

# Laparoscopic vs open colorectal surgery

## Economic and clinical outcomes in the Brazilian healthcare

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### Abstract

Laparoscopic surgery has become the preferred surgical approach of several colorectal conditions. However, the economic results of this are quite controversial. The degree of adoption of laparoscopic technology, as well as the aptitude of the surgeons, can have an influence not only in the clinical outcomes but also in the total procedure cost. The aim of this study was to evaluate the clinical and economic outcomes of laparoscopic colorectal surgeries, compared to open procedures in Brazil.

All patients who underwent elective colorectal surgeries between January 2012 and December 2013 were eligible to the retrospective cohort. The considered follow-up period was within 30 days from the index procedure. The outcomes evaluated were the length of stay, blood transfusion, intensive care unit admission, in-hospital mortality, use of antibiotics, the development of anastomotic leakage, readmission, and the total hospital costs including re-admissions.

Two hundred eighty patients, who met the eligibility criteria, were included in the analysis. Patients in the laparoscopic group had a shorter length of stay in comparison with the open group ( $6.02 \pm 3.86$  vs  $9.86 \pm 16.27$ ,  $P < .001$ ). There were no significant differences in other clinical outcomes between the 2 groups. The total costs were similar between the 2 groups, in the multivariate analysis (generalized linear model ratio of means 1.20,  $P = .074$ ). The cost predictors were the cancer diagnosis and age.

Laparoscopic colorectal surgery presents a 17% decrease in the duration of the hospital stay without increasing the total hospitalization costs. The factors associated with increased hospital costs were age and the diagnosis of cancer.

**Abbreviations:** CI = confidence interval, GLM = generalized linear model, ICD = International Classification of Diseases, ICU = intensive care unit, LOS = length of stay, RR = relative risk.

**Keywords:** colorectal surgery, cost analysis, laparoscopy

### 1. Introduction

Laparoscopic surgery has become the preferred method in the surgical treatment of several colorectal diseases. Many studies, including randomized clinical trials, have shown that laparoscopic access is both effective and safe, with better short-term

results in patient recovery compared to the open surgical approach.<sup>[1–14]</sup>

Regarding long-term clinical outcomes, studies have shown that there are no differences between laparoscopic or open surgery in cancer patients, or that laparoscopic surgery is superior

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. By doing so, we confirm that we have followed the regulations of our institutions concerning intellectual property.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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to open surgery in the disease-free survival rate of colonic resections.<sup>[1,9,14–18]</sup>

Regarding the economic outcomes, the evidence is rather controversial. Although a few publications have shown that laparoscopic colorectal surgery is more costly, despite the better short-term clinical outcomes,<sup>[19–22]</sup> others have demonstrated that laparoscopy may be either cost-neutral or yield savings from the perspective of hospitals and the payers.<sup>[4,10,11,23–26]</sup>

The difference in the results might be explained by the impact of the cost of the device in the total hospital cost, according to the healthcare system and health technology incorporation characteristics of each country.<sup>[27]</sup> Besides, laparoscopy adoption in a country, as well as the degree of aptitude of the surgeons can influence the clinical outcomes and, consequently, the total procedure cost.<sup>[20,28–30]</sup> Some publications have shown that after the learning curve period, laparoscopic surgery may either be cost-neutral, or cost-saving compared to the open surgical approach.<sup>[31]</sup>

Thus, the objective of this study was to evaluate the clinical and economic outcomes of laparoscopic colorectal surgeries, compared to open procedures, in the Brazilian private healthcare system according to the perspective of the payers and providers.

## 2. Methods

### 2.1. Study design

The study was a retrospective cohort. The dataset used for the analyses was a hospital patients' billings database (reimbursement information) from Orizon. The database contains information about the transaction between health insurance plans and hospitals from the Brazilian private healthcare system, including all the billed items during hospital admissions. It also contains information from ambulatory service transactions. About 12 million patients – who represent around 25% of patients in the Brazilian private healthcare system – are included in Orizon's registries.

All patients who were admitted between January 2012 and December 2013 who underwent rectum or sigmoid colon procedures (hereafter referred to as colorectal surgeries) were considered potentially eligible. The TUSS codes used to determine the procedures were: 31003559 – retosigmoidectomy abdominal (abdominal rectosigmoidectomy) and 31003796 – retosigmoidectomy abdominal por videolaparoscopia (laparoscopic abdominal rectosigmoidectomy). The eligible patients had their procedure in multiple location across different states in Brazil, but due to confidentiality rules, the location of the patients was not described in the dataset.

The following eligibility criteria were used for the inclusion of patients:

- Availability of age, gender, international classification of diseases (ICD) code information and surgical approach (laparoscopic vs open);
- The procedure should be elective (urgent surgeries were excluded).
- The colorectal surgery must have been performed in a maximum of 3 days after hospital admission;

The outcomes of perioperative procedures and readmission for up to 30 days were analyzed. As all the analyzed data were obtained from the administrative claims data of the routine care of the patients and were made anonymous by the researchers, no

informed consent was required. Lastly, as there was no possibility of any harm arising as a result of the conduct of this research, no Ethical Review Board approval was required.

### 2.2. Study variables

The Patients were grouped according to surgical approach (laparoscopic vs open). The following variables were evaluated for each patient: age, gender, ICD code for the admission related to the surgery: cancer status, use of chemotherapy and radiotherapy, extent of the surgery (multivisceral resection vs simple procedures), need for perioperative blood transfusion, length of stay (LOS), intensive care unit (ICU) admission, 30-day readmission, the use of antibiotics, mortality, the occurrence of anastomotic leakage, and hospital costs.

Surgical treatment involving only the rectum or sigmoid colon with or without lymph nodes resection and with or without colostomy associated, were classified as simple procedures. If an additional procedure including hysterectomy, oophorectomy, or cystectomy were billed on the same day of the colorectal procedure, the surgery was classified as a multivisceral resection.

Perioperative transfusion was defined as the use of a concentrate of red blood cells between the date of surgery and the following 30 days. Readmissions were defined whenever a patient had billed items for at least 2 consecutive days. Only an emergency room visit was not considered readmission.

The rate of the use of postoperative antibiotics was defined as a postoperative exposure (up to 30 days from index surgery) to antimicrobial drugs, which suggested a therapeutic use – whenever the utilization was suggestive of prophylaxis, it was not considered. The criteria used were: prescriptions for at least 7 days and use of 1 of the following antimicrobials: carbapenems, 3<sup>rd</sup> and 4<sup>th</sup> generation cephalosporins, vancomycin, aminoglycosides, piperacillin, and a combination of quinolones with either clindamycin or metronidazole.

The definition of anastomotic Leakage occurrence was the result of the simultaneous presence of the following conditions:

1. The patient had an infection under investigation, where the proxy used was the billing of a postoperative blood culture exam;
2. There was at least 1 postoperative imaging study, such as an abdominal X-ray, computerized tomography or another abdominal exam with an intravenous contrast.
3. A second surgical abdominal procedure or image-guided percutaneous drainage must have been undertaken up to 30 days after the index surgery.

Hospital costs were categorized as index admission costs, which included all billed items during the index surgery admission, and 30-day readmissions costs, which included all the billed items from any other hospital admission initiated within 30 days of the index surgery. In both cases, we did not use a termination date. If the index admission or a readmission began in less than 30 days after the index surgery and lasted for example 4 months, all expenditures associated with this admission were included. The total patients' costs were also calculated - by summing the costs of the index admission and 30-day readmission.

### 2.3. Statistical analysis

Categorical variables are presented as absolute values and proportions, and continuous variables are presented as the mean

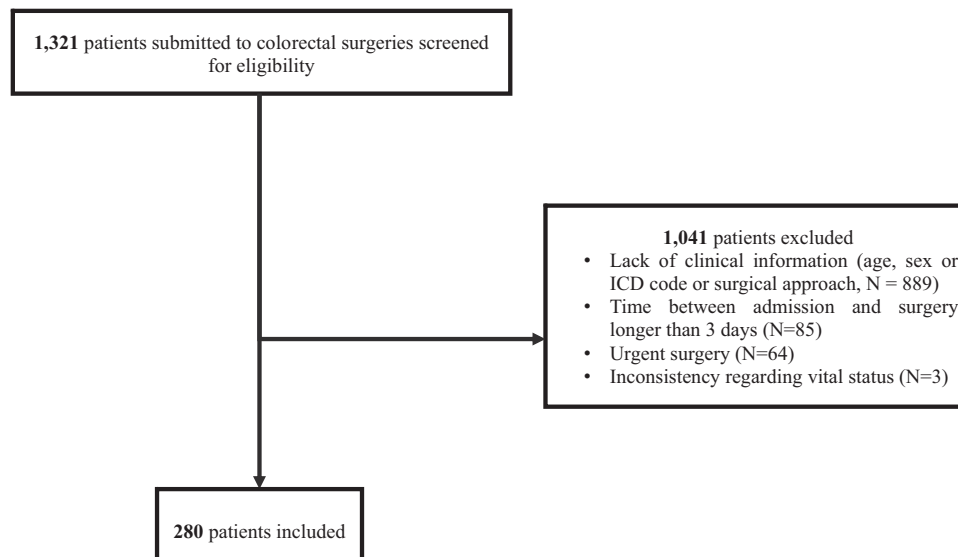


Figure 1. Flowchart of the patient selection for the study.

and standard deviation. Comparison between the laparoscopic versus open surgery groups employed the Student Fisher exact test for categorical variables and the Student *t* test for continuous variables with normal distribution. Considering that both costs and LOS, the 2 main continuous outcomes of this study, usually present a gamma distribution, we also employed univariate generalized linear model (GLM) with the gamma distribution for these analyses.

Multivariate analyses used Poisson regression for dichotomous outcomes (which was chosen as some of the outcomes had an incidence much larger than 10%, contraindicating logistic regression) and GLMs for costs and LOS. Variables with a *P* value of .10 or less in the univariate analyses were selected to enter the multivariate analyses. In all analyses, a *P* value smaller than .05 was considered statistically significant. SPSS (Statistical Package for Social Sciences, version 20.0, Chicago, IL, USA) was used for the analyses.

### 3. Results

Among 1,321 potentially eligible patients, 280 fulfilled the eligibility criteria and were included in the analyses (Fig. 1). The group of patients operated laparoscopically were younger (mean age of 47 years, vs 53 in the open surgical group, *P* = .001), and had a smaller proportion of cancer diagnosis (17.2% vs 41.5% in the open surgical group, *P* < .001), as shown in Table 1.

The proportion of male patients and multivisceral resections did not show a statistically significant difference. Although the comparison of the 2 groups showed a higher proportion of patients receiving chemotherapy in the open surgery group, the proportion of such patients considering only the ones with cancer in each group did not reach statistically significant difference (15.0% in the laparoscopic vs 27.9%, *P* = .379).

In the univariate analysis evaluating clinical outcomes (Table 2), the proportion of patients with blood transfusion requirement and ICU admissions was smaller in the laparoscopic group. In the multivariate analysis, however, these outcomes did not reach the statistically significant differences (adjusted relative

risk [RR] for transfusion need = 0.54, 95% confidence interval [CI] 0.27–1.05, adjusted RR for ICU admission = 0.84, 95% CI 0.65–1.09).

Patients in the laparoscopic surgery group had a shorter LOS, which was reduced by 17% (95% CI: 2%–30%) in the analysis adjusted for age, gender, cancer status, and multivisceral resection. The incidence of anastomotic leak, readmissions, use of antibiotics and the mortality rate did not differ between the 2 groups.

The mean index admission costs (presented in Table 3) were lower in the laparoscopic group (R\$ 32,915, vs R\$ 41,652 in the open surgery group, *P* = .024), as well as total costs, where 30-day readmissions were also computed (R\$ 35,424 in the laparoscopic vs R\$ 44,461 in the open surgery group, *P* = .026).

Table 1

Demographics and perioperative data of the study cohort according to surgical approach.

Variable	Laparoscopic (N=116)	Open (N=164)	<i>P</i> value
Male gender	37 (31.9)	68 (41.5)	.132 <sup>a</sup>
Age	47.3 ± 13.5	53.4 ± 14.8	.001 <sup>b,*</sup>
ICD code			< .001 <sup>c,*</sup>
Gastrointestinal cancers	18 (15.5)	57 (34.8)	
Other cancers	2 (1.7)	11 (6.7)	
Endometriosis	32 (27.6)	12 (7.3)	
Diverticular disease	17 (14.7)	10 (6.1)	
Other	47 (40.5)	74 (45.1)	
Chemotherapy	4 (3.4)	19 (11.6)	.015 <sup>a,*</sup>
Radiotherapy	3 (2.6)	11 (6.7)	.165 <sup>a</sup>
Multivisceral resection	42 (36.6)	62 (37.8)	.803 <sup>a</sup>

Data is presented as number of patients (%) except for age, which is expressed as mean ± standard deviation.

ICD = International Classification of Diseases.

\* significant at *P* < .05.

<sup>a</sup> Fisher exact test.

<sup>b</sup> *T* test.

<sup>c</sup> Chi-Squared.

**Table 2**  
**Clinical outcomes of 280 patients according to surgical approach.**

Outcomes	Laparoscopic (N = 116)	Open (N = 164)	Crude RR (95% CI)	P value	Adjusted RR (95% CI)	P value
LOS	6.02 ± 3.86	9.86 ± 16.27	0.59 (0.50–0.70)	<.001*	0.83 (0.70–0.98)	.034*
Blood transfusion	11 (9.5)	33 (20.1)	0.47 (0.25–0.89)	.019*	0.54 (0.27–1.05)	.069
ICU admission	43 (37.1)	92 (56.10)	0.66 (0.50–0.87)	.002*	0.84 (0.65–1.09)	.19
Mortality	1 (0.9)	5 (3.0)	0.28 (0.03–2.39)	.406		
Use of antibiotics	50 (43.1)	77 (47.0)	0.92 (0.70–1.20)	.54		
Anastomotic leak	5 (4.3)	9 (5.5)	0.78 (0.27–2.28)	.784		
Readmission	12 (10.3)	17 (10.4)	0.99 (0.49–2.00)	1.000		

Data is presented as N (%) except for LOS, which is presented as mean ± standard deviation. Crude relative risks (which presents the comparison of laparoscopic vs open) were calculated from contingency tables, except for the LOS, where a generalized linear model was employed (both in the crude and adjusted relative risk). Adjusted relative risk (except for length of stay [LOS]) were calculated with Poisson regression. Adjusted analyses were conducted only in outcomes with  $P < .05$  in the univariate analysis. The analyses included co-variables with  $P < .10$  in univariate analysis: age (for the 3 multivariable analysis), cancer status and gender (for the blood transfusion and LOS models) and multivisceral procedure (for the LOS model).  $P$  values were obtained with Fisher exact test (in univariate analysis) and Poisson regression (in the multivariable analysis) for all variables except for LOS, which was calculated with generalized linear model. CI = confidence interval, ICD = International Classification of Diseases, LOS = length of stay, RR = relative risk.

\* significant at  $P < .05$ .

Conversely, in the GLM multivariate analysis of total costs (Table 4), with adjustments for age, gender, and cancer status, the means' ratio was not statistically significant: 1.20, 95% CI 0.98–1.46 ( $P = .074$ ). Results for the index admission costs were very similar (data not being shown). The predictors that remained statistically significant in the multivariate analyses were the status of cancer (GLM ratio of means = 1.84, 95% CI 1.48–2.28) and the age (GLM ratio of means = 1.02, 95% CI 1.01–1.02).

#### 4. Discussion

In this study, which compared economic and clinical outcomes between laparoscopic and open colorectal surgery in a sample of patients from the Brazilian private healthcare system, the main difference between the 2 groups was the LOS. After adjustment for age, gender, cancer status, and multivisceral resection in the multivariate analysis, the LOS was 17% shorter (95% CI: 2%–30%) in the laparoscopic group. This result is comparable to those found in the literature that show that laparoscopic rectal surgeries present a shorter hospitalization period compared to open surgeries.<sup>[1,2,4,7,9,11–14,21,24]</sup>

Regarding the other clinical outcomes in the current study, patients had a lower need of blood transfusion and a smaller ICU admission rate in the univariate analysis. However, these associations did not maintain statistical significance in the multivariate analysis. The requirement for blood transfusions, which showed a 53% decrease in univariate analysis (95% CI: 11%–75%), lost its significance in the analysis adjusted for age, gender, and the cancer status (RR = 0.54, 95% CI: 0.27–1.05,  $P = .069$ ). The ICU admission rates, which were reduced by 34% in the univariate analysis, lost its significance in the analysis adjusted for age (RR = 0.84, 95% CI: 0.65–1.09,  $P = .19$ ). It is likely that the analysis of clinical outcomes suffered from

insufficient statistical power, especially for mortality, where the number of events was small.

The results regarding index admission and total expenses (which included 30-day readmissions) demonstrated that the laparoscopic approach is not more costly than open surgery. In fact, in the univariate analysis, laparoscopic surgery was associated with a lower cost when compared to the open approach and presented a lower standard deviation, which could suggest that laparoscopy has a greater predictability of total costs in comparison with the open surgery (35,424 ± 18,350 vs 44,461 ± 95,789,  $P = .026$ ). However, this comparison lost statistical significance in the multivariate GLM. Age and cancer diagnosis were identified as independent risk factors to increase the total hospital costs in colorectal procedures (multivariate estimate: 1.02, 95% CI: 1.01–1.02,  $P < .001$ ) and (multivariate estimate: 1.84, 95% CI: 1.48–2.28,  $P < .001$ ), respectively.

This study shows that, in the Brazilian private healthcare system scenario, laparoscopic colorectal surgery is not more expensive than the open procedure. This cost comparison has a great variability in the literature, which suggests that the impact of the cost of medical devices in the total hospital costs, can be the leading cause to determine if laparoscopy is cost-saving or expensive.<sup>[19,21,22,32]</sup>

The cost balance between the 2 surgical approaches occurs when the reduction of postoperative costs, resulting from better short-term clinical outcomes, compensate higher intraoperative costs, which can result in cost neutrality or even saving costs. In addition to the present study, other studies in the literature have found cost neutrality between the open and laparoscopic approach.<sup>[4,10,33]</sup>

In a study with rectal cancer patients, which used propensity score matching, laparoscopy had intraoperative costs which were 21% higher than the open approach ( $P < .001$ ). However, non-surgical costs, including laboratory, radiology, and nursing post-operative care were lower in the laparoscopic group. The total costs were 7% lower in the laparoscopic group, although this difference was not significant.<sup>[4]</sup>

It should be noted that the studies that evaluated the costs of open and laparoscopic colorectal procedures are mostly focused on rectal cancer. The present study aimed to evaluate all diseases that required colorectal surgical intervention, including benign diseases, showing that laparoscopic surgery may be cost-neutral in comparison to the open surgery in a wider population as well.

**Table 3**  
**Cost outcomes (Brazilian R\$) according to surgical approach.**

Time period	Laparoscopic (N = 116)	Open (N = 164)	P value
Index admission	32,915 ± 16,314	41,652 ± 95,127	.024*
Readmissions	2508 ± 7511	2808 ± 13,679	.650
Total costs	35,424 ± 18,350	44,461 ± 95,789	.026*

Values are expressed as mean ± standard deviation. The  $P$  value was calculated with a univariate generalized linear model, with gamma distribution for costs.

\* significant at  $P < .05$ .

**Table 4****Generalized linear model for total costs.**

Variable	Crude estimate	95% CI	P value	Multivariate estimate	95% CI	P value
Laparoscopy	0.80	0.65–0.97	.026*	1.20	0.98–1.46	.074
Age	1.02	1.01–1.03	<.001*	1.02	1.01–1.02	<.001*
Male gender	1.59	1.30–1.94	<.001*	1.03	0.83–1.28	.78
Cancer	2.03	1.66–2.48	<.001*	1.84	1.48–2.28	<.001*
Intercept				11,616	7944–16,986	<.001*

Multivariate analysis of each variable included all the other variables from this table as possible confounders. CI=confidence interval.

\*significant at  $P < .05$ .

This comparative evaluation of the costs and clinical outcomes from a hospital and payer perspective is unprecedented in the Brazilian private healthcare system, and its importance lies in the fact that the budgetary constraints imposed on the private health systems have been aggravated by the medical scenario and the scenario of the country's economic recession.

Some limitations in our study must be acknowledged.

The database used for all analyses was based on the patients' billing information. This approach presents the risk of bias of other retrospective studies, and the limitations secondary to the lack of individual clinical patient information. A better adjustment in the multivariate models would probably be achieved with more detailed clinical information.

The exclusion of the majority of the original sample (secondary to eligibility criteria) can lead to selection bias and compromise the generalizability of the study. In this regard, the high proportion of patients with an endometriosis ICD code is noteworthy. Although this disease is seldom presented as a frequent motive for colorectal surgeries, its rate can be substantial, as seen in a national colorectal surgeries database from France.<sup>[34]</sup> One possible explanation for the high proportion of endometriosis in this study is that, considering that the disease is fairly uncommon, an indication for colorectal surgeries, the physician might have informed this ICD code more accurately than other diseases, in order to receive approval by the health insurance plans. Since our inclusion criteria demanded information about the ICD code, the high proportion of endometriosis in the sample might be the consequence of better filling of this information by physicians.

Lastly, some of the 95% CI from the estimates were substantially wide (except in the costs GLM), suggesting that a larger sample would be important to confirm some of our findings.

## 5. Conclusion

The Real-World Evidence of the Brazilian Healthcare System shows that laparoscopic colorectal surgery presents a 17% decrease in the hospital stay time without increasing the total hospitalization costs. Factors associated with increased hospital costs were age and the diagnosis of cancer. These findings suggest that the laparoscopic procedure may be considered the preferred procedure in patients submitted to colorectal surgery, regardless of the type of pathology, whenever there are no contraindications. The study also concludes that the laparoscopic method can be economically sustainable even in developing countries that present budgetary constraints.

## Author contributions

All authors had full access to all the data in the study and assumed responsibility for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved. Furthermore, all authors were accountable for the parts of the work they did, able to identify which co-authors were responsible for specific other parts of the work and confident in the integrity of the contributions of their co-authors. Ulysses Ribeiro Jr affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained. Ulysses Ribeiro Jr, Daiane Oliveira Tayar, Rodrigo Antonini Ribeiro, Priscila Andrade, and Silvio Mauro Junqueira Jr had substantial contribution to the conception and design of the work; Ulysses Ribeiro Jr, Daiane Oliveira Tayar, and Rodrigo Antonini Ribeiro had substantial contribution in the data acquisition and/or analysis and interpretation of the data of the work; Daiane Oliveira Tayar and Rodrigo Antonini Ribeiro drafted the manuscript; Ulysses Ribeiro Jr, Daiane Oliveira Tayar, Priscila Andrade, and Silvio Mauro Junqueira Jr reviewed the article critically for important intellectual content; all authors provided the final approval of the version to be published.

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