gender ratios. In addition, this table shows the comorbidity conditions, ASA-PS, operative durations, preoperative ileus, and emergency/elective operation status of the patients. No significant difference between the control and the case group in the frequency of comorbidity was observed. When patients were classified into two groups based on ASA-PS scores, the results showed no significant differences between the two groups in surgical sites and procedures.

There were also no significant differences in the operative durations between the case and control groups, irrespective of surgical sites and procedures. However, there were significant differences observed between the two groups in the ratio of elective and emergency surgery, as well as in the presence of preoperative ileus when surgical sites and procedures were not taken into account.

Length of hospital stay and total health care costs

Table 2 presents LOS durations by surgical sites and procedures (LC, OC, LP and OP). The total LOS of each surgical site and procedure in the case group was significantly longer than that of the corresponding control group. As a result, the case group had an additional LOS of 24.8 days (95% CI: 17.5-33.2, $p < 0.001$). Within the four groups, the total LOS for OP patients in the case group (71.5 ± 45.2 days) was the longest and that of LC patients (20.7 ± 7.9 days) was the shortest.

LOS was further analyzed at the preoperative and postoperative LOS levels. We found no significant differences in preoperative LOS, but observed significant differences in postoperative LOS by surgical sites and procedures. Furthermore, although not illustrated in Table 2, LOS and postoperative LOS of LC patients were significantly longer than those of OC patients (case group: 8.1 days, 95% CI: 3.1-13.1, $p = 0.002$; control group: 3.1 days, 95% CI: 0.23-5.9, $p = 0.035$). There was no significant difference in the LOS between LP and OP patients ($p = 0.065$), but the postoperative LOS of LP patients was significantly longer than that of OP patients (7.8 days, 95% CI: 0.18-7.8, $p = 0.045$) in the control group. In contrast, there were no significant differences between laparoscopic and open surgery patients in the case group.

Table 3 shows the DPC- and FFS-based THCs during hospitalization. The results showed significant differences between the two groups by surgical sites and procedures, but there were no differences between laparoscopic and open surgery in each surgical

Table 2. Total LOS and Postoperative LOS

	Control (mean±SD)		Case (mean±SD)		Additional stay (95% CI)	*p*-value
All patients	24.6±12.1 15.9±7.3	(112)	49.4±35.2 39.6±34.1	(49)	24.8 (17.5 – 32.2) 23.7 (17.0 – 30.3)	<0.001 <0.001
Colon (124)						
LC (76)	20.7±7.9 14.0±5.6	(63)	40.5±30.1 29.8±25.2	(13)	19.8 (11.2 – 28.4) 15.9 (9.0 – 22.8)	<0.001 <0.001
OC (48)	28.9±16.3 17.0±7.6	(27)	46.3±31.9 37.2±30.5	(21)	17.4 (3.2 – 31.7) 20.2 (8.0 – 32.4)	0.017 0.002
Rectum (37)						
LP (23)	25.8±10.9 16.7±5.5	(12)	57.9±42.8 48.2±43.1	(11)	32.1 (5.6 – 58.6) 15.9 (9.0 – 22.8)	0.020 0.002
OP (14)	35.9±13.3 24.5±11.2	(10)	71.5±45.2 60.0±49.3	(4)	35.6 (2.9 – 68.3) 35.5 (1.3 – 69.7)	0.035 0.043

Upper values: total length of hospital stay (LOS); Lower values: postoperative LOS
LC: laparoscopic colectomy; OC: open colectomy
LP: laparoscopic proctectomy, rectal resection and amputation using laparoscopy
OP: open proctectomy, rectal resection and amputation

site. Among the four groups, DPC- and FFS-based THCs for LC control patients (US$14,045±3,202 and US$12,997±2,934, respectively) were the lowest, and those for OP case patients (US$33,260±17,598 and US$31,997±18,696) were the highest. DPC-based AMCs for LC patients were US$5,188 (95% CI: US$2,689-7,688), US$6,514 (US$1,813-11,215) for OC patients, US$9,239 (US$109-18,369) for LP patients, and US$14,202 (US$2,045-26,360) for OP patients. The FFS-based AMCs were similar to those of the DPC.

Health care costs by clinical services

Table 4 presents the FFS-based medical fees by clinical services and by surgical sites and procedures. For each surgical procedure, the highest fees were surgery/procedure fees, followed by admission fees and injection fees, in that order. Laboratory examination fees and diagnostic imaging fees were fourth or fifth ranked among the various procedures.

The differences in admission fees between the case and control groups were the largest among the clinical services in each surgical procedure. The largest difference between the two groups was US$5,685 (95% CI: US$487-10,883, p = 0.035) in OC patients, and we found that this difference was dependent on total LOS (coefficient determination: R^2 = 0.969) and postoperative LOS (R^2 = 0.892). The difference in THC for OP patients between the two groups was the largest among the surgical procedures, and was found to be dependent on surgery/procedure (US$4,649, 95% CI: US$1,235-8,063) and injection fees (US$2,610, 95% CI: US$487-10,883).

For the component ratios of medical fees by clinical services, our results indicated that surgery/procedure fees were the most highly represented of the various clinical service fees. In addition, injection fees, diagnostic imaging fees, and laboratory examination fees were significantly higher than the other fees in the case group.

Antimicrobial prophylaxis drug use

Table 5 presents the durations of AMP drug use in the control group by individual drugs and by surgical procedures (colectomy/proctectomy and laparoscopic/open surgery). As this study targeted cases with colorectal surgery, the surgeries essentially involved clean-contaminated operations. However, if an intra-abdominal cavity was contaminated with

Table 3. DPC- and FFS-based THC

	Control (mean±SD)		Case (mean±SD)		Additional medical costs (95% CI)	*p*-value*
Total health care costs	15134±3933	(112)	23128±12123	(49)	7993 (5481 – 10506)	<0.001
	13856±3405		21438±11677		7582 (5208 – 9956)	<0.001
Colon (124)						
LC (76)	14045±3202	(63)	19234±7182	(13)	5188 (2689 – 7688)	<0.001
	12997±2934		17739±6356		4742 (2491 – 6994)	<0.001
OC (48)	14990±4280	(27)	21504±11153	(21)	6514 (1813 – 11215)	0.008
	13828±3924		19380±10491		5552 (1148 – 9957)	0.015
Rectum (37)						
LP (23)	17906±3631	(12)	27145±14758	(11)	9239 (109 – 18369)	<0.001
	16070±2699		25898±13706		9828 (1445 – 18212)	0.048
OP (14)	19058±3922	(10)	33260±17598	(4)	14202 (2045 – 26360)	0.021
	16690±3112		31997±18696		15307 (2766 – 27848)	0.026

Upper: DPC-based THC; Lower: FFS based THC * t-test
DPC, Diagnosis Procedure Combination; FFS, fee-for-service; THC, total health care costs
LC: laparoscopic colectomy; OC: open colectomy
LP: laparoscopic proctectomy, rectal resection and amputation using laparoscopy
OP: open proctectomy, rectal resection and amputation

Table 4. Fee-for-service-based medical fees (US$) by clinical services

	Control	Case	AMC (95% CI)	*p*-value
All patients (161)	(112)	(49)		
THC	13856±3405	21438±11677	7582 (5208 – 9956)	<0.001
Administration	106 ± 59	132 ± 76	26 (5 – 48)	0.018
Medication	98 ± 176	283 ± 469	185 (85– 286)	<0.001
Injection	392 ± 476	1719 ± 2344	1327 (871 – 1783)	<0.001
Treatment	101 ± 81	354 ± 749	252 (111 – 393)	0.001
Surgery/Procedure	7663 ± 1701	8600 ± 3017	937 (198 – 1676)	0.013
Laboratory examination	629 ± 301	957 ± 564	328 (193 – 463)	<0.001
Diagnostic imaging	433 ± 363	1050 ± 762	617 (442 – 792)	<0.001
Admission	4423 ± 1907	8210 ± 5820	3787 (2578 – 4995)	<0.001
Laparoscopic colectomy (76)	(63)	(13)		
THC	12997±2934	17739±6356	4742 (2491 – 6994)	<0.001
Administration	94 ± 47	121 ± 93	27 (7 – 62)	0.121
Medication	59 ± 89	183 ± 274	124 (41– 207)	0.004
Injection	279 ± 224	1163 ± 1002	884 (610 – 1159)	<0.001
Treatment	84 ± 43	498 ± 1322	414 (90 – 738)	0.013
Surgery/Procedure	7714 ± 1791	7577 ± 1084	-137 (-1167 – 892)	0.791
Laboratory examination	590 ± 279	863 ± 498	273 (75 – 470)	0.007
Diagnostic imaging	371 ± 299	824 ± 663	453 (221 – 685)	<0.001
Admission	3798 ± 1260	6493 ± 4206	2696 (1452 – 3939)	<0.001
Open colectomy (48)	(27)	(21)		
THC	13828±3924	19380±10491	5552 (1148 – 9957)	0.015
Administration	116 ± 54	142 ± 66	26 (-9 – 61)	0.138
Medication	115 ± 108	325 ± 591	210 (-23– 443)	0.076
Injection	678 ± 810	1399 ± 1610	721 (4 – 1438)	0.049
Treatment	133 ± 118	230 ± 268	97 (-19 – 213)	0.099
Surgery/Procedure	6547 ± 993	7679 ± 3253	1132 (-198 – 2463)	0.093
Laboratory examination	699 ± 380	939 ± 606	240 (-48 – 528)	0.100
Diagnostic imaging	447 ± 324	937 ± 693	490 (187 – 793)	0.002
Admission	5086 ± 2486	7605 ± 4859	2519 (347 – 4692)	0.024
Laparoscopic proctectomy (23)	(12)	(11)		
THC	16070±2699	25898±13706	9828 (1445 – 18212)	0.024
Administration	100 ± 42	123 ± 86	24 (-34 – 82)	0.404
Medication	197 ± 409	239 ± 270	42 (-262– 346)	0.777
Injection	234 ± 110	2473 ± 3898	2239 (-97 – 4575)	0.059
Treatment	105 ± 127	404 ± 566	299 (-50 – 647)	0.089
Surgery/procedure	9650 ± 599	10106 ± 1304	456 (-411– 1323)	0.286
Laboratory examination	570 ± 190	1018 ± 521	448 (114 – 783)	0.011
Diagnostic imaging	504 ± 327	1321 ± 788	817 (302 – 1332)	0.003
Admission	4698 ± 1615	10039 ± 8086	5341 (392 – 10290)	0.036
Open proctectomy (14)	(10)	(4)		
THC	16690±3112	31997±18696	15307 (2766 – 27848)	0.021
Administration	162 ± 110	143 ± 64	19 (-149 – 110)	0.751
Medication	174 ± 246	506 ± 720	332 (-207– 872)	0.204
Injection	519 ± 382	3129 ± 3032	2610 (609 – 4610)	0.015
Treatment	122 ± 41	397 ± 467	275 (-29 – 579)	0.072
Surgery/Procedure	7965 ± 1092	12614 ± 4948	4649 (1235 – 8063)	0.012
Laboratory examination	761 ± 266	1194 ± 787	433 (-155 – 1021)	0.134
Diagnostic imaging	705 ± 675	1633 ± 1113	928 (-112 – 1969)	0.076
Admission	6242 ± 2248	11927 ± 7063	5685 (487 – 10883)	0.035

feces, it was judged to be a contaminated surgery. According to the guidelines for antimicrobial drug use issued by the Japanese Society of Chemotherapy, second-generation cephamycins, first- and second-generation cephalosporins, and second-generation oxacephems are recommended for AMP until three days after surgery [16].

Recommended AMP agents were given to 102 (91.1%) of the 112 patients in the control group: 65 (58.0%) of 112 patients were given cefotiam (CTM, a second-generation cephalosporin antibiotic), 23 patients (20.5%) were given cefmetazole (CMZ, a second-generation cephalosporin antibiotic), and 14 patients (12.5%) were given flomoxef (FMOX, a second-generation cephalosporin antibiotic). The remaining 10 patients in the control group included two patients who had been given cefazolin (CEZ), four patients given cefotaxime (CTX), one patient given CMZ and CEZ, one patient given CTM and ampicillin (ABPC, a penicillin antibiotic), one patient given imipenem/cilastatin (IMP/CS, a carbapenem antibiotic), and one patient given sulbactam/cefoperazone (SBT/CPZ, a beta-lactam-based combination antibiotic).

The results showed that most patients in the control group (102/112 patients; 91.1%) were appropriately provided with second-generation antibiotics in a manner consistent with the guidelines set by the Japanese Association for Infectious Diseases and the Japanese Society of Chemotherapy.

Factors associated with postoperative infections

Table 6 presents the results of the logistic regression analysis to identify factors associated with postoperative infections in the case group. The analysis revealed that patients who had hypertension (p = 0.029), ASA-PS scores of 3 or higher (p = 0.030), and preoperative ileus (p < 0.001) were significantly associated with postoperative infections; the respective ORs for postoperative infections were 2.14 (95% CI: 1.082-4.232), 3.447 (95% CI: 1.127-10.546), and 6.618 (95% CI: 2.491-17.579). Similarly, the surgical factors associated with postoperative infections were open surgery (p = 0.032), contaminated surgical wound (p < 0.001), and operative duration exceeding 400 minutes (p = 0.027); the respective ORs were 2.111 (95% CI: 1.065-4.187), 11.784 (95% CI: 3.151-44.066), and 2.465 (95% CI: 1.111-5.471).

DISCUSSION

AMP drug use

It has been previously reported that Japanese physicians tend to use more antimicrobial drugs than physicians in the United States and European countries [18]. Approximately a quarter-century ago, the infection rate of MRSA in Japan was among the highest in the world [19]. With an increasing emphasis on evidence-based medicine, concerns about the proper use of antimicrobial drugs in Japan have

Table 5. Antimicrobial prophylaxis in the control group by individual drug

Drug	Surgery	Duration of antimicrobial prophylaxis				Total
		Day of surgery	POD 1	POD 2	POD 3	
CTM	Colectomy	8 (7,1)	29 (25,4)	11 (8,3)	5 (3,2)	53 (43,10)
	Proctectomy	0 (0,0)	11 (7,4)	1 (1,0)	0 (0,0)	12 (8,4)
CMZ	Colectomy	7 (4,3)	5 (2,3)	4 (2,2)	3 (2,1)	19 (10,9)
	Proctectomy	1 (1,0)	0 (0,0)	2 (0,2)	1 (0,1)	4 (1,3)
FMOX	Colectomy	3 (2,1)	2 (1,1)	3 (2,1)	2 (0,2)	10 (5,5)
	Proctectomy	1 (0,1)	2 (2,0)	0 (0,0)	1 (1,0)	4 (3,1)
Total	Colectomy	18 (13,5)	36 (28,8)	18 (12,6)	10 (5,5)	82 (58,24)
	Proctectomy	2 (1,1)	13 (9,4)	3 (1,2)	2 (1,1)	20 (12,8)

POD, postoperative day
Figures on the left side within parentheses indicate the number of patients with laparoscopic surgery, and those on the right side indicate the numbers of patients with open surgery.
Proctectomy included rectal resection and amputation.

led to the development and implementation of multiple practice guidelines.

Most patients in the control group of this study (102/112 patients; 91.1%) were provided AMP in a manner consistent with the guidelines published by the Japanese Association for Infectious Diseases and the Japanese Society of Chemotherapy, as well as the guidelines for the prevention of SSIs established in 1999 by the Hospital Infection Control Practices Advisory Committee [16]. Bratzler *et al*. analyzed 4,855 patients who had undergone colon surgery, and found that 3,683 patients (75.9% unweighted; 95% CI: 74.6-77.1) had received AMP drug administration in compliance with published guidelines [20]. In contrast, the vast majority of patients in this study had been provided AMP agents in compliance with guidelines, and we were therefore able to verify that the surgeons at SUH generally administer AMP agents in an appropriate manner in colorectal surgical patients.

Additional hospital stay and medical costs during hospitalization

This study found that patients in the case group were associated with an additional LOS duration of 24.8 days (95% CI: 17.5-32.2) and additional DPC-based AMCs of US$7,993 (95% CI: US$5,481-10,506) when compared with the control group. For the different surgical sites and procedures, additional LOS and AMCs for LC patients were 19.8 days (95% CI: 11.2-28.4) and US$5,188 (95% CI: US$2,689-7,688), respectively. Similarly, the additional LOS and AMCs for OC, LP, and OP patients were 17.4 days (95% CI: 3.2-31.7) and US$6,514 (95% CI: US$1,813-11,215); 32.1 days (95% CI: 5.6-58.6) and US$9,239 (95% CI: US$109-18,369); and 35.6 days (95% CI: 2.9-68.3) and US$14,202 (95% CI: US$2,045-26,360); respectively.

In a recent Japanese study designed to investigate the additional costs of SSI in colorectal surgical

Table 6. Factors associated with postoperative infections

		Odds ratio	95% CI	p-value
Age		1.02	0.988 – 1.056	0.205
Gender	Male	1.00		
	Female	0.56	0.281 – 1.116	0.099
Comorbidity condition	Absent	1.00		
	Present	1.93	0.923– 4.035	0.089
Diabetes	Absent	1.00		
	Present	0.920	0.456 – 1.858	0.816
Hypertension	Absent	1.00		
	Present	2.140	1.082 – 4.232	0.029
Hyperlipidemia	Absent	1.00		
	Present	1.768	0.791– 3.948	0.165
ASA-PS	<3	1.00		
	3=<	3.447	1.127 – 10.546	0.030
Preoperative ileus	Absent	1.00		
	Present	6.618	2.491 – 17.579	<0.001
Operative site	Colon	1.00		
	Rectum	1.805	0.839 – 3.881	0.131
Operative procedure	Laparoscopy	1.00		
	Open	2.111	1.065 – 4.187	0.032
Contaminated	Clean-contaminated	1.00		
	Contaminated	11.784	3.151 – 44.066	<0.001
Operative duration	<400 min	1.00		
	≥401 min	2.465	1.111 – 5.471	0.027

patients admitted to seven institutions (including three university hospitals; hospital size ranging from 383-736 beds), Kashimura *et al*. reported that patients with SSI had an additional mean LOS of 17.8 days (95% CI: 11.9-23.5) and AMC of US$5,938 (95% CI: US$3,610-8,367) [10]. That study was a multi-center, retrospective-matched case-control study using 167 SSI/non-SSI pairs that compared postoperative additional LOS and AMCs. For the different surgical sites and procedures, the additional LOS and AMCs for LC, OC, LP, and OP patients were 15.2 days (95% CI: -0.6-31.1) and US$6,819 (95% CI: US$1,529-15,166); 18.9 days (10.6-27.1) and US$5,565 (US$3,053-8,077); 12.6 days (-2.1-27.2) and US$4,330 (US$1,026-9,686); and 18.0 days (7.3-28.9) and US$6,249 (US$1,173-11,325); respectively. Although our study and the study by Kashimura *et al*. were performed during approximately the same time period, the additional LOS and AMCs in our study were higher. The reason for this difference may be that the case group in our study may also include patients with other postoperative adverse events, and not only SSI. For example, the total LOS (postoperative LOS) of three patients in our sample who also had major leakage were 156 (154) days, 138 (132) days, and 99 (89) days; the THCs were US$62,699, US$59,346, and US$44,626; respectively.

Previous reports from other countries have examined the prolongation of LOS and AMCs associated with SSI in colorectal surgical patients. These infections were found to be associated with increases in LOS of 6-14 days and increases in costs of US$2,671-17,955 [4-8]. Although the additional LOS durations reported in our study and in the study by Kashimura *et al*. were relatively longer than those of previous reports, the additional LOS and AMCs reported in this study were not excessively long or expensive in the Japanese context. While the WHO has lauded Japan's overall health system, the LOS in Japanese hospitals remains much longer when compared with those in other developed countries [21], which may explain in part the longer additional LOS durations observed in our study.

Under Japan's social insurance medical fee schedule, reimbursements are calculated using a point system. The reimbursement points for an LC procedure were listed as 41,700 points (US$4,170; as one point is equivalent to 10 Japanese Yen, or US$0.1) in 2007 to 2009. Similarly, the points for open rectal resection (proctectomy), open rectal lower anterior resection, and open rectal amputation were 27,000 (US$2,700), 44,200 (US$4,420) and 50,100 points (US$5,010), respectively. The points for laparoscopic rectal resection, laparoscopic rectal lower anterior resection, and laparoscopic rectal amputation were 42,100 (US$4,210), 53,400 (US$5,340), and 60,000 (US$6,000) points. As a result, the differences in points for colectomy between open and laparoscopic surgery was essentially 9,000 points (US$900). Similarly, the differences in medical points for rectal resection ranged from 9,900 (US$990) to 15,100 (US$1,510). Based on this fee schedule, admission fees are increased with longer LOS durations. It can therefore be concluded that the AMCs are mostly influenced by additional LOS, with a large proportion of these costs explained by increased injection fees, laboratory examination fees, and diagnostic imaging fees; rather than by surgery/procedure fees due to postoperative adverse events (including infectious disease).

Furthermore, it is important to investigate the factors associated with the case group. From the results shown in Table 6, the AMCs are likely to be influenced by the following factors: operative duration, wound class, higher ASA-PS score, elective or emergency surgery, and presence of ileus before surgery.

From a socioeconomic perspective, it is important for health care professionals to consider why these types of practice variations occur. However, only a few published reports have examined the relationship between LOS, medical costs, and socioeconomic factors in Japan. From the patients' perspective, the following socioeconomic factors may contribute to additional LOS and AMCs: (1) Patients (social insurance beneficiaries) are responsible for co-payments that amount to only 30% of their THC [22]; (2) Patients typically expect to stay in the hospital until they completely recover from illness [23]; (3) Popular belief in numerology leads patients to request discharge on an "auspicious" day [24]; and (4) Patients who have private supplemental health insurance are likely to receive larger reimbursements for longer hospital stays [25].

There are a couple of limitations. First, as this study was performed using only 162 surgical patients at one university hospital in Japan, the result in this study might not be generalized. It is, however, very important for administrators in hospitals to grasp their socioeconomic burden due to the hospital-acquired adverse events including postoperative infections [3]. Second, additional medical costs might be underestimated due to the difference of health care system, for example, social insurance based health care system in Japan and market-based health insurance in the United States. The average unadjusted price for all colectomy-related hospital stays about US$21,257 ± 12,605 (OC) and 18,113 ± 11,830 (LC) in the United Staes [26], but US$14,990 ± 4,280 (OC) and US$14,045 ± 3,202 in this study. Third, this study was performed as a case study and its evidence level is relatively low. In near future, many studies like this should be performed based on the rigid study designation from socioeconomic perspectives.

CONCLUSIONS

Although the surgeons in our hospital were found to have generally utilized AMP agents in concordance with the recommended guidelines, there were still some cases where overutilization was observed. It is important for hospital administrators to quantify the AMCs associated with postoperative infections in order to appropriately address infection control and hospital management.

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