# Non-surgical complications in oncological colorectal surgery: a comparison between open and laparoscopic techniques

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BACKGROUND: *Most of the studies on laparoscopic surgery in the treatment of colorectal cancer analyzed the oncological or surgical outcome. It remains to be clarified, if laparoscopic surgery leads to a significant reduction in the incidence of systemic complications in the postoperative period.*
MATERIALS AND METHODS: *We undertook a quantitative and qualitative assessment of non-surgical complications arising in our patients during the postoperative stay ,in relation to laparoscopic surgery compared to open surgery for colorectal cancer. In the study, 426 patients were recruited. The interventions were performed by an open technique for 225 patients, in VL for 145 patients and 56 patients were subjected to intraoperative conversion.*
RESULTS: *The correlation between surgical technique and onset cardiac complications showed a higher rate of onset of these in open (11.7%) than the VL technique (5.5%). Same result for pulmonary complications (open 13.2%, VL 3.4%) and renal (open 5.7%, VL 1.4%). Average age of patients treated with open surgery 75 years, average operating time duration 169 minutes. Average age patients treated in VL 69 years, average operating time duration 175 minutes.A possible benefit of videolaparoscopic rectal surgery on non-surgical complications has also been investigated, but a significant conclusion has not been reached due to the small number of adverse events found in the reference sample. The evaluation of the duration of the operating session in relation to non-surgical complications showed an increase in the occurrence of pulmonary, renal and systemic adverse events. There was also a significantly greater risk of pulmonary complications in male patients (M 12.7%, F 6.8%). Finally, by stratifying patients by age, a significant positive correlation emerged in the onset of pulmonary complications in the subgroup of patients aged ≥ 70 years, operated with open technique (open 14.6%, vl 3.8).*
CONCLUSIONS: *The data analysed shows a reduction of pulmonary and renal cardiac adverse events after laparoscopic oncological surgery, it has not come to a conclusion for rectal cancer. There is also an increase in adverse events related to the duration of the operating session, the male sex and the age ≥ 70 years, thus enhancing the hypothesis that elderly patients are actually the population who can ultimately benefit more of minimally invasive surgical techniques.*

KEY WORDS: Adverse eventColectomy, Colorectal cancer, Laparoscopy, Open surgery

## Introduction

Starting from 1990, concurrent with its introduction, laparoscopic surgery has achieved a great success in the treatment of colorectal cancer, with an oncological outcome overlapping with that of the traditional open surgery [1-4]. The short-term benefits of laparoscopic surgery, such as lower pain, reduced blood loss, reduced hospitalization times, faster healing, have been studied and described in numerous publications [4-6]. Another advantage of videolaparoscopic surgery may lie in an improvement in cardiopulmonary morbidity [7] due to minor surgical stress. This aspect could also be considered as an important target for reducing both mortality and health costs, aspects directly related to postoperative non-surgical complications [7-12].

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Non-surgical complications mean those adverse events arising from the execution of a surgical act characterised by systemic involvement cardiac,pulmonary and urogenital tract.

## Materials and Methods

The study covered a period of six years, from January the 1st 2010 to December the 31th 2015. The data were extracted after obtaining the authorization to consult the medical records of the patients in the study from the Medical Records Office of the Parma University Hospital on cases surgically treated for colorectal cancer.
The inclusion criteria for the study were:
– Preoperative diagnosis of colorectal adenocarcinoma;
– Signing of the informed consent to the intervention.
The exclusion criteria:
– Patient undergoing colorectal surgery for benign pathology / of a non-neoplastic nature;
– Refusal of surgery.
Following careful preoperative evaluation, patients were referred to open surgical or videolaparoscopic .
Given the ultimate goals of our study, patients were stratified on the basis of:
– Sex;
– Age;
– Surgical procedure performed (right hemicolectomy, left hemicolectomy, segmental colectomy of the transverse colon, anterior resection of the rectum);
– Duration of the surgical session;
– American Society of Anesthesiologists (ASA) Score;
– Surgical technique used (open / videolaparoscopy);
– Regular postoperative course finding;
– Detection of any cardiac postoperative complications;
– Detection of any pulmonary postoperative complications;
– Detection of any postoperative renal complications;
– Detection of any postoperative urogenital complications;
– Detection of any non-surgical systemic complications of other nature (under the heading of "other non-surgical complications").
Once the detailed informed consent was signed, the patients undergoing surgery were: right hemicolectomy (203 cases), left hemicolectomy (97 cases), segmental colectomy of the transverse (19 cases) and anterior resection of the rectum (107 cases ). The surgical elective interventions examined were performed by videolaparoscopic technique (145 cases), open surgical technique (225 cases) and 56 cases converted; thus determining the establishment a conversion rate of 27.8%. Due to the presence of laparotomic incision, for the purpose of stratification in the statistical survey, the converted interventions were considered as interventions performed with open technique. Measurement of outcome in the comparison between laparoscopic and open surgery for colorectal cancer was calculated based on the incidence of adverse events in short-term follow-up (understood as staying in the hospital ward or within 30 days after operating session). The main target of the study was the search for the correlation between the surgical technique adopted by the operator and the onset of cardiovascular and pulmonary complications. The remaining complications arising were subdivided into further categories, such as renal, urogenital and systemic, and were evaluated as secondary endpoints of the study. In the absence of adverse events in the immediate or intermediate postoperative period, it was our concern for each individual case considered, to make sure that no further hospital admissions were present within 30 days following the colorectal surgery and, if there were any, we read the Medical Records of patients who were hospitalized again. The following non-surgical complications emerged from the study carried out on the Medical Records (Table I). Statistical data analysis was performed using SPSS (version 20.0; SPSS Inc. Chicago, IL, USA). To compare parametric variables, the Pearson's chi-square test or the

Table I - *Non surgical complications*

Cardiac Complications:
- Angina pectoris;
- Acute myocardial infarction
- Heart failure
- Rhythm alterations: paroxysmal supraventricular tachycardia, atrial fibrillation with high or medium ventricular response
- New onset hypertension.

Pulmonary Complications
- Frankish lobar pneumonia
- Pneumonia ab ingestis
- Respiratory failure
- Pleural effusion
- Pulmonary thromboembolism
- Exacerbation of known COPD
- atelectasis.

Renal Complications
- Acute renal failure.

Urogenital Complications
- Acute urinary retention;
- Urinary tract infections

Other Non-Surgical Complications
- Sepsis caused by the following pathogens: Streptococcus Mitis subs. Viridans, S. Epidermidis, Serratia Marcescens, Klebsiella Pneumoniae, Pseudomonas Aeruginosa, Enterococcus Faecalis, Candida Albicans;
- Septic Shock
- Severe electrolyte imbalances: hyponatremia, hyperkalemia:
- Severe imbalances in the base acid balance: metabolic acidosis, respiratory alkalosis;
- Seizures
- Liver failure
- Splenic infarction
- Metabolic encephalopathy
- hypokinetic syndrome

Fisher exact test was used. To compare non-parametric variables, the Kolmogorov-Smirnov test or the Shapiro-Wilk test was used. A value of p <0.05 was considered significant.

## Results

In our study 426 patients were enrolled, 220 men and 206 women, admitted to the OU of General Surgery of Parma University Hospital. Surgeries were performed with open tecnique for 225 patients, with VL tecnique for 145 patients, and 56 patients underwent intraoperative conversion and therefore they were considered as open surgery cases for our work's purposes. Since that, the conversion rate was 27,8%. Patients' avarage age for open surgery was 75 years (Fig. 1), average duration of operative session was 169 minutes. Patients' average age for videolaparoscopic tecnique was 69 years (Fig. 2), average duration was slightly higher, 175 minutes (Fig. 3). Having analyzed our reference sample, we highlighted an higher incidence rate in cardiac complications in open surgeries (11.7%) rather than in VL (5.5%) with a Pearson's Chi square test statistically significant p=0.039. Our study results showed a strong statistical significance (p= 0.001) about onset of pulmonary complications for

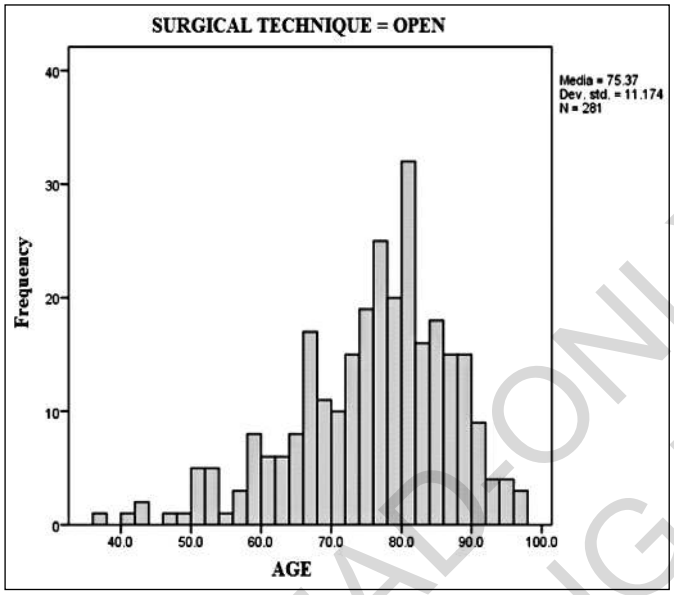


Fig. 1: Histogram related to patients' average age who underwent open tecnique.

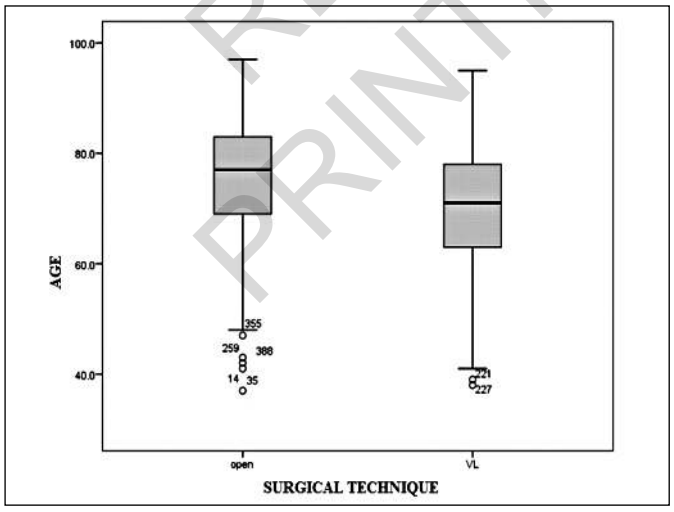


Fig. 2: Box Plot related to the comparison between patients' average age. The trend is slightly superior in the patients who underwent open tecnique.

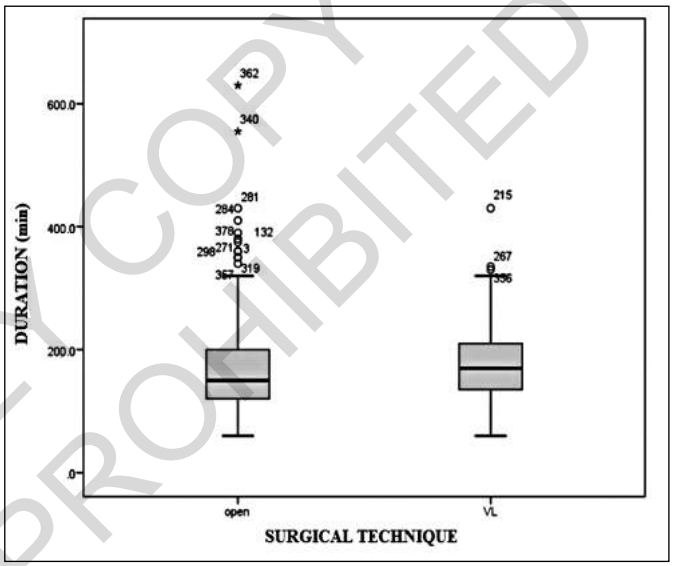


Fig. 3: Box Plot related to the comparison between patients' average surgery duration. The trend is superior in the patients who underwent VL tecnique.

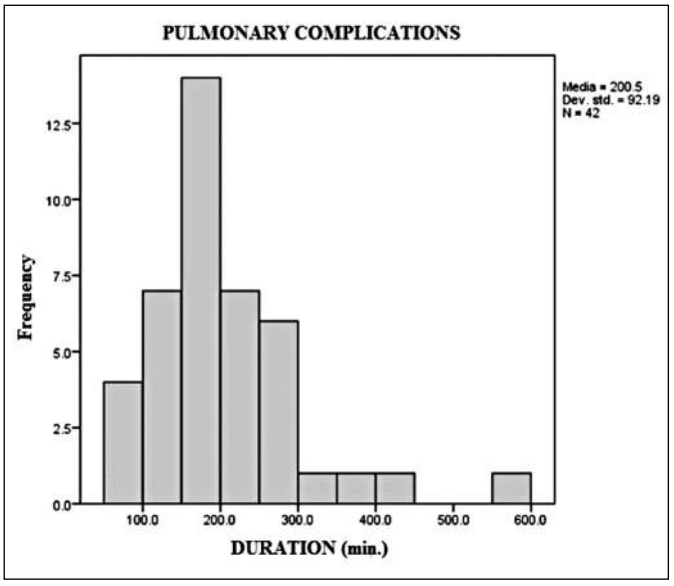


Fig. 4: Histogram related to relationship between operating duration and pulmonary complications onset.

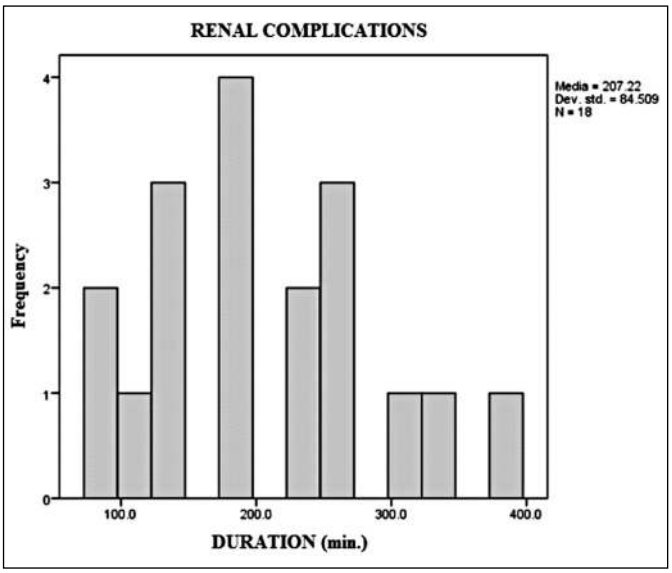


Fig. 5: Histogram related to relationship between operating duration and renal complications onset.

TABLE II - *Incidence of non surgical complications*

| | Open | Vl | P |
|---|---|---|---|
| Cardiac complications | 11.7% | 5.5% | 0.039 |
| Pulmonary complications | 13,2% | 3.4% | 0.001 |
| Renal complications | 5.7% | 1.3% | 0.036 |
| Age>70 years*** | 14.6% | 3.8% | 0.012 |

*open surgery
**VL videolaparosocpic surgery
*** Incidence of complications

open surgery. On the one hand 13.2% of these appeared after open surgery, on the other hand 3.4 % were pulmonary problems after VL surgery. Onset of urogenital complications related to open surgery was not found. Renal complications were found in 5.7 % after open surgery, 1.3 % in patients who underwent laparoscopic tecnique.A significant relation between onset of adverse events and surgical tecnique used in the treatment of rectal cancer was not found. This is due to the reduced number of adversal events found in the analyzed sample, insufficient to draw consistent conclusions in this regard (Table II). Our study proved that operating duration caused the onset of pulmonary complication rather than cardiac ones. The rate of pulmonary complications increase if the surgeries reach the 200 minutes duration (statistics strongly highlighted this). The renal complications appear when the surgery reaches 207 minutes (Fig. 4). Non surgical problems significantly developed starting from 208 minutes' operations (Fig. 6) (p=0.036) We divided our study's patients into 2 groups: the ones who are younger than 70 years old and the ones who are 70 or even older. Cardiac as well as non surgical complications were not statistically relevant when related to the patients' age. Nevertheless, we could see that the older patients who underwent a traditional surgery suffered more complications than the ones who underwent a mini invasive surgery (14.6% against 3.85) p=0.012.

## Discussion

Laparoscopic surgery has gained widespread popularity for colectomy, despite a literary debate on the optimal surgical resection technique of rectal cancer [13,14]. In spite of the recent technological advances and the increase of the surgeon's experience in minimally invasive techniques, in fact, there is still a significant and marked improvement in the rate of postoperative complications for colorectal surgery [14-17]. In recent studies, non-surgical morbidity has been identified as a potential target for further improvement [18,19]. Our work demonstrates a significant reduction in cardiac morbidity after laparoscopic surgery for colon cancer. According to a meta-analysis conducted and published by Shiphorst et al. a significantly lower incidence of cardiac adverse events is obtained following videolaparoscopic technique compared to traditional surgeries performed with laparotomic incision [20]. There are various possible explanations. Firstly, laparoscopy leads to a decrease in intraoperative blood loss and the need to transfuse, as shown by many studies [13,21-24]. Blood loss can cause hypotension and hypoperfusion, leading to increased susceptibility to cardiac injury. Secondly, minimally invasive surgery is associated with a reduction of the physiological stress response [25], and the coagulation pathways are activated to a lesser extent in laparoscopic procedures than open surgery [26], leading to a favorable outcome due to reduced activation of inflammatory mediators and consequently reduced inflammatory insult and reduced activation of cytokine patterns.

It is also shown that laparoscopic surgery leads to a reduction in post-operative pain and some studies have suggested that this results in a decrease in the incidence of pulmonary complications [18,27,28] as in ourstudy finding evidence in an obvious statistical significance. According to the reference literature [20] for rectal cancer resection, no advantage has been found of laparoscopic surgery with respect to cardio-pulmonary complications. One reason could be that rectal surgery is generally more extensive and associated with an overall higher overall morbidity rate [13,14]. Since the duration of total mesorectal excision is generally longer than in colectomy, and laparoscopic techniques further prolong the duration of surgery [13,14] the benefits of laparoscopic surgery for rectal cancer may be less evident. There is a debate on this according to some authors, on the contrary, despite the rectal resection is significantly associated with a greater number of post-operative complications compared to other surgical procedures, the laparoscopic approach maintains its benefits in any case, also in patients with known preoperative comorbidity [29]. Our work has not

come to an answer to this question, due to the small amount of adverse events found following rectal surgery in patients analyzed . Other studies have shown that the duration of the operative session is associated with a proportional increase in the risk of cardiopulmonary complications [27,30]. This finding was confirmed by our study, which found a significance in the increase in pulmonary complications related to the duration of the operative session, together with a significant increase in renal and systemic complications. Cardiac and pulmonary adverse events following colo-rectal surgery are more frequent in older patients [15,16]. According to some research, it is the elderly patients who can benefit most from minimally invasive surgery [31,32]. However, in the metanalytic study published by Shiphorst et al. [20], there were insufficient data to draw conclusions on the effect of laparoscopy on the incidence of cardiac or pulmonary complications for elderly patients. In our study, we found a positive statistical significance relative to the incidence of respiratory-type adverse events in patients who underwent laparotomic colectomy in the ≥70-year-old subgroup.It seems that the use of laparoscopic techniques in colorectal surgery provides only marginal advantages in terms of reduction of cardio-pulmonary and other non-surgical complications compared to the data expected from a minimally invasive approach: despite the technique used, studies agree to say that the prediction of postoperative morbidity remains, therefore, essential. This requires careful pre-surgical evaluation and adjustment of care. A very interesting and recently validated data demonstration shows that some form of "pre-rehabilitation" with preoperative cardiopulmonary exercise can improve the patient's physical fitness and reduce postoperative morbidity [33,34].

In conclusion, our analysis showed a reduction in cardiac adverse events and a significantly lower number of pulmonary and renal complications following laparoscopic colectomy, although for rectal cancer this reduction was not observed due to insufficient data. We also confirmed the data on the increase in the incidence of pulmonary, renal and systemic adverse events in relation to the duration of the operative session, and found a significant increase in the incidence of postoperative pulmonary complications in male patients, probably due to a statistically greater habit of smoking with predisposition to exacerbation or manifestation of respiratory pathology established preoperatively. Finally, we demonstrated a significant correlation between the occurrence of pulmonary adverse events in patients ≥70 years old and the performance of traditional laparotomic colectomy, thus supporting the hypothesis that elderly patients are actually the population that can ultimately benefit most of minimally invasive surgical techniques. These results must be interpreted with caution. The overall morbidity rates for colorectal surgery remain high, and this is a well-established fact. Therefore, a personalized approach to the decision of the surgical intervention will be necessary, through an appropriate evaluation of the pre-existing co-morbidities. This will be facilitated by the implementation of a targeted clinical evaluation of the population of patients most vulnerable by age and / or with important preoperative risk factors. Therefore, it is recommended that this will be a standard attitude in the future research.


## Riassunto

BACKGROUND: La maggior parte degli studi pubblicati sul trattamento laparoscopico del carcinoma del colon retto analizzano gli outcome oncologici. Rimane da definire se la chirurgia laparoscopica porta ad una riduzione delle complicanze sistemiche nel periodo postoperatorio.

MATERIALI E METODI: Abbiamo analizzato una serie di complicanze non chirurgiche nei pazienti sottoposti a chirurgia laparoscopica verso tradizionale e trattati per carcinoma colorettale. Nello studio abbiamo analizzato 426 pazienti . In 225 casi abbiamo trattato i pazienti con tecnica tradizionale, in 145 casi con tecnica laparoscopica ed in 56 casi con conversione intraoperatoria.

RISULTATI: La correlazione tra la tecnica laparoscopica e la Chirurgia "open" hanno evidenziato un tasso di complicazioni cardiache maggiore per I pazienti sottospoti a tecnica tradizionale (11,7%) vs laparoscopia (5,5%).Lo stesso risultato per le complicanze polmonari (13,2% vs 3.4%) e renali (5,7% vs 1,4%). L'età media dei pazienti trattati con chirurgia open è risultata pari a 75 anni con una durata media dell'intervento pari a 169 minuti mentre l'età media dei pazienti trattati con chirurgia laparoscopica è risultata pari a 69 anni con una durata media di 169 minuti.Abbiamo analizzato I possibili benefici dei pazienti trattati con tecnica laparoscopica per carcinoma del retto ma il numero dei casi non ha reso possibile alcuna considerazione.All'aumentare dei tempi operatori si è evidenziato un incremento dell'incidenza di complicanze non chirurgiche a carico dell'apparato polmonare, renale e eventi avversi sistemici.Il tasso di complicanze polmonari è risultato più alto negli uomini (male 12.7% vs female 6.8%) ed infine stratificando il paziente per età, si è evidenziata una significativa correlazione nell'incidenza di complicanze polmonari tra i pazienti operati con tecnica open maggiori di 70 anni (open 14.6%, VL 3.8).

CONCLUSIONI: I dati analizzati evidenziano una riduzione degli eventi avversi polmonari, renali e cardiaci dopo chirurgia laparoscopica per carcinoma del colon. Abbiamo evidenziato un aumento dell'incidenza di eventi avversi correlati alla durata dell'intervento chirurgico, al sesso maschile ed all'età del paziente maggiore di 70 anni.


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