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Original article

Risk factors for prolonged length of stay after colorectal surgery☆

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ABSTRACT

Objective: Colorectal surgeons often struggle to explain to administrators/payers reasons for prolonged length of stay (LOS). This study aim was to identify factors associated with increased LOS after colorectal surgery.

Design: The study population included patients from the 2007 American-College-of-Surgeons-National-Surgical-Quality-Improvement-Program (ACS-NSQIP) database undergoing ileocolic resection, segmental colectomy, or anterior resection. The study population was divided into normal (below 75th percentile) and prolonged LOS (above the 75th percentile). A multivariate analysis was performed using prolonged LOS as dependent variable and ACS-NSQIP variables as predictive variables. P-value < 0.01 was considered significant.

Results: 12,269 patients with a median LOS of 6 (inter-quartile range 4-9) days were included. There were 2,617 (21.3%) patients with prolonged LOS (median 15 days, inter-quartile range 13-22). 1,308 (50%) were female, and the median age was 69 (inter-quartile range 57-79) years. Risk factors for prolonged LOS were male gender, congestive heart failure, weight loss, Crohn's disease, preoperative albumin < 3.5 g/dL and hematocrit < 47%, baseline sepsis, ASA class ≥ 3, open surgery, surgical time ≥ 190 min, postoperative pneumonia, failure to wean from mechanical ventilation, deep venous thrombosis, urinary-tract infection, systemic sepsis, surgical site infection and reoperation within 30-days from the primary surgery.

Conclusion: Multiple factors are associated with increased LOS after colorectal surgery. Our results are useful for surgeons to explain prolonged LOS to administrators/payers who are critical of this metric.

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Fatores de risco para prolongamento do tempo de permanência após cirurgia colorretal

Palavras-chave:
Colectomia
Morbidade
Tempo de internação

RESUMO

Objetivo: Os cirurgiões proctologistas muitas vezes enfrentam dificuldades para explicar aos administradores/contribuintes as razões para o prolongamento do tempo de internação hospitalar (TIH). O objetivo deste estudo foi identificar os fatores associados ao aumento do TIH após cirurgia colorretal.

Método: A população do estudo incluiu pacientes que constam do banco de dados do American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) no ano de 2007 e que foram submetidos à ressecção ileocólica, colectomia segmentar ou ressecção anterior. A população do estudo foi dividida em normal (abaixo do percentil 75) e TIH prolongado (acima do percentil 75). A análise multivariada foi realizada usando o TIH prolongado como variável dependente e as variáveis do ACS-NSQIP como preditivas. Um valor de $p < 0,01$ foi considerado significativo.

Resultados: No total, 12.269 pacientes com um TIH mediano de 6 dias (intervalo interquartil, 4-9) foram incluídos. Havia 2.617 pacientes (21,3%) com TIH prolongado (mediana, 15 dias; intervalo interquartil, 13-22). A idade média dos pacientes era de 69 anos (intervalo interquartil, 57-79) e 1.308 (50%) eram do sexo feminino. Os fatores de risco para TIH prolongado foram sexo masculino, insuficiência cardíaca congestiva, perda de peso, doença de Crohn, albumina < 3,5 g/dL e hematócrito < 47% no pré-operatório, sepse basal, classe ASA ≥ 3, cirurgia aberta, tempo cirúrgico ≥ 190 minutos, pneumonia no pós-operatório, falha no desmame da ventilação mecânica, trombose venosa profunda, infecção do trato urinário, sepse sistêmica, infecção do sítio cirúrgico e reoperação dentro de 30 dias da cirurgia primária.

Conclusão: Vários fatores estão associados ao aumento do TIH após a cirurgia colorretal. Nossos resultados são úteis para que os cirurgiões possam explicar os TIH prolongados aos administradores/contribuintes que são críticos dessa métrica.

Introduction

According to the World Health Organization in the year of 2000 the Brazilian government spent about 4 percent of its gross domestic product on health care. By 2010 that number had risen to 9 percent and is expected to continue its upward trend[1]. Therefore, reducing hospital costs is currently one of the greatest priorities of any health care provider. The current policy of many health insurance companies and the Brazilian public health system (SUS) is to pre-determine the cost of each surgical procedure while hospital administrators have to control patient expenses in order to match or, ideally, stay bellow this cost. When patients' treatment expenses overcome this predetermined cost, hospital administration needs to go through a very bureaucratic pathway to try, quite often with a small chance of success, to get all these additional expenses paid by the health insurance companies or Brazilian government.

In order to avoid financial losses one of the principal strategies used by health administrators is to reduce the length of stay (LOS) as it is one of the major determinant of hospital cost and can be used as an indicator of quality of care.[1]

Colorectal procedures are widely recognized by carrying increased risk of postoperative complications and prolonged LOS in comparison to general surgery.[2] As a result, colorectal surgeons frequently face the difficult task to give explanations to hospital administrators about the reasons why patients have LOS longer than expected, as there is no consistent data in the literature regarding the factors associated with prolonged LOS after colorectal surgery.[3]

Therefore, the aim of our study was to determine the risk factors for prolonged LOS after select common major colorectal surgery operations through analysis of the American College of Surgeons – National Surgical Quality Improvement Program (ACS-NSQIP) database, which is a validated resource with comprehensive inclusion of multiple preoperative, operative, and postoperative variables, and risk-adjusted outcomes for surgical patients treated at approximately 200 different hospitals in the United States, many of them very similar to Brazilian hospitals.[4-6]

Methods

The ACS – NSQIP database, for the period between January 1st and December 31st 2007, was queried for patients who underwent the following colorectal operations as identified by their current procedural terminology (CPT) codes: ileocolectomy (leoCol) – 44610 (open) and 44205 (laparoscopic), segmental colectomy (SegCol) – 44140 (open) and 44204 (laparoscopic), colectomy with colorectal anastomosis (CRA) – 44145 (open) and 44207 (laparoscopic). Length of stay was defined as the number of days between the day of surgery and the day of hospital discharge. Prolonged LOS was defined as duration above the 75 percentile for LOS in each surgical group. Patients were divided into two groups: Regular LOS and Prolonged LOS. Groups were

compared with respect to preoperative, operative and postoperative ACS – NSQIP variables. While all of the 129 ACS – NSQIP variables were used for the analysis, only variables occurring in at least one percent of the patients and with a minimal difference between the comparing groups of two percent were depicted in the tables of this manuscript.

Statistical Analysis

Categorical variables were expressed as absolute numbers and percentages and were compared with the Pearson's χ^2 test. Continuous variables were expressed as medians and interquartile ranges (IQR) with the Wilcoxon rank sum and Kruskal–Wallis tests for comparison. Continuous variables were also dichotomized and used with the categorical variables to build a logistic regression model to predict prolonged LOS. In order to assure the logistic regression analysis accuracy, we followed the recommendation that a logistic regression model should be constructed with at least 10 events for each model parameter.[7] A p-value < 0.01 was considered statistically significant. Statistical analysis was performed with JMP (JMP 8.0 for Macintosh 2009, SAS Institute Inc.). The Cleveland Clinic Institutional Review Board approved this study.

Results

All patients

The query returned 12,269, of which 4,532 (47.4 percent) were male and 6,545 (52.6 percent) female. The median LOS was 6 (inter-quartile range 4–10) days and 2,712 (22 percent) with a LOS greater than 10 days were classified as having a prolonged LOS. Tables 1, 2 and 3 outline the pre-operative, intra-operative and post-operative variables, respectively. Due to the size of the study population, all differences between variables reached statistical significance. However, in only few of the variables was the difference, in terms of frequency, greater than five percent.

Ileocolic resection

A total of 3,004 patients with a median age of 66 (inter-quartile range 53-77) years underwent IleoCol. Of these, 1,638 (54.5 percent) were female. The median LOS was 6 (inter-quartile range 4-10) days. Patients with LOS greater than 10 days were included in the prolonged LOS group.

Segmental colectomy

The SegCol group included 6,813 patients, 3,543 (52 percent) of them were females. The median age was 64 (inter-quartile range 53-75) years. For SegCol patients the median LOS was 6 (inter-quartile range 4-10) days. Patients with LOS greater than 10 days were included in the prolonged LOS group.

Colectomy with colorectal anastomosis

The number of patients undergoing CRA was 2,620 and the median age was 61 (inter-quartile range 51-71) years. One thousand fifty-six (47.9 percent) patients were males. The median LOS was 6 (inter-quartile range 4-8) days. Patients with LOS greater than 8 days were included in the prolonged LOS group.

Table 1 – All patients – normal LOS vs. prolonged LOS – pre-operative variables.

Variable	Normal LOS n = 9726 (78.2%)	Prolonged LOS n = 2717 (21.8%)	Differences between variables[a]
Gender			3.6%
Male	4532 (46.6%)	1361 (50.1%)	
Age (years)	62 (52 – 73)	69 (57 – 79)	7 years
BMI Kg/m^2	28 (25 – 32)	27 (24 – 32)	1 Kg/m^2
Diagnosis			
Cancer	4346 (50.8%)	1247 (60.5%)	9.7%
CD	365 (4.3%)	104 (5%)	0.7%
UC	22 (0.2%)	369 (17.9%)	15.7%
Diverticular	2199 (25.7%)	323 (15.7%)	10%
Other	1625 (19%)	18 (0.9%)	18.1%
Diabetes	1242 (12.8%)	488 (18%)	5.8%
Smoking	1676 (17.2%)	565 (20.8%)	3.6%
COPD	411 (4.2%)	297 (11%)	6.8%
Hypertension	4716 (48.5%)	1636 (60.3%)	11.8%
CHF	43 (0.4%)	111 (4.1%)	3.7%
CVA	314 (3.2%)	230 (8.5%)	5.3%
PCI	528 (5.4%)	230 (8.5%)	3.1%
PCS	513 (5.3%)	274 (10.1%)	4.8%
Coagulopathy	362 (3.7%)	303 (11.2%)	7.5%
Ascites	137 (1.4%)	185 (6.8%)	5.4%
Disseminated Cancer	317 (3.3%)	208 (7.7%)	4.4%
Chemotherapy	104 (1.1%)	68 (2.5%)	1.4%
Steroids use	408 (4.2%)	206 (7.6%)	3.4%
Weight loss	361 (3.7%)	269 (9.9%)	6.2%
Wound Infection	111 (1.1%)	140 (5.2%)	4.1%
Sepsis	494 (5.1%)	606 (22.4%)	17.3%
Prior surgery within 30 days	88 (0.9%)	155 (5.7%)	4.8%
Creatinine (mg/dL)	0.9 (0.8 – 1.1)	0.9 (0.7 – 1.2)	0 mg/dL
Urea (mg/dL)	14 (10 – 18)	13 (8 – 20)	1 mg/dL
Albumin (g/dL)	4 (3.6 – 4.3)	3.3 (2.7 – 3.8)	0.7 g/dL
Sodium (mEq/L)	140 (138 – 141)	138 (136 – 141)	2 mEq/dL
International normalized ratio	1 (1 – 1.1)	1.1 (1.1 – 1.2)	0.1
Partial thromboplastin time. (seconds)	28.6 (26.4 – 31.2)	29.6 (26.8 – 33.8)	1 seconds
Hematocrit (%)	39.4 (35.4 – 42.7)	34.8 (31 – 39.1)	4.6 %
White blood cells count (x103/µL)	7 (5.7 – 8.7)	7.7 (6 – 10.6)	0.7x103/µL
Platelets (x109/L)	263 (217 – 321)	263 (202 – 344)	0x109/L

Categorical variables expressed as absolute numbers with percentage in parenthesis. Continuous variables expressed as medians and interquartile ranges. BMI, body mass index; CD, Crohn's disease; UC, ulcerative colitis, COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; TIA, transient ischemic attack; CVA, cerebral vascular accident; PCI, percutaneous coronary interventions; PCS, palliative care service.

[a]Due to the larger sample size all variables were statistically significant different (p < 0.001) even without a real clinical difference. The differences between variables are shown in the last column and were calculated for each variable subtracting the higher incidence from the lower incidence. For continuous variables the difference between the medians were expressed.

Factors associated with prolonged LOS

In order to evaluate the factors associated with prolonged LOS we performed a logistic regression analysis utilizing prolonged LOS as dependent variable (Tables 4 and 5). Pre-operative hypoalbuminemina, pre-operative anemia and need for reoperation were the factors associated with a prolonged LOS in all surgical groups.

Discussion

This study was set out to identify factors associated with prolonged LOS after commonly performed major colorectal procedures. In the preoperative period, history of congestive heart failure, hypoalbuminemia and anemia were the top three factors associated with prolonged LOS, while in the intra-operative period, those factors were increased ASA classification, operative time and surgical technique (i.e. open vs. laparoscopic). Notwithstanding the impact of certain preoperative and operative variables on LOS, postoperative complications were the major determinant of prolonged LOS in our study.

Previous studies have evaluated factors associated with increased LOS after colorectal surgery. These studies have shown that open surgical procedures, high ASA class, prolonged surgery, and occurrence of postoperative complications are related to a prolonged LOS. However, there are important limitations in these studies such as small samples, data from single institutions, inclusion of other surgical specialties in the analysis and restriction to a single procedure or diagnosis.[1,7,8] In order to overcome these limitations we utilized the ACS-NSQIP, which is a nationwide validated database and, therefore, can provide a large sample with great representativeness of the America surgical population.[6,9] As a result more discrete, but important, associations between variables and prolonged LOS could be detected, and the results are more applicable to different types of institutions. Also, different colorectal diagnosis and surgical procedures were included in this study making its results more useful to colorectal surgeons.

A recent publication,[10] demonstrated that the ACS-NSQIP program is useful to identify participant hospitals that are outliers for LOS after colorectal operations. Cohen's study also evaluated the factors associated with prolonged LOS among those patients with and without post-operative complications. Cohen found that, among patients without postoperative complications, ASA class, diagnosis, surgical extent and

Table 2 – All patients – Normal LOS vs. Prolonged LOS – Intra-operative variables.

Variable	Normal LOS n = 9726 (78.2%)	Prolonged LOS n = 2717 (21.8%)	Differences between variables[a]
Procedure			
IleoCol	2313 (23.8%)	691 (25.5%)	1.7%
SegCol	5205 (53.5%)	1609 (59.3%)	5.8%
CRA	2208 (22.7%)	412 (15.2%)	2.5%
Laparoscopic	4280 (44.2%)	491 (18.1%)	26.1%
ASA			
1	430 (4.4%)	25 (0.9%)	3.5%
2	5358 (55.1%)	702 (25.9%)	29.1%
3	3606 (37.1%)	1534 (56.6%)	19.5%
4	325 (3.4%)	449 (16.6%)	13.2%
Emergency	702 (7.2%)	551 (20.3%)	13.1%
Operative time (min)	138 (101 – 187)	143 (100 – 200)	5 min
Transfusion	409 (4.2%)	480 (17.7%)	13.3%
Wound class			
Clean	0 (0%)	0 (0%)	0%
Clean/ Contaminated	8062 (83%)	1850 (68.2%)	14.8%
Contaminated	1126 (11.6%)	416 (15.3%)	3.7%
Dirty/Infected	538 (5.5%)	446 (16.5%)	11%
Additional procedure	790 (8.1%)	289 (10.7%)	2.6%

Categorical variables expressed as absolute numbers with percentage in parenthesis. Continuous variables expressed as medians and inter-quartile ranges. IleoCol, ileo – colectomy; SegCol, segmental colectomy; CRA, colectomy with colorectal anastomosis; ASA, American Society of Anesthesiologists classification.

[a]Due to the larger sample size all variables were statistically significant different ($p < 0.01$) even without a real clinical difference. The differences between variables are shown in the last column and were calculated for each variable subtracting the higher incidence from the lower incidence. For continuous variables the difference between the medians were expressed.

Table 3 – All patients – Normal LOS vs. Prolonged LOS – Post-operative variables.

Variable	Normal LOS n = 9726 (78.2%)	Prolonged LOS n = 2717 (21.8%)	Differences between variables[a]
Surgical site infection			
Superficial	709 (7.3%)	370 (13.6%)	6.3%
Deep	92 (1%)	92 (3.4%)	2.4%
Organ/Space	153 (1.6%)	271 (10%)	8.4%
Wound dehiscence	68 (0.7%)	134 (4.9%)	4.2%
DVT/PE	97 (1%)	155 (5.7%)	4.7%
Urinary infection	211 (2.2%)	202 (7.6%)	5.4%
Pneumonia	77 (0.8%)	290 (10.7%)	9.9%
Unplanned intubation	70 (0.7%)	246 (9.1%)	8.4%
Failure to wean	51 (0.5%)	377 (13.9%)	13.4%
Sepsis	197 (2%)	382 (14.1%)	12.1%
Septic Shock	92 (1%)	280 (10.3%)	9.3%
Reoperation	257 (2.6%)	507 (18.7%)	16.1%
Morbidity probability[b]	14 (11 – 19)%	23 (17-36%)	9%
Mortality probability[b]	0.4 (0.1 – 2)%	2 (0.7 – 5)%	1.6%

Categorical variables expressed as absolute numbers with percentage in parenthesis. Continuous variables expressed as medians and inter-quartile ranges. DVT, deep venous trombosis; PE, pulmonary embolism.

[a]Due to the larger sample size all variables were statistically significant different ($p < 0.001$) even without a real clinical difference. The differences between variables are shown in the last column and were calculated for each variable subtracting the higher incidence from the lower incidence. For continuous variables the difference between the medians were expressed.

[b]Values calculated by the ACS – NSQIP team.

pre-operative were of major importance for LOS: On the other hand, for patients with post-operative complications, the top four factors impacting LOS were septic, respiratory and infectious complications, in addition to post-operative deep venous thrombosis. A limitation of this approach is that it created samples that cannot be found in daily practice; therefore, we decided to analyze all patients together, regardless of the occurrence of post-operative complications. Moreover, as the median LOS varied in accordance to the type of surgical procedure, we evaluated the factors associated with prolonged LOS within each surgical group, and, in fact, we verified that, except by pre-operative hypoalbuminemia, pre-operative anemia and need for reoperation, the factors associated with prolonged LOS for each procedure were different in each surgical group.

Table 4 – All patients: Multivariate analysis using prolonged LOS as dependent variable.

All Patients		
Variable	OR	99% CI
CHF	3.05	1.50 - 6.51
Alb < 3.5 g/dL	2.28	1.84 - 2.82
Hct < 37%	1.95	1.58 - 2.41
Sepsis	1.93	1.35 - 2.75
Male	1.37	1.13 - 1.67
CD	2.00	1.17 - 3.41
CVA	1.70	1.13 - 2.53
Weight loss	1.50	1.07 - 2.09
Age > 65 years	1.31	1.04 -1.64
Open Surgery	2.42	1.54 - 3.94
ASA class 3 or 4	1.49	1.18 - 1.88
Op time > 190 min	1.40	1.12 - 1.74
CRA	0.72	0.55 - 0.93
Pneumonia	3.74	2.1 – 6.52
Failure to wean	3.60	1.80 - 7.56
DVT/PE	3.16	1.71 - 5.91
Reoperation	2.93	2.00 - 4.29
Sepsis	2.54	1.70 - 3.79
Organ Space SSI	2.34	1.42 - 3.83
Urinary infection	1.91	1.23 - 2.96
Superficial SSI	1.74	1.29 - 2.34
ProbMorb > 22%	1.71	1.30 - 2.25

Alb, serum albumin; ASA, American Society of Anesthesiologists classification; CD, Crohn's disease; CHF, congestive heart failure; CI, confidence interval; Cr, serum creatinine; CRA, colectomy with colorectal anastomosis; CVA, cerebral vascular accident; DVT, deep venous thrombosis; Hct, hematocrit; IleoCol, ileocolectomy; Op time, operative time; OR, odds ratio; PCS, palliative care service; PE, pulmonary embolism; SegCol, segmental colectomy; SSI, surgical site infection.

Our study has limitations typical of a retrospective researchs. The first is related to the use of ACS-NSQIP database. One could argue that the increased availability of surgical instruments and other medical resources in some U.S. hospitals compared to Brazilian hospitals could limit the applicability of our results. However, we believe these possible differences would not be significant enough to influence the operative results, as there are no major difference in postoperative results from Brazilian institutions when compared to those from US hospitals.[11-19]

Another limitation is related to definition of prolonged LOS used in this study. Although one could consider it arbitrary, there is no standard definition available in the literature and we believe that defining prolonged LOS as a LOS within the 4th quartile for LOS makes clinical and statistical sense. Another limitation is the fact that surgical procedures and diagnosis were selected based on the CPT and the international classification of diseases (ICD-9) codes, which sometimes may not have enough accuracy to determine the exactly procedure performed.

Finally, despite the ACS-NSQIP team provides a full training to all registered nurses responsible for data collection and entry, the fact that the database is filled by several individuals from a variety of hospitals increase the probability for potential inaccuracies.

Conclusion

In conclusion this study demonstrated factors associated with prolonged LOS after major colorectal procedures. Our data is

Table 5 – Ileocol, SegCol and CRA: Multivariate analysis using prolonged LOS as dependent variable.

IleoCol			SegCol			CRA		
Variable	OR	99% CI	Variable	OR	99% CI	Variable	OR	99% CI
Alb < 3.5 g/dL	2.67	2.01 - 3.56	Hct < 37%	2.32	1.50 - 3.59	Alb < 3.5 g/dL	2.23	1.28 - 3.85
Hct < 37%	1.96	1.47 - 2.62	Alb < 3.5 g/dL	1.67	1.08 - 2.56	Hct < 37%	1.79	1.08 - 2.96
Sepsis	1.95	1.21 - 3.15	Male	1.58	1.06 - 2.37	Reoperation	5.26	2.02 - 13.59
Male	1.34	1.03 - 1.75	CHF	6.19	1.19 – 44.07	Superficial SSI	2.51	1.31 - 4.69
CHF	2.50	1.04 - 6.43	CVA	2.44	1.07 - 5.48	Pneumonia	3.75	1.06 - 13.19
Cr >1.2 mg/dL	0.68	0.47 - 0.99	Failure to wean	6.55	1.53- 37.03	Septic shock	5.48	1.05 - 33.01
Weight loss	1.59	1.01 - 2.49	Sepsis	2.6	1.23- 5.60			
Open Surgery	3.59	1.83 - 7.76	Reoperation	2.5	1.13- 5.54			
ASA class 3 or 4	1.68	1.23 - 2.31	Urinary infection	3.17	1.14- 8.84			
Op time > 190 min	1.40	1.03 - 1.90	Superficial SSI	2.01	1.08- 3.66			
Failure to wean	4.19	1.64 – 11.8	DVT/PE	3.52	1.13- 12.15			
Pneumonia	3.55	1.67 - 7.88	Pneumonia	3.13	1.04- 9.95			
DVT/PE	3.44	1.49 - 8.12						
Sepsis	2.95	1.62 - 5.40						
Reoperation	2.87	1.72 - 4.81						
Org Space SSI	2.68	1.31 - 5.51						
ProbMorb > 22%	2.07	1.43 - 3.01						

useful for surgeons to explain prolonged length of stay to administrators or payers who are critical of this metric.

Conflict of interest

The authors declare no conflict of interest.

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