

# Conversion risk factors in laparoscopic colorectal surgery

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## Abstract

**Introduction:** This study is aimed at identifying important risk factors associated with conversion of laparoscopic colorectal surgery. Laparoscopic surgery is usually associated with less operative trauma, more favourable post-operative course and lower morbidity than open surgery. However, conversion is connected with some risks according to some authors.

**Aim:** To identify the risk factors associated with conversion and to create a model to predict possible conversion for a patient before surgery.

**Material and methods:** The source data file contained information about 649 patients who underwent laparoscopic colorectal surgery between 2001 and 2009 at the University Hospital Ostrava, Czech Republic. Conversion to open surgery was necessary in 54 cases. The variables gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, stage of disease, number of previous operations and operation severity were included in the analysis as the potential risk factors of conversion. Discriminant analysis was used for the data evaluation; statistical software SPSS 17 and NCSS 2004 were used for the calculations.

**Results:** The created model had only low discriminating ability. The variable ASA classification was identified as the most important risk factor of conversion, followed by the variables operation severity, gender and BMI.

**Conclusions:** Discriminant analysis did not find the chosen input variables satisfactory enough to make a reasonable model for the prediction of conversion. The expected fact was confirmed that large bowel surgery and greater BMI mean greater risk of conversion, whereas there is no reason to refuse laparoscopy for a patient with higher ASA classification.

**Key words:** colorectal surgery, laparoscopy, conversion, risk factors, discriminant analysis.

## Introduction

This study examines risk factors of conversion of laparoscopic colorectal surgery. Laparoscopic surgery is usually associated with less operative trauma, more favourable post-operative course and lower morbidity than open techniques. Many research studies have compared morbidity and mortality after both types of surgery. One of them was carried out at

the Clinic of Surgery, University Hospital Ostrava in 2006. Logistic regression and discriminant analysis were applied to the data from colorectal operations and a significantly lower morbidity among patients operated on laparoscopically was demonstrated [1].

However, there are also some negative factors in using laparoscopic techniques in colorectal surgery, which can contribute to morbidity to a large extent, e.g. the risk of capnoperitoneum, longer operative time

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and extreme positioning of patients, and also the risk of conversion. The results from converted laparoscopic operations are demonstrably worse than the results from open operations according to some research papers [2-4]; thus the open technique should be considered if the risk of conversion is too high.

## Aim

The current study aimed to identify the important risk factors associated with the conversion of laparoscopic to open colorectal surgery and to create a model to predict possible conversion for a patient before surgery.

## Material and methods

The processed data file consists of information about 649 patients (411 men and 238 women) who underwent elective laparoscopic colorectal surgery between 2001 and 2009 at the University Hospital Ostrava, Czech Republic. The average age was 63.72  $\pm$  12.84 years old (range: 18-97 years old). Conversion to open surgery was necessary in 54 cases (8.3%). The basic data of each patient were monitored, such as the data describing the surgery, post-operative process and complications and the physiological state of the patient before surgery (body mass index (BMI), American Society of Anesthesiologists (ASA) classification, age, cardiac stress, blood pressure, etc.). Many descriptive studies (for example [5-7]) have identified various risk factors of conversion to open surgery. According to these studies and to the experience of the surgeons from the Clinic of Surgery, University Hospital Ostrava, the following six independent variables were included in the analysis: gender, BMI, ASA classification, stage of disease, number of previous operations and operation severity. These quantities play the role of independent variables. The dependent variable here is the surgical technique. Two states of this variable are distinguished for the analysis: laparoscopy with conversion and laparoscopy without conversion.

Numeric values were assigned to nominal variables in this way: gender (1 – female, 0 – male), stage of disease (values 1-4 were assigned in accordance with histological tumour node metastasis (TNM) classification for colorectal cancer; a value of 0 represents benign disease), operation severity (values 2, 4, 8 were assigned in accordance with methods published by Copeland *et al.* [8]), surgical technique

(1 – laparoscopy with conversion, 0 – laparoscopy without conversion).

Discriminant analysis was used to find the variable with the greatest impact on possible conversion and to create the model for prediction of conversion for a patient before surgery.

Discriminant analysis is a statistical method used for multivariate data processing. Its principles have been presented by Huberty and Olejnik [9] and Neil [10]. Discriminant analysis serves as a descriptive tool for describing differences among groups of units with regard to the group of independent variables and for the classification of objects with unknown group membership into predefined groups.

Statistical software SPSS version 17 (PASW Statistics 17.0) and NCSS 2004 were used for calculations.

## Results

The source data file consists of information about 649 patients who underwent laparoscopic colorectal surgery. It was divided into two groups: patients who required conversion (54 cases) and patients without conversion (595 cases). The impact of the following six variables on conversion was examined: gender, BMI, ASA classification, stage of disease, number of previous operations and operation severity.

Basic descriptive statistics were first computed to obtain an initial idea about the whole sample. They are presented in Table I. We used the Mann-Whitney test for testing differences between groups for the continuous parameter BMI, the  $\chi^2$  test for the dichotomous parameter gender, and the Kruskal-Wallis test for the remaining parameters, which are ordinal. No significant differences were found between the groups with and without conversion, except for the variables ASA classification ( $p = 0.011$ ) and operation severity ( $p = 0.008$ ).

Multivariate analysis of variance was then performed (see Table II) to find out if the variables differ significantly in individual groups in the multivariate context. The hypothesis of equality of group mean vectors was rejected at the significance level 1% ( $p = 0.006$ ); thus the influence of these six monitored quantities upon conversion was confirmed. The additional one-way tests for individual variables confirmed that the variables ASA classification ( $p = 0.011$ ) and operation severity ( $p = 0.022$ ) have the greatest impact on conversion. Finally, we used discriminant analysis to confirm the significance of these variables and to create a model to predict possible conversion for a patient before surgery.

The canonical discriminant function coefficients were calculated (Table III), which can be used for predicting the conversion. They indicate (analogously to the regression analysis coefficients) the individual impact of the original variables on the canonical vari-

able, provided that the other variables are constant. On the basis of these coefficients the discriminant score of the *i*-th patient could be computed as:  $y_i = 1.138x_{i,1} - 0.064x_{i,2} + 0.884x_{i,3} + 0.017x_{i,4} - 0.462x_{i,5} - 0.287x_{i,6} + 0.722$ , where:  $x_{i,1}$  = value of the

**Table I.** Descriptive statistics

Parameter	With conversion	Without conversion	Total	Value of <i>p</i>
Gender				
Men, <i>n</i> (%)	40 (74.1)	371 (62.4)	411 (63.3)	0.087
Women, <i>n</i> (%)	14 (25.9)	224 (37.6)	238 (36.7)	
Body mass index [years]				
Median (5 <sup>th</sup> ; 95 <sup>th</sup> percentile)	27.2 (20.0; 33.8)	26.1 (19.8; 33.7)	26.2 (19.9; 33.8)	0.205
Range	14.6-38.2	15.6-45.7	14.6-45.7	
Average ± SD	27.1 ±4.9	26.5 ±4.4	26.6 ±4.5	
ASA classification, <i>n</i> (%)				
1	10 (18.5)	77 (12.9)	87 (13.4)	0.011
2	31 (57.4)	274 (46.1)	305 (47.0)	
3	13 (24.1)	216 (36.3)	229 (35.3)	
4	0 (0.0)	28 (4.7)	28 (4.3)	
Stage of disease, <i>n</i> (%)				
0	14 (25.9)	101 (17.0)	115 (17.7)	0.570
1	5 (9.3)	86 (14.5)	91 (14.0)	
2	8 (14.8)	125 (21.0)	133 (20.5)	
3	20 (37.0)	185 (31.1)	205 (31.6)	
4	7 (13.0)	98 (16.5)	105 (16.2)	
Number of operations, <i>n</i> (%)				
0	26 (48.1)	331 (55.6)	357 (55.0)	0.355
1	21 (38.9)	188 (31.6)	209 (32.2)	
2	5 (9.3)	63 (10.6)	68 (10.5)	
3	2 (3.7)	11 (1.8)	13 (2.0)	
4	0 (0.0)	2 (0.3)	2 (0.3)	
Operation severity, <i>n</i> (%)				
2	1 (1.9)	87 (14.6)	88 (13.6)	0.008
4	41 (75.9)	420 (70.6)	461 (71.0)	
8	12 (22.2)	88 (14.8)	100 (15.4)	

variable gender,  $x_{i,2}$  = value of the variable BMI,  $x_{i,3}$  = value of the variable ASA classification,  $x_{i,4}$  = value of the variable stage of disease,  $x_{i,5}$  = value of the variable number of previous operations,  $x_{i,6}$  = value of the variable operation severity of the  $i$ -th patient.

Each patient is then classified into that group (with or without conversion) where the group centroid is closer to his discriminant score. The groups' centroids are presented in Table IV. For example, if a patient who is a woman with BMI of 18 kg/m<sup>2</sup>, ASA grade 2, benign disease and one previous operation is undergoing surgery of severity 2, her discriminant score is:  $y = 1.138 \times 1 - 0.064 \times 18 + 0.884 \times 2 + 0.017 \times 0 - 0.462 \times 1 - 0.287 \times 2 + 0.722 = 1.44$ . Such a patient would be classified into group 0 (without conversion), because their discriminant score is closer to the group centroid of group 0, which is 0.051.

The accuracy of this classification rule is recorded in a verification matrix (Table V). The discriminant score of each patient was computed and each patient was classified into one of the two groups – with conversion or without conversion. The predicted group membership was then compared with the actual one. The numbers and percentages of the correctly and wrongly classified patients are shown in the upper half of the table (“Original”). The total number of correctly classified patients is 407 (369 without and 38 with conversion), which is 62.7%. This number determines the probability of correct classification. However, this value is overestimated, so the cross-validated method was used to obtain an unbiased estimation of the probability, which is only 61.6%. Regrettably, this number is so small that such a model cannot be used in practice.

We can find out which quantitative variable has the greatest impact on conversion from the correlation coefficients of the predictor variables with the canonical discriminant function. They are computed in Table VI. The coefficients with larger absolute values correspond to the variables with greater discriminating ability, which implies that the most important variable for discrimination is ASA classification with the coefficient 0.592. A larger value of this variable means a smaller risk of conversion. The second important variable is operation severity; larger values mean greater risk of conversion.

## Discussion

The end of the 20<sup>th</sup> century was characterized by rapid progress in minimally invasive techniques in

**Table II.** Multivariate analysis of variance

MANOVA Tests Section Term (DF)	Test value	Value of $p$	(0.05)
<b>Test statistic</b>			
<b>A(1): surgical_technique</b>			
Wilks' lambda	0.9720	0.006	Reject
Gender	0.6802	0.087	Accept
Body mass index	17.3496	0.352	Accept
ASA classification	3.6675	0.011	Reject
Stage of disease	0.9399	0.470	Accept
Number of operations	0.3882	0.424	Accept
Operation severity	15.1228	0.022	Reject

**Table III.** Canonical discriminant function coefficients

Parameter	Function 1
Gender	1.138
Body mass index	-0.064
ASA classification	0.884
Stage of disease	0.017
Number of operations	-0.462
Operation severity	-0.287
(Constant)	0.722

**Table IV.** Group centroids

Surgical technique	Group centroid
Without conversion	0.051
With conversion	-0.562

colorectal surgery. The proportion of laparoscopic colorectal operations is still increasing worldwide [11, 12], including among complicated surgical procedures [13]. As the demand for laparoscopic colorectal surgery increases, interest in the risk of conversion to open surgery grows as well.

Although some authors did not find converted laparoscopic operations significantly worse than standard, open techniques [14-16], some others did. Various aspects are taken into account when comparing the results of converted laparoscopic tech-

**Table V.** Classification results

Surgical technique		Predicted group membership		Total	
		Without conversion	With conversion		
Original	Count	Without conversion	369	226	595
		With conversion	16	38	54
	%	Without conversion	62.0	38.0	100.0
		With conversion	29.6	70.4	100.0
Cross-validated	Count	Without conversion	369	226	595
		With conversion	23	31	54
	%	Without conversion	62.0	38.0	100.0
		With conversion	42.6	57.4	100.0

62.7% of original grouped cases correctly classified, 61.6% of cross-validated grouped cases correctly classified

**Table VI.** Structure matrix

Variables	Correlation coefficients
ASA classification	0.592
Operation severity	-0.531
Gender	0.397
Body mass index	-0.216
Number of operations	-0.185
Stage of disease	0.168

niques and open ones. Some papers reported longer surgery time [15, 17], longer post-operative hospital stay [18, 19], more frequent post-operative complications [18], higher costs [19] and higher morbidity and shorter survival time [18, 20-23] in patients who underwent conversion. But there is still not a clear conclusion in comparing these two techniques in the contemporary literature.

Laparoscopic conversion rates in colorectal surgery, which vary from 7-25% in larger studies to 2-41% in smaller series [17, 22], depend on many factors. Previous studies have identified various risk factors associated with conversion to open surgery such as age, gender, BMI, ASA classification, number of previous operations, diagnosis, etc. Some studies reported a significantly larger proportion of men in “converted” groups [18, 24, 25], especially in the case of rectal diseases [19]. Age was found as a risk factor of conversion by Janson *et al.* [19] and in the case of rectal diseases also by Tan *et al.* [25]. Some other studies did not find age as a risk factor at all [24, 26].

Also concerning ASA classification the conclusions are not unequivocal [19, 25, 26]. The multicentre, randomized study MRC CLASSIC [21] concluded that the risk of conversion grows in patients with ASA > 3 in these cases: right-sided and left-sided hemicolectomy, sigmoid resection, low anterior resection and abdominoperineal amputation. Another factor associated with a higher conversion rate in colorectal surgery is BMI > 27.5 kg/m<sup>2</sup> [24], > 29 kg/m<sup>2</sup> [27], > 30 kg/m<sup>2</sup> [7]. For example, Pilarsky *et al.* [7] reported a significantly higher conversion (and also complication) rate for obese patients with a BMI exceeding 30 kg/m<sup>2</sup> in his group of 162 patients (19% of them were obese). The conversion rate was 39% for the patients with BMI > 30 kg/m<sup>2</sup> and 13.5% for the others. Various studies have shown that the number of previous operations also has a significant influence on possible conversion to open surgery [28-30]. Reported conversion rates were 16.5-26.1% in the groups with and 5.1-15% in the groups without previous intra-abdominal operations.

The present study focused on the risk of conversion of laparoscopic to open colorectal surgery with regard to the following six factors: gender, BMI, ASA classification, stage of disease, number of previous operations and operation severity. Discriminant analysis did not find the chosen input variables satisfactory enough to make a sufficient model for the prediction of conversion, which means that a new choice of independent predictors is necessary. This task will be solved in the future using a larger group of patients.

In our study, we found significant association of conversion with ASA classification and operation

severity. Paradoxically, larger values of the variable ASA classification correspond to a smaller risk of conversion, which means that the patients with a higher ASA score were not associated with higher risk of conversion in our data set. Regarding the variable operation severity, larger values mean greater risk of conversion, which confirms the fact that large bowel operations exceed the technical limitations of laparoscopic surgery. No significant individual impact of the variables gender, BMI, stage of disease and number of previous operations on conversion was found.

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