Original Article

The Risk Factors Associated with 30-day Readmission after Colorectal Surgery: A Single-institute Analysis

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Key Words
30-day readmission;
Colorectal surgery;
Preoperative factors;
Postoperative factors

Purpose. Unplanned readmission has a negative impact on health insurance costs, patient satisfaction, and clinical outcome. Readmission rates indicate surgical quality and quality of care. This study aimed to identify the risk factors that may affect the 30-day readmission after colorectal surgery.

Materials and Methods. This retrospective study included 440 patients who underwent colorectal surgery at Chang Gung Memorial Hospital Keelung Branch between January 2, 2013, and December 21, 2015. Patients who received combined operation such as hepatectomy or cystectomy during the index surgery were excluded. Readmission due to scheduled stage operation were also excluded. The chi-square test (for categorical variables) and Student *t* test (for continuous variables) were used for the analysis. Logic regression analysis was used for single-variable and multivariable analyses. p values of < 0.05 indicated significance.

Results. Of the 440 patients, 340 were included in the analysis after applying the exclusion criteria, of whom 35 (10.2%) were readmitted within 30 days after index admission discharge. Although the comorbidities, high American Society of Anesthesiologist (ASA) classification, lower preoperative albumin level, previous cerebral vascular accident, and index admission with major complications had significant impacts on readmission in the single-variable analysis, only the postoperative major complications had a significant impact on readmission in the multivariate analysis.

Conclusions. Although patient-related factors have a less direct influence on readmission within 30 days after index admission discharge, this study may lead us to change the strategies for addressing the readmission rate by focusing on reducing the incidence of avoidable postoperative complications.

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Unplanned readmission is associated with decreased patient satisfaction, increased health cost, and negative impact on clinical outcomes. In addition, readmission rates also represent medical and surgical qualities in our facility.

Among patients who underwent colorectal surgery, readmission rates were estimated to range from 9% to 25%.[1] Previously reported risk factors are inconsistent among different countries, races, demographics, and perioperative factors.[2] In this study, our primary goal was to identify the factors associated with hospital readmission after colorectal surgery.

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The secondary goal of this study was to generate strategies to prevent readmission after colorectal surgery.

Materials and Methods

Patients

This study was approved by the institutional review board (IRB No. 201601057B0) of Chang Gung Memorial Hospital Keelung Branch.

From January 2, 2013, to December 21, 2015, consecutive patients who received colorectal surgery at Chang Gung Memorial Hospital Keelung Branch were identified on the basis of the International Classification of Diseases, Ninth Revision, disease codes (codes 153, 153.0-9, 154, 154.0-3, and 154.8) and procedure codes (codes 457.1-4, 457.5, 457.6, and 485). Readmission was defined as a hospital admission within 30 days after the index admission discharge. Only patients who received procedures performed by colorectal surgeons with a surgical indication of curative or palliative resection for malignant neoplasm were included in this study. Patients who had a concurrent surgery on another organ or body cavity (e.g., combined hepatectomy or lung wedge resection), had a readmission within 30 days for adjuvant chemotherapy or staged operation, had a readmission within 30 days due to an irrelative reason (e.g., trauma), or died during the index admission were excluded (Fig. 1). A retrospective chart review was conducted using the patients' electronic medical charts, including inpatient and outpatient records.

Data collection

The patients' characteristics such as sex, age, body mass index (BMI), length of hospital stay (LOS), tobacco use (current only), alcohol use (current only), and betel nut use (current only) were collected. Information on perioperative medical condition was obtained by calculation of the Charlson comorbidity score[3] and American Society of Anesthesiologist (ASA) score. Additional information on clinical status and perioperative conditions was collected, including history of coronary artery disease (CAD), cerebral vascular accident, end-stage renal disease (ESRD), hepatitis B or C virus infection, preoperative weight

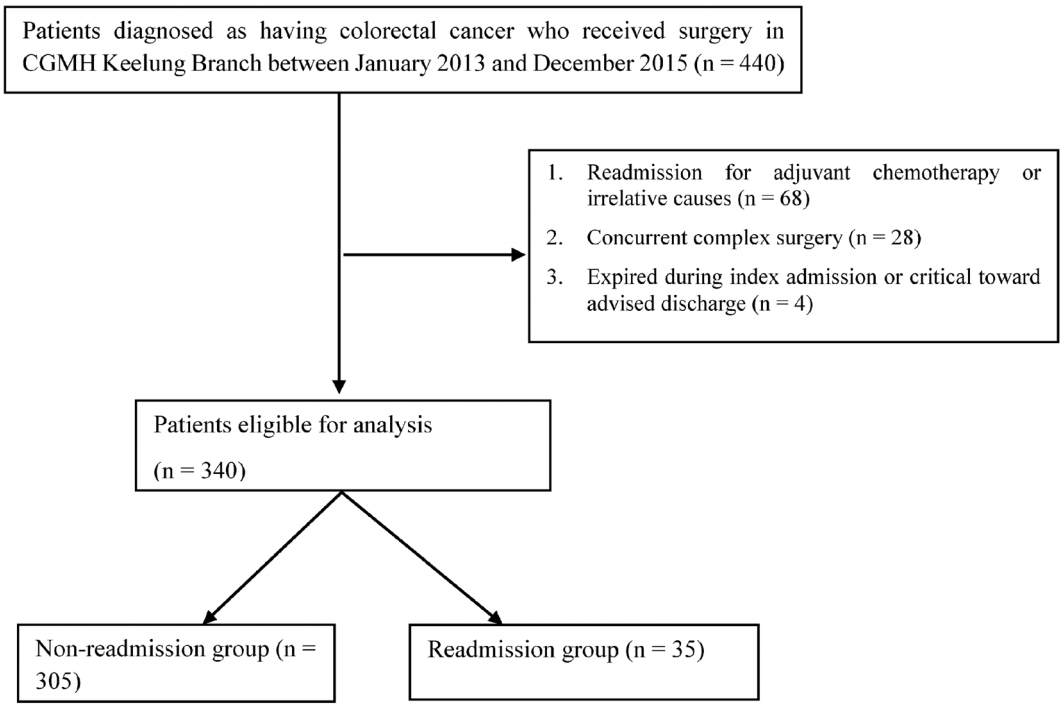

Fig. 1. Flowchart of the patient selection process.

loss, and chronic obstructive pulmonary disease.

Procedures were defined by the surgical removal of colorectal segments (right, left, transverse, anterior resection, total, and subtotal). Other procedures such as transrectal polypectomy, the Hartmann procedure, abdominal peritoneal resection, and stoma creation were also included for analysis.

During the index admission, the following major complications were found: generalized peritonitis, organ-specific surgical site infection, cerebrovascular accident or myocardial infarction during the perioperative period, septic shock, and unplanned reintubation. Minor complications were defined as superficial surgical site infection, stress ulcer, minor leakage without surgical intervention, paralytic ileus, urinary tract infection, and pneumonia.

Statistical analysis

Data analysis was performed using the SPSS version 20.0 software (SPSS Inc., Chicago, IL, USA). Demographic factors were compared between the two groups by using the chi-square or Student *t* test. A two-tailed *p* value of < 0.05 was considered statistically significant. Significant predictors in the univariate analysis with *p* values of < 0.1 were included in the multivariate logistic regression analysis. Odds ratios (ORs) with 95% confidence intervals (95% CI) were calculated using the Cox proportional-hazards model.

Results

From 2013 to 2015, 440 patients were diagnosed as having colorectal adenocarcinoma and received colorectal surgery either with curative or palliative intent. The exclusion criteria included concurrent complex surgery, readmission for adjuvant chemotherapy or scheduled staged operation, and death during index admission. A total of 340 patients were included in our study. Patient characteristics, procedures, and postoperative events were evaluated as risk factors of readmission (Table 1). The mean age was 68.23 ± 12.09 years (range, 37-96 years), and the median LOS was 10 days. Most of the patients were male (n = 201; 59.1%). The Charlson comorbidity score[3] was determined as a measure of the preoperative medical condition of our patients.

Surgical resection included right hemicolectomy (27.1%), transverse colectomy (1.8%), left hemicolectomy (9.4%), high anterior resection (30.9%), low anterior resection (22.4%), combined abdominoperitoneal resection (2.9%), Hartmann procedure (1.2%), total colectomy (0.9%), subtotal colectomy (2.6%), and other procedures (1.8%). Among the patients who received surgical resection, 332 (97.6%) had an elective surgery. Minimal invasive surgery was performed in 35 patients (10.3%). A total of 192 patients (56.5%) had a tumor grading that indicated a localized disease.

Among the 340 patients who received colorectal surgery, 10.2% (n = 35) were readmitted within 30 days after discharge. The most common etiology was urinary tract infection (23%), followed by ileus (20%), superficial/deep surgical site infection (17%), stress ulcer-related gastrointestinal bleeding (17%), pneumonia (14%), nonspecific abdominal pain or diarrhea (6%), and deep organ space infection (3%) (Table 2).

The patients who were readmitted were more likely to have longer LOS, multiple comorbidities, hypoalbuminemia, and major postoperative complications during the index admission. In the univariate analysis, the Charlson comorbidity score (OR, 1.166; $p < 0.008$), LOS (OR = 1.032, $p = 0.028$), albumin (OR, 0.588; $p = 0.03$), old stroke history (OR, 2.948; $p = 0.032$), ASA (OR, 2.030; $p = 0.016$) and major postoperative complications (OR, 6.104; $p < 0.001$) were statistically significant. However, in multivariate model, only the postoperative major complications were statistically significant (OR, 4.126; $p = 0.012$; (Table 3).

The postoperative complications rate was 20.8% (n = 71). The major complication rate was 5.5% (n = 19), 9 cases (47.3%) were diagnosed as anastomosis leakage with associated intraabdominal abscess or peritonitis, of which 4 required additional surgical intervention (e.g., colostomy or ileostomy) during the index admission. The other patients were treated with total parenteral nutrition and intravenous antibiotic therapy. Five patients (26.3%) had deep organ space

Table 1. Demographic characteristics between non-readmission and readmission groups

Variables	Non-readmission (n = 305)	Readmission (n = 35)	Total (n = 340)	*p* value
Male (%)	183 (60.0)	18 (51.4)	201 (59.1)	0.329
Age (mean ± SD)	67.96 ± 11.81	70.54 ± 14.27	68.23 ± 12.09	0.309
CCS (mean ± SD)	6.33 ± 2.94	7.80 ± 3.43	6.48 ± 3.02	**0.006**
LOS (mean ± SD)	15.49 ± 9.34	19.51 ± 13.49	15.91 ± 9.90	0.094
BMI ≥ 30 (%)	15 (5.7)	0	15 (5.1)	0.379
Albumin (mean ± SD)	3.88 ± 0.61	3.57 ± 0.72	3.85 ± 0.63	**0.007**
Comorbidities				
Diabetes mellitus (%)	78 (25.6)	14 (40.0)	92 (27.1)	0.069
Previous CVA (%)	20 (6.6)	6 (17.1)	26 (7.6)	**0.038**
End-stage renal disease (%)	13 (4.3)	4 (11.4)	17 (5.0)	0.085
CAD (%)	17 (5.6)	3 (8.6)	20 (5.9)	0.446
COPD (%)	10 (3.3)	3 (8.6)	13 (3.8)	0.139
HBV/HCV carrier (%)	35 (11.5)	2 (5.7)	37 (10.9)	0.400
Pre-op weight loss (%)	28 (9.2)	4 (11.4)	32 (9.4)	0.758
ASA (mean ± SD)	2.62 ± 0.62	2.89 ± 0.58	2.64 ± 0.62	**0.014**
Initial diagnosis				
A-colon cancer (%)	77 (25.2)	11 (31.4)	88 (25.9)	0.429
T-colon cancer (%)	25 (8.2)	2 (5.7)	27 (7.9)	> 0.999
D-colon cancer (%)	27 (8.9)	2 (5.7)	29 (8.5)	0.753
S-colon cancer (%)	83 (27.2)	12 (34.3)	95 (27.9)	0.377
Rectal cancer (%)	99 (32.5)	11 (31.4)	110 (32.4)	0.902
Elective operation (%)	298 (97.7)	34 (97.1)	332 (97.6)	0.585
Surgical procedure				
Right hemicolectomy (%)	83 (27.2)	9 (25.7)	92 (27.1)	0.850
Left hemicolectomy (%)	31 (10.2)	1 (2.9)	32 (9.4)	0.226
Transverse colectomy (%)	5 (1.6)	1 (2.9)	6 (1.8)	0.482
Stoma creation (%)	58 (19.0)	11 (31.4)	69 (20.3)	0.084
HAR (%)	92 (30.2)	13 (37.1)	105 (30.9)	0.397
LAR (%)	70 (23.0)	6 (17.1)	76 (22.4)	0.435
Hartmann (%)	3 (1.0)	1 (2.9)	4 (1.2)	0.354
Total colectomy (%)	2 (0.7)	1 (2.9)	3 (0.9)	0.279
Subtotal colectomy (%)	8 (2.6)	1 (2.9)	9 (2.6)	> 0.999
APR (%)	10 (3.3)	0	10 (2.9)	0.607
Other (%)	5 (1.6)	1 (2.9)	6 (1.8)	0.482
Minimal invasive surgery (%)	33 (10.8)	2 (5.7)	35 (10.3)	0.556
Pathology staging				
Localized, stage I-II (%)	177 (58.0)	15 (42.9)	192 (56.5)	0.086
Postoperative complications				
Major (%)	12 (3.9)	7 (20.0)	19 (5.5)	**< 0.001**
Minor (%)	44 (14.4)	8 (22.8)	52 (15.2)	0.189

LOS: length of stay; CCS: Charlson comorbidity score; BMI: body mass index.

Table 2. Main reasons of readmission

Reason for readmission	N (total = 35)	Proportion of patient readmitted (%)
Urinary tract infection	8	23
Ileus	7	20
Superficial or deep surgical site infection	6	17
GI bleeding	6	17
Pneumonia	5	14
Nonspecific abdominal pain, nausea, vomiting, or diarrhea	2	6
Deep organ space infection	1	3

Table 3. Univariate and multivariate analysis of risk factor in readmission

Predictor	Univariate			Multivariate		
	Odds ratio	95% CI	*p* value	Odds ratio	95% CI	p value
Carlson comorbidity index	1.166	1.042-1.306	**0.008**	1.053	0.888-1.248	0.552
Length of stay	1.032	1.003-1.061	**0.028**	1.003	0.968-1.039	0.882
Albumin	0.588	0.363-0.951	**0.03**	0.914	0.492-1.699	0.777
Diabetes mellitus	1.94	0.941-4.00	0.073	1.364	0.583-3.191	0.474
Old stroke history	2.948	1.097-7.927	**0.032**	1.873	0.616-5.696	0.268
ESRD	2.898	0.89-9.434	0.077	1.380	0.309-6.163	0.673
ASA	2.030	1.141-3.612	**0.016**	1.178	0.592-2.342	0.641
Stoma creation	1.952	0.905-4.211	0.088	1.583	0.683-3.667	0.284
Advanced stage	1.844	0.909-3.739	0.09	1.347	0.547-3.316	0.518
Major complications	6.104	2.224-16.752	**< 0.001**	4.126	1.369-12.442	**0.012**

infection that needed percutaneous drainage during the index admission. Two patients (10.5%) had an unplanned reintubation due to pneumonia with septic shock. One patient had a postoperative transient ischemic attack and seizure. Another patient had an acute myocardial infarction, and emergent percutaneous coronary angioplasty was arranged after the diagnosis. One patient had a hypovolemic shock due to stress ulcer-related bleeding that required transarterial embolization (Table 4).

Discussion

Thirty-day readmission rate has been used as a measure of surgical quality and a crucial indicator for surgeons to identify patients at risk of developing postoperative adverse events or readmission. However, owing to the limited study period and small number of patients included in our study, our results may not reflect the true impact of readmission on the quality of our health care.

In our study, the readmission rate was approximately 10%, similar to those reported in recent studies.[4,5] However, in other studies, the primary outcome definition may be heterogeneous. Most studies observe readmission usually within 30 days after hospital discharge, but other studies extend this period up to 90 days.[6,7]

In the univariate analysis, the CCS, LOS, albumin level, ASA score, postoperative complications, and previous stroke history were associated with readmission. However, in the multivariate analysis, because these covariates highly correlated with each other, only the occurrence of postoperative complication was associated with readmission ($p = 0.012$). The patients who had postoperative complications had 4 times higher odds of readmission than the patients who did not develop major adverse events. Similarly to a review study that used data from the Michigan Surgical Quality Collaborative database for elective colectomy-related readmission analysis, the postoperative complications highly correlated with readmission while the preoperative factors had less direct influence on readmission in our study.[8]

Postoperative complications such as anastomosis

Table 4. Major complications during index admission

	N (total = 19)	Ratio of major complications rate (%)
Anastomosis leakage with peritonitis or intraabdominal abscess	9	47.3
Deep organ space infection	5	26.3
Unplanned reintubation	2	10.5
Transient ischemic attack	1	5
Acute myocardial infarction	1	5
GI bleeding with hypovolemic shock	1	5

leakage after colorectal surgery had severe impacts on patient survival and quality of life in our study. Nine patients had an anastomosis leakage that needed repeated surgical intervention or long-term antibiotic treatment. The other major complication was deep organ-specific abscess formation that needed percutaneous drainage. These 2 types of major complications may be modified or decrease severity if patients' perioperative factors are accessed and corrected meticulously, including aggressive nutritional support, adequate prevention antibiotics, use of new techniques for bowel perfusion detection, and adequate index surgical drainage. With these efforts, the incidence of surgery-associated infection and readmission rate may be further reduced.

During the study period, the use of minimally invasive procedures was limited because of immature skill of surgeons and faculties. However, the increasing number of cases of minimally invasive surgery in our field (from 10% to 40% in the recent 2 years) had significant decreases in LOS, which may impact the post-discharge readmission rate.[9,10] On the other hand, worldwide application of the "enhanced recovery after surgery" protocol had also improved patient postoperative recovery and reduced the number of unplanned readmissions.[11]

This study was limited by the characteristics of a retrospective study, single-institute experience, relatively small sample size, and short study period. Nevertheless, the results implied that index surgery had a significant impact on the readmission of patients who received colorectal cancer surgery.

Conclusion

The predictive factor in our study was the postoperative complications of colorectal surgery, and preoperative patient factors had less impact on the readmission rates.

Although several important patient-related factors, such as age, albumin level, ASA class, and old stroke history were not found to be independent predictors of 30-day readmission. However, they must contribute to some degree by increasing the risk for complications. In our study, we suggest current strategies addressing readmission rates should focus on reducing preventable complications while still accepting that much may not be completely avoidable.

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原　著

大腸直腸癌術後 30 天內再住院率之原因分析

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目的　臨床上病患重返率常被視為醫療照護品質指標。非預期內的再住院可能會造成醫療資源上的負擔、病患預後及術後恢復品質的下降。這篇研究旨在分析造成大腸直腸癌術後出院的 30 日內再住院之原因。

方法　研究收錄了從 2013 年 1 月至 2015 年 12 月共 440 位初診斷為大腸直腸癌並接受根治性或姑息性手術切除的病患，首次住院期間合併其他術式如肝切除或膀胱切除、30 日內再住院化療病患等則排除不收案。此篇研究採用回顧性病歷收集病患資料、術式及造成再住院之原因。χ^2 test 使用於比較類別變數、Student t test 則用於連續變數。顯著意義之變因再使用單變量及多變量分析來找出造成再住院之原因。

結果　在比較收案條件後，共 340 位病患符合條件。其中 35 位為接受大腸直腸癌術後出院 30 日內再住院之病患。於單變量分析中，多重合併症、較高的 ASA 分數、低白蛋白指數、中風病史及首次住院術後發生重大併發症為危險因子；然而，在多變量分析中，造成收案族群 30 日內再住院之唯一獨立危險因子為首次住院有無發生術後重大合併症。

結論　雖然病患本身相關因子並未對再住院率有直接顯著影響，但可以從這篇研究中瞭解到術後發生併發症為獨立危險因子，因此可讓我們來重新擬定預防 30 日內再住院率的策略。

關鍵詞　30 日再住院率、大腸直腸手術、術前及術後因子。