Original Article

Risk Factors for Predicting Conversion in Laparoscopic Colorectal Cancer Surgery

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Key Words
Laparoscopic surgery;
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Purpose. To identify the risk factors for malignancy-related conversion in laparoscopic colorectal resections.
Methods. We retrospectively analyzed all laparoscopic colorectal cancer surgeries performed between July 2007 and December 2010 by 1 specialist to investigate the risk factors for conversion.
Results. Of the 280 laparoscopic colorectal cancer surgeries, 16 were converted to open surgery, an overall conversion rate of 5.7%. Univariate analysis revealed that a body mass index (BMI) of > 27 kg/m^2, T4 lesions, and being among the first 20 operations performed by the surgeon were factors significantly associated with conversion. Multivariate analysis also showed that a BMI of > 27 kg/m^2 (p = 0.025), T4 lesions (p = 0.001), and being among the first 20 operations (p = 0.001) were independent factors of conversion. Other factors, such as gender, age, tumor location, tumor size, TMN staging, any metastasis, neo-adjuvant treatment, pre-op carcinoembryonic antigen (CEA) level, and albumin level, showed no influence on the likelihood for conversion.
In our study, the reasons for conversion fell into 3 categories: (1) patient-related factors, such as obesity, adhesion, and enlarged ovaries, (2) disease-related factors, including tumor invasion of adjacent organs such as the bladder, small bowel, and abdominal wall, and (3) surgery-related factors such as uncontrollable bleeding, vessel disruption, and difficult localization of the tumor.
Conclusion. A BMI exceeding 27 kg/m^2, T4 lesions, and being among the first 20 cases (the learning curve) all correlated with conversion risk in this study. These factors should be taken into consideration during the preoperative evaluation.
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Since the first laparoscopic colonic resection performed by Dr. Jacobs in 1991,[1] several randomized trials have confirmed the feasibility and the safety of laparoscopic colorectal surgery.[2-4] However, some concerns about this procedure still need to be addressed.

One of the major concerns is regarding intra-operative conversion from laparoscopic to open surgery. Conversion rates from 2% to more than 40% have been reported by several investigators.[5,6] Additionally, conversion may negate some of the benefits of laparoscopic surgery, resulting in short-term complications that include an increased rate of wound infec-

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tions, higher rates of anastomotic leaks, longer hospital stays,[7] increased rates of postoperative morbidity and mortality,[2-4,8] and even adverse survival outcomes for patients with stage I-III colorectal cancer.[9] Our objective was to determine the factors affecting conversion and to improve the conversion rate.

Materials and Methods

We analyzed all cases of colorectal cancer treated laparoscopically by a particular specialist (S-H Y) between July 2007 and December 2010. Two hundred and eighty patients were included in our study.

Conversion to open surgery is defined as "any incision made earlier than planned".[10] The pre-morbid status, intra-operative findings, and operative outcomes were retrospectively analyzed from our prospectively compiled database.

We determined whether various clinicopathological characteristics could predict conversion. Eleven variables that could be associated with open conversion were analyzed. These included age (70 years), gender, BMI (27 kg/m^2, defined as overweight), tumor location (right colon, left colon, or rectum), tumor invasion depth (Tis-3, T4), TNM stage (stage I & II, III & IV), any pre-operative neo-adjuvant treatment, learning curve (checking whether a particular operation was among the surgeon's first 20 operations), tumor size (5 cm), pre-operative (pre-op) carcinoembryonic antigen (CEA) level (6 ng/mL), and pre-op albumin (3.5 g/dL). A chi-square test was performed for univariate analysis of the prognostic value of these variables. All variables that showed $p < 0.1$ were also entered into the multivariate model. Multivariate analysis was performed using the multiple logistic regression method, and $p < 0.05$ was considered statistically significant. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. Statistical analyses were performed using SPSS software (version 16.0 for Windows, SPSS, Chicago, IL, USA).

Results

Two hundred eighty patients were enrolled in the study between July 2007 and December 2010. The majority of the patients were men (n = 162, 58%), and the median age was 66 years old (range: 27-96 years). The median BMI was 23 kg/m^2 (range: 16-34 kg/m^2); the median pre-op albumin level was 4.0 g/dL (range: 2.3-5.1 g/dL); and the median CEA level was 2.55 ng/mL (range: 0.67-3473 ng/mL). Most of the procedures performed were RH, AR, and LAR, comprising about 78% of all the procedures performed. The median operating time was 230 minutes (range: 90-600 minutes), and the median blood loss was 50 mL (range: 10-1650 mL). The median tumor size was 4 cm (range: 0.5-11 cm), and the median number of harvested lymph nodes was 16 (range: 0-57). Thirty-four patients had received blood transfusions.

A total of 16 surgeries (5.7%) required conversion. The reasons for conversion can be categorized into 3 main groups: the first groups includes patient factors (n = 6), such as obesity (n = 2), easy bleeding due to low platelet count (n = 1), adhesion (n = 2), and enlarged ovaries (n = 1); the second group includes disease-related factors (n = 5) such as tumor invasion of adjacent organs, including urinary bladder (n = 3), small bowel (n = 2), and abdominal wall (n = 1); the third group included surgery-related factors (n = 5) such as uncontrollable bleeding (n = 2), vessel disruption (n = 2), and difficult localization of the tumor (n = 1). This information is compiled into Table 1.

Table 2 shows a comparison between cases with and without conversion, in terms of patient and tumor characteristics and treatment-related variables. Univariate analysis revealed that BMI > 27 kg/m^2 (p = 0.016), T4 lesions (p = 0.000), and the being part of the learning curve (p = 0.02) were significantly associated with an increased conversion rate. Multivariate analysis further showed that these factors were independent factors of conversion (p = 0.025, 0.001, 0.001, respectively). The results of the multivariate analysis are shown in Table 3. Other factors that were assessed, such as gender, age, tumor location, tumor size, TMN staging, any neo-adjuvant treatment before operation, and pre-op CEA and albumin (the nutrition status) levels, showed no influence on conversion.

Table 1. The information of 16 conversions

Sex	Age	Tumor location	Reason for conversion
I: patient-related factors			
Male	81	Sigmoid colon	Severe adhesion
Female	56	Middle rectum	Severe adhesion due to previous hysterectomy
Male	69	Cecum	Obesity
Male	69	Transverse colon	Obesity and bulky tumor
Female	73	Upper rectum	Huge left ovarian cyst
Female	81	Sigmoid colon	Easy bleeding due to low platelet count
II: disease-related factors			
Male	62	Sigmoid colon	Urinary bladder invasion
Male	77	Sigmoid colon	Urinary bladder invasion
Male	96	Upper rectum	Ileum and urinary bladder invasion
Female	62	Transverse colon	Small bowel invasion
Female	52	Sigmoid colon	Abdominal wall invasion
III: operator-related factors			
Female	58	Middle rectum	Presacral bleeding
Male	81	Ascending colon	Check bleeding
Male	61	Sigmoid colon	Marginal artery disruption
Male	66	Middle rectum	Re-anastomosis due to poor blood perfusion
Male	80	Sigmoid colon	Difficult localization of the tumor

Discussion

The overall conversion rate in our study was 5.7%, which was lower than what has been observed in other large studies, such as 19% in the COLOR trial[3] and 27% in the MRC-CLASICC trial.[4] In fact, a meta-analysis[8] for laparoscopic colorectal resections that included 28 studies with more than 3,000 patients reported a conversion rate of 15.4% (1.9-40.9%).[5,6]

In most studies, the definition of the term "conversion" was not addressed. Conversion rates between 17% and 29% were previously reported for laparoscopic colorectal resections in prospective randomized multicenter trials.[2-4,11-13] In other non-randomized studies with over 100 colorectal resections, conversion rates varied from 2% to 41%.[8,9,14,15] This variation could be explained by a lack of consistency in the definition of conversion. In this study, we adopted the generally accepted definition of conversion to be "any incision made earlier than planned".[10]

Another possible reason for the lower conversion rate in our study may be our careful patient selection. Because there are possible adverse effects of conversion, candidates for laparoscopic surgery are carefully selected.

In a MRC-CLASICC follow-up trial,[16] the authors categorized the factors influencing conversion into 3 groups: patient-related factors (tumor stage, obesity, and previous abdominal surgery), surgeon-related factors (learning curve, experience, and technical ability), and procedural factors (site of cancer and equipment failures). Because we believe this classification is very useful in defining reasons for conversion, we used a similar categorization. We found that adhesion and obesity were still major patient-related factors, comprising 4 out of 16 (25%) conversions. Disease-related factors, specifically, local invasion of the tumor to adjacent organs, were responsible for 5 out of 16 (31.25%) conversions. However, the invasions might have not been clearly seen during the pre-op image studies. As for surgery-related factors, bleeding and vessel disruption were the major reasons for conversion. These intra-operative complications could have been avoided by using delicate technique and increasing the experience levels of the surgeons.[15,17]

Several studies have tried to identify conversion predictors in patients undergoing laparoscopic surgeries for both benign[18] or malignant[19,20] colorectal cancers. In our study, we focused only on malignant cancer cases and identified 3 risk factors: BMI of > 27

Table 2. Univariate analysis of risk factors for conversion

Variables	Conversion		*p*
	No	Yes	
Gender			0.798
Female	112 (40.0%)	6 (2.1%)	
Male	152 (54.3%)	10 (3.6%)	
Age			0.591
< 70	172 (61.4%)	9 (3.2%)	
> 70	92 (32.9%)	7 (2.5%)	
BMI			0.016
< 27	187 (77.6%)	6 (2.5%)	
> 27	42 (17.4%)	6 (2.5%)	
AJCC staging			0.603
I&II	156 (55.7%)	8 (2.9%)	
III&IV	108 (38.6%)	8 (2.9%)	
Tumor invasion depth			0.000
Tis, T1, T2, T3	256 (91.8%)	11 (3.9%)	
T4	7 (2.5%)	5 (1.8%)	
Neo-adjuvant treatment			0.077
No	144 (51.4%)	5 (1.8%)	
Yes	120 (42.9%)	11 (3.9%)	
Operation number			0.020
< 20	16 (5.7%)	4 (1.4%)	
> 20	248 (88.6%)	12 (4.3%)	
Tumor location			0.844
Right colon	84 (30.0%)	4 (1.4%)	
Left colon	102 (36.4%)	7 (2.5%)	
Rectum	78 (27.9%)	5 (1.8%)	
Tumor size			0.252
< 5 cm	190 (68.1%)	9 (3.2%)	
> 5 cm	73 (26.2%)	7 (2.5%)	
Pre-op albumin			0.068
< 3.5	35 (12.9%)	5 (1.8%)	
> 3.5	221 (81.2%)	11 (4.0%)	
Pre-op CEA			0.768
< 6	198 (71.0%)	13 (4.7%)	
> 6	65 (23.3%)	3 (1.1%)	

kg/m^2, T4 lesions, and being among the first 20 surgeries performed by a particular surgeon.

Body weight has been a predictive factor in many studies. In one study,[19] patient weight was represented as a 3-level variable, believed to be a trade-off for the model's accuracy and simplicity. A better indicator of obesity, such as BMI,[21] might be more accurate. One study showed that patients with a BMI greater than 28.5 kg/m^2 were 2.2-fold more likely to experience conversion to open surgery. Pikarsky et al.[22] also reported significantly higher conversion and complication rates in obese patients with a BMI exceeding 30

Table 3. Multivariate analysis of risk factors for conversion

Variables	OR	95% CI	*p*
BMI > 27	5.29	1.24-22.60	0.025
T4 lesion	29.72	4.19-210.97	0.001
Neo-adjuvant treatment	1.48	0.28-7.72	0.641
> 20 cases	0.05	0.01-0.29	0.001
Albumin < 3.5	0.61	0.09-4.00	0.609

kg/m^2. Examination of the BMI levels in our database revealed that a BMI > 27 kg/m^2 showed significance in both univariate analysis (p = 0.016) and multivariate analysis (OR = 5.3, p = 0.025). In general, Asian people are smaller in size than Westerners. Asian patients with a BMI > 27 kg/m^2 tend to have more adipose tissue and a "round" structure; this would result in more conversions.

T4 lesions showed the greatest significance in both univariate and multivariate analysis (OR = 29.7, p = 0.001). This is consistent with other studies.[23,24] According to recommendations of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), an open approach is required if laparoscopic en bloc resection for a T4 lesion cannot be safely performed (Level II evidence, Grade B recommendation). Thus, in our study, in patients with any T4 lesions that could not be adequately resected en bloc by laparoscopic examination, early conversion would be suggested. The structure to which the tumor is adherent, in addition to surgeon skill and experience, determines whether en bloc resection can be performed laparoscopically. When curative resection is the goal, intraoperative discovery of a T4 lesion requires careful consideration of conversion, unless the surgeon is capable of properly resecting the lesion en bloc.

Finally, inexperience has been associated with higher conversion rates in many studies,[17,19,20,25] but this was not found by Wishner et al.[26] In our study, the "learning curve" was determined to be 20 operations. We had also evaluated case numbers 30, 40, 50, and 60; they all showed no significant power in conversion. In fact, the conversion rate remained stable over the past 2 years.

One shortcoming of this study is that we did not consider the influence of previous operations,[16,27] the American Society of Anesthesiologists (ASA) score,[11,16]

underlying disease, smoking, or steroid administration.[18] Data for these factors were incomplete, and we failed to run the statistics. Another pitfall is that patient selection was largely at the discretion of the treating surgeon and varied according to the surgeon's individual experience. We acknowledge that selection criteria may have varied over the years, but this is a problem that has been recognized by other authors.[11] In addition, there was invariably some selection bias generated by analysis of retrospective reviews of laparoscopic colorectal resections, as study subjects are nonrandomized.

To summarize, even though laparoscopic-assisted bowel resections offer benefits over open techniques, such as reduced postoperative pain, less analgesic consumption, better cosmesis, faster return of gastrointestinal function, shorter hospital stay, and less expenses related to operative time and direct costs,[2,4] conversions still occur. While some studies reported no significant influence of conversion on the postoperative morbidity rate,[28] conversion is usually associated with worse perioperative outcomes, including an increase in operative time,[8,14] blood loss,[29] blood transfusion requirement,[14] wound-related complications,[13] length of hospital stay,[8,13,29] and even worse long-term postoperative morbidity and mortality rates.[5,14] On the basis of our study, surgeons should seriously consider the potential for conversion before performing operations on patients with a BMI > 27 kg/m^2 and those with T4 lesions. While the learning curve varies among surgeons, better preparation and training could shorten the surgeon's learning curve, thus being advantageous to the patients undergoing laparoscopic colorectal cancer surgery.

Conclusion

A BMI of > 27 kg/m^2, T4 lesions, and being among the surgeon's first 20 operations were all factors associated with a higher possibility of conversion; patients with these risk factors should be warned of the likelihood of conversion. Future studies will focus on the consequences of conversion, including perioperative data and long-term outcomes, such as disease-free survival, overall survival, and time to recurrence.

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原　著

腹腔鏡大腸直腸癌手術術中轉換為開腹式手術的原因分析

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目的　了解本院腹腔鏡大腸直腸癌手術術中轉換為開腹式手術的原因。

方法　我們統計自 2007 年 7 月到 2010 年 12 月，將所有接受單一醫師腹腔鏡大腸直腸癌手術的病患，與術中轉換為開腹式手術的病患進行分析。期能找出轉換為開腹式手術之原因。

結果　共有 280 位病患接受腹腔鏡大腸直腸癌手術，其中有 16 位在術中轉換為開腹式手術，比率為 5.7%。在單變異分析中，身體質量指數 (BMI) 值超過 27 kg/m^2 (輕度肥胖以上)、T4 病灶、手術例為 20 例之前等三項因子達到顯著差異；而在多變異分析中，身體質量指數 (BMI) 值超過 27 kg/m^2 (輕度肥胖以上)、T4 病灶、手術例為 20 例之前等三項因子仍達到顯著差異。其他如性別、年齡、腫瘤位置、腫瘤大小、TMN 分期、術前接受輔助性治療與否、術前血清白蛋白、CEA 的數值，都不會對腹腔鏡術式的完成造成影響。

結論　根據本院的資料統計，在單一資深大腸直腸專科手術醫師，腹腔鏡大腸直腸癌手術轉為開腹式手術的比率為 5.7%。身體質量指數 (BMI) 值超過 27 kg/m^2 (輕度肥胖以上)、T4 病灶、手術例為 20 例之前是危險因子。這些訊息將能對以後的術前評估有所幫助。

關鍵詞　腹腔鏡、大腸直腸癌、轉換。