MEDICAL SCIENCE MONITOR

CLINICAL RESEARCH

e-ISSN 1643-3750
© Med Sci Monit, 2018; 24: 3244-3248
DOI: 10.12659/MSM.906973

Received: 2017.09.05
Accepted: 2017.11.22
Published: 2018.05.17

Effects of Laparoscopic and Conventional Methods on Lung Functions in Colorectal Surgery

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Funds Collection G

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Source of support: Departmental sources

Background: We aimed to compare the lung functions, complication rates, and durations of the hospital and intensive care unit stays of patients who had undergone laparoscopic colorectal resection and open colorectal resection.

Material/Methods: In this study, data were collected prospectively and then evaluated retrospectively. The study was carried out between January 2015 and November 2016 in 2 university hospitals. Pulmonary function tests (PFT) and chest radiography were performed in all patients preoperatively. In the postoperative period, PFT was performed in all patients but chest radiography was obtained only in patients for whom it was clinically indicated.

Results: There were no significant differences between the 2 groups regarding their preoperative PFT parameters ($p>0.05$ for all variables). When compared to their preoperative PFT results, FEV1 and FVC values were determined to be significantly reduced on the 5th postoperative day ($p\leq0.05$) in both groups. When the postoperative 5th day PFT results of the Laparoscopy (LG) and Open group (OG) were compared, there were no significant differences (for all variables $p>0.05$). Consolidation developed in 11 patients, all of whom were in the OG, but this result was not associated with surgical procedure ($p=0.080$). The median duration of the postoperative intensive care stay was 1 day in the LG, whereas it was 2 days in the OG ($p<0.001$).

Conclusions: In terms of pulmonary functions, both laparoscopic surgery and open surgery procedure have the same results. However, in terms of hospital stay and pulmonary infections, laparoscopy is more reliable.

MeSH Keywords: Colorectal Surgery • Laparoscopy • Respiratory Function Tests

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/906973

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Background

Laparoscopy was first used for diagnostic purposes in the 1950s and its utilization in colorectal surgery began in the early 1990s [1]. Today, minimally invasive technique has achieved a highly advanced state in colorectal surgery as well as in many surgical methods [2]. Laparoscopic surgery has several advantages compared to open surgery, such as shorter duration of hospital stay, less postoperative pain, faster recovery of gastrointestinal functions, and faster recovery of the patient, in addition to better cosmetic results [3]. However, laparoscopic colorectal surgery is still not considered the criterion standard when compared with open surgery, and many authors have failed to demonstrate the superiority of one over the other [4,5].

A significant problem of major abdominal surgery is lung complications, which are usually more common in upper abdominal surgery than in lower abdominal surgery [6]. The incidence of the development of lung complications following major abdominal surgery is approximately 20–25% in the literature, and the mortality rate of these complications is reported to be 3–4% [7]. In such cases, lung complications are considered to develop due to the incisional pain and the atelectasis as the result of inadequate ventilation, diaphragmatic dysfunction, and deterioration of the ventilation mechanism due to other reasons [8]. Laparoscopic abdominal surgery is considered to cause less pulmonary dysfunction than open abdominal surgery since it causes less incisional pain in the postoperative period and consequently has less effect on postoperative lung oxygenation [6,8]. While there are many studies in the literature that compared open and laparoscopic surgery regarding their pulmonary effects in procedures such as cholecystectomy, obesity surgery, esophagogastric surgery, and nephrectomy, there are very few such studies on colorectal surgery [9]. Therefore, in the present study we investigated the effects of laparoscopic and open surgical procedures on lung functions, complication rates, and durations of hospital and intensive care unit stays in our patients who underwent colorectal surgery.

Material and Methods

We prospectively collected data between January 2015 and November 2016 at 2 university hospitals. The study was conducted in general surgery and pulmonary diseases departments and was granted approval by the local ethics committee of Adnan Menderes University. Written consent was obtained from all patients participating in the study. Patients who were admitted to the General Surgery Clinic for colorectal resection were allocated into 2 groups – the laparoscopy group (Group 1) and the open surgery group (Group 2) – according to patient priorities and surgeon preference. Patients who had already undergone an abdominal operation were excluded from the study. Pulmonary function tests (PFT) were performed and posterior-anterior and lateral chest radiographic images were obtained for all patients in the preoperative period. Patients who were followed up in the intensive care unit postoperatively by the specialist in anesthesiology and reanimation were admitted to the intensive care unit in the postoperative period. Posteroanterior and lateral chest radiographs were obtained with the suspicion of atelectasis and pneumonia in patients who manifested postoperative pulmonary symptoms such as chest pain, fever, and dyspnea. PFT maneuvers were performed in all patients who were not in the intensive care unit on the 5th postoperative day; the test was completed in the patients who were sufficiently coordinated. PFT was performed in those who were in the intensive care unit when they were stable and coordinated enough. Those who had been discharged prior to the 5th day were called and tested. In both patient groups, we recorded and retrospectively evaluated demographic data (age, body mass index, smoking history), type and duration of surgery, PFT parameters, duration of hospitalization, need for intensive care, need for non-invasive mechanical ventilator support, and whether complications been detected in the postoperative chest radiographs.

Statistical analysis

SPSS 20 statistical analysis software (IBM Corp, released 2011, IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY: IBM Corp.) was used to evaluate the data. The normality assumption was examined by the Kolmogorov-Smirnov test. According to normality testing, the variables used in the analysis are expressed as mean ± standard deviation or median (maximum-minimum). The differences between the 2 groups were evaluated by the *t* test when the parametric test prerequisites were met, and by the Mann-Whitney U test when the parametric test prerequisites were not met. The Fisher exact test and chi-square test were used for categorical data analysis. Statistical significance was set at $p<0.05$.

Results

A total of 101 patients were included in the study: 68 (67.3%) males and 33 (32.7%) females All of the patients had malignant diseases, and their average age was 64.98±10.28 years. Out of 101 patients, 70 (69.3%) underwent open surgery and 31 (31.7%) underwent laparoscopic procedure. Sixty-one (60.4%) of the patients were smokers and 40 (39.6%) were non-smokers. Of the 61 smokers, 41 (67.2%) were in the open surgery group and 20 (32.9%) were in the laparoscopy group. Of the 40 non-smoking patients, 29 (72.5%) were in the open surgery group and 11 (27.5%) were in the laparoscopy group ($p=0.750$). There was no statistically significant difference between the 2 groups in preoperative PFT parameters: predicted

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Table 1. Demographic data, preoperative and postoperative characteristics of patients and of surgical procedures.

Characteristics	Surgical procedure	N	Median	Minimum–Maximum	p
Age	Open	70	62.0	44–85	0.234
	Laparoscopic	31	69.0	54–81	
BMI	Open	70	26.6	20.1–39.6	0.774
	Laparoscopic	31	25.6	21.2–37.6	
Smoke (packet-years)	Open	70	11.0	0.0–45.0	0.711
	Laparoscopic	31	20.0	0.0–50.0	
Intensive care unit (day)	Open	70	2.0	0.0–17.0	<0.001**
	Laparoscopic	31	1.0	0.0–2.0	
Hospital (day)	Open	70	7.5	3.0–20.0	0.001**
	Laparoscopic	31	6.0	3.0–9.0	
FEV1	Open	70	83.15	25.7–114.5	0.348
	Laparoscopic	31	75.80	40.8–110.0	
FVC	Open	70	92.9	24.5–122.3	0.461
	Laparoscopic	31	88.0	62.0–112.0	
FEV1/FVC	Open	70	73.29	50.90–84.82	0.137
	Laparoscopic	31	73.58	51.20–80.86	
Operation time (min)	Open	70	165.0	100.0–210.0	0.615
	Laparoscopic	31	163.75	120.0–300.0	

FEV1 – forced expiratory volume in 1 second, FVC – forced vital capacity.

forced expiratory volume in the 1st s (FEV1) (%), forced vital capacity (FVC) (%), and the FEV1/FVC ratio, which is the ratio of the former 2 values (p≥0.05). When the body mass index and the smoking habits were evaluated, it was seen that the 2 groups were not significantly different from each other (p≥0.05). In terms of duration of the operation, the median duration 165.0 (100–210) min in the open surgery procedure and 165.0 (120–300) min in the laparoscopy procedure (p=0.615). Regarding the duration of postoperative intensive care unit stay, the median duration was 1 day (0.0–2.0) in the laparoscopy group and 2 days (0.0–17.0) in the open surgery group (p<0.001). For duration of total hospital stay, the median duration was 6.0 days in the laparoscopy group and 7.5 days in the open surgery group (p=0.001) (Table 1). When the 2 groups were compared in terms of non-invasive mechanical ventilation support, no statistically significant difference was found (p=0.398).

When the PFT results of the open surgery and laparoscopy groups in the postoperative period were compared, FEV1, FVC, and FEV1/FVC values were not significantly different (Table 2).

When the preoperative chest radiographs were examined, 67 (66.3%) of the patients had normal radiographs and 34 (33.7%) patients had symptoms of emphysema, but there was no significant difference between the 2 groups (p=0.854). In 87 patients, a postoperative chest radiograph was obtained: 53 patients (60.9%) had normal findings and 34 had atelectasis (39.1%). When the patients with atelectasis were evaluated, 26 (76.5%) were in the open surgery group, and 8 (23.5%) were in the laparoscopy group (p=0.452). Consolidation was detected in 11 of the 87 cases (12.6%). All patients with consolidation were in the open surgery group, but this difference was not significantly different (p=0.08) (Table 2).

Discussion

Postoperative complications are now regarded as very important parameters for evaluation of surgical technique [8]. Pulmonary complications such as hypoxia, atelectasis, pulmonary embolism, and pneumonia are the major complications that can develop after major abdominal surgery [10]. The main known advantages of laparoscopic colorectal surgery over open surgery are a less postoperative pain, shorter hospitalization, and better cosmetic results [3]. Therefore, we planned this study considering that the procedure with fewer pulmonary complications would be the more efficient procedure and we discussed the parameters, such as PFT parameters, chest radiography, and the duration of intensive care unit stay, which could determine the risk of postoperative pulmonary complications.

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Table 2. Postoperative pulmonary function test results and pulmonary complications according to the operation procedure.

Characteristics		Open	Laparoscopy	p
FEV1, Median (minimum–maximum)		76.5 (32.40–107.50)	70.5 (38.3–101.2)	0.186
FVC, Median (minimum–maximum)		86.2 (45.6–105.0)	80.3 (39.5–110.3)	0.646
FEV1/FVC, Median (minimum–maximum)		72.5 (55.6–82.80)	70.5 (51.02–82.55)	0.055
Pulmonary consolidation	Yes (n,% in row)	11 (100%)	0 (0%)	0.080
	No (n,% in row)	59 (%77.6)	17 (%22.4)	
Atelectasis	Yes (n,% in row)	26 (%76.5)	8 (%23.5)	0.452
	No (n,% in row)	44 (%83.0)	9 (%17.0)	

FEV1 – forced expiratory volume in 1 second, FVC – forced vital capacity.

In a meta-analysis study, Jiang et al. compared laparoscopic gastrectomy with open gastrectomy, reporting that lung functions were better preserved and there were fewer pulmonary complications in the laparoscopic group [11]. Damiani et al. also compared laparoscopic and open cholecystectomy in the same way, and they reported that fewer pulmonary complications were found following the laparoscopic procedure [12]. Our results suggest that lung ventilation is better and there are fewer pulmonary complications in laparoscopic surgery compared to open surgery since it results in less incision pain in the postoperative period. We could not find any statistically significant difference regarding the PFT parameters between the 2 groups in the preoperative period or in the postoperative period. When we compared the postoperative 5th day PFT parameters, we observed that the FEV1 and FVC1 values in both groups were lower than those of the preoperative period. In a study by Yıldırım et al., all of the postoperative 1st day FEV1, FVC, and FEV1/FVC values of patients who had undergone either laparoscopic or open cholecystectomy were compared [8]; all parameters were reported to decrease more in the open surgery group, but on the postoperative 6th day no significant difference was found between groups regarding these parameters. Similarly, in our study, due to the inability of some patients in the open surgery group to tolerate PFT in the early period (postoperative 3rd day), we performed PFT on the 5th day, and the data from patients on the postoperative 5th day led us to a similar conclusion. The average duration of normalization of the pulmonary function test results after open surgery was reported to be about 10 days [13]. This information is supported by the problems such as diaphragmatic dysfunction and incisional pain that developed in our open surgery patients due to anesthesia, and is also supported by our results on the postoperative 5th day.

Atelectasis and pneumonia are generally the most commonly developing pulmonary complications following major abdominal surgery [6,14]. Many studies have investigated the pulmonary complications of open and laparoscopic cholecystectomy, particularly after laparoscopic cholecystectomy became widespread in the early 1990s. Bablekos et al. reported that laparoscopic cholecystectomy gave better results when compared to open cholecystectomy in terms of respiratory functions and pulmonary respiratory physiopathology and that the complication rate was lower [6]. In another study, Boni et al. reported that the immune system was better preserved and there was less proinflammatory cytokine response in all laparoscopic surgical procedures; consequently, the infection rate, including the pulmonary system infections, was lower in laparoscopic surgery than in open surgery [15]. Antoniou et al. reported that, in obesity surgery, the obesity itself was a pulmonary risk factor for complications in the postoperative period, together with parameters such as incisional pain, diaphragmatic irritation, and hypoventilation; they reported less pulmonary complications in their patients who had undergone laparoscopic surgery [16]. In our study, we compared the chest radiographs obtained in the postoperative period and found that 34 patients developed atelectasis, 26 (76.5%) of whom belonged to the open surgery group and 8 (23.5%) to the laparoscopy group. Our assessment of the chest radiographs showed consolidation findings in 11 patients who were later diagnosed with pneumonia when they were evaluated by clinical and physical examination; all of these patients were in the open surgery group, although this difference was not statistically significant. We think that the reason for the lower lung complication rate in the laparoscopy group, when compared to the open surgery group, is that the immune system was less affected and therefore the proinflammatory cytokine response was lower, and mobilization and ventilation were better.

We consider that durations of hospital stay and intensive care unit stay are 2 of the important parameters in the postoperative period. Pneumonia developing in the hospital is a very important factor, especially in terms of postoperative mortality and morbidity of patients who undergo surgery [17]. As the durations of intensive care unit and hospital stays increase, the risk of pneumonia in the hospital also increases for the

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patient [18]. Our study showed a significant difference between the laparoscopy and the open surgery groups regarding the durations of intensive care unit and hospital stays. We think that the shorter durations of intensive care unit and hospital stays in the laparoscopy group reduce the risk of pulmonary complications.

Conclusions

We suggest that laparoscopic surgery is a more reliable procedure in colorectal surgery compared to open surgery, as it is in other surgical procedures, in terms of shorter intensive care unit and hospital stays, and lower pulmonary complication rates. However, open and laparoscopic surgery for colorectal cancer have the same results in terms of the preservation of lung functions.

Acknowledgement

We thank Dr. Sule Tas Gülen for her technical support for pulmonary functions evaluation of patients.

Conflict of interest

None.

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