Cost minimization analysis of laparoscopic surgery for colorectal cancer within the enhanced recovery after surgery (ERAS) protocol: a single-centre, case-matched study

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Abstract

Introduction: *The goal of modern medical treatment is to provide high quality medical care in a cost-effective environment.*
Aim: *To assess the cost-effectiveness of laparoscopic colorectal surgery combined with the enhanced recovery after surgery protocol (ERP) in Poland.*
Material and methods: *We designed a single-centre, case-matched study. Economic and clinical data were collected in 3 groups of patients (33 patients in each group): group 1 – patients undergoing laparoscopy with ERP; group 2 – laparoscopy without ERP; group 3 – open resection without ERP. An independent administrative officer, not involved in the treatment process, matched patients for age, sex and type of resection. Primary outcome was cost analysis. It was carried out incorporating institutional costs: hospital bed stay, anaesthesia, surgical procedure and equipment, drugs and complications. Secondary outcomes were length of stay (LOS), readmission and complication rate.*
Results: *Cost of laparoscopic procedure alone was significantly more expensive than open resection. However, implementation of the ERAS protocol reduced additional costs. Total cost per patient in group 1 was significantly lower than in groups 2 and 3 (EUR 1826 vs. EUR 2355.3 vs. EUR 2459.5, $p < 0.0001$). Median LOS was 3, 6 and 9 days in groups 1, 2 and 3 respectively ($p < 0.001$). Postoperative complications were noted in 5 (15.2%), 6 (18.2%) and 13 (39.4%) patients in groups 1, 2, 3 respectively ($p = 0.0435$).*
Conclusions: *In a low medical care expenditure country, minimally invasive surgery combined with ERP can be a safe and a cost-effective alternative to open surgery with traditional perioperative care.*

Key words: *enhanced recovery, colorectal cancer, laparoscopy, perioperative management, postoperative complications, fast-track.*

Introduction

The goal of modern medical treatment is to provide high quality medical care in a cost-effective environment. Nowadays an extremely important factor in clinical decision-making is health economics. This aspect is often as relevant as evidence-based medical practice, especially to national medical care providers. Therefore thorough cost-effectiveness evaluations of practically all new technologies and protocols

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are routinely performed. In the field of surgery it usually means not only the surgical procedure itself but also hospital stay, potential complication costs, as well as postoperative recovery after discharge. Although there is enough evidence to support the benefits of laparoscopic surgery in both short- and long-term outcomes, its implementation in developing countries remains challenging, mostly due to higher operative costs and lack of expertise [1–5].

Over the last decade substantial changes have also been made in perioperative care. Due to enhanced recovery after surgery programmes (ERPs), where the main goal is to attenuate postoperative metabolic stress, it is possible to reduce complication rates and shorten length of stay, which is crucial in every oncological patient. Several studies have confirmed that modern evidence-based multidisciplinary perioperative care is safe and feasible in most hospitals [6–10]. Despite the strong evidence and clear guidelines on perioperative care in colorectal surgery according to Enhanced Recovery After Surgery Society principles, their adoption among medical staff is slow [11–13]. The reason for this phenomenon is the reluctance to accept modern perioperative care strategies that differ from personally preferred practice, and the misconception of an increased complication rate, which in turn might generate additional costs [14].

According to Kehlet, often referred to as the father of fast-track surgery, economic benefits of laparoscopy and ERP would doubtlessly promote their wider adoption [15]. Although recent analyses support the cost-effectiveness of ERP, they cover only high-income countries and include mixed open and laparoscopic groups [16–20]. Since no study has investigated this topic in a country with limited expenditure on health care, we aimed to assess the cost-effectiveness of laparoscopic colorectal surgery combined with ERP in Poland.

Material and methods

We designed a case-matched study to analyse direct treatment costs of patients undergoing colorectal resection for cancer. Inclusion criteria were: age ≥ 18 years, elective surgery, suitable for curative resection involving only the large intestine, laparoscopic or open technique (depending on the study group), ASA 1–3. Patients with inflammatory bowel diseases, after previous colorectal resection, stage IV cancers or patients with incomplete medical data were excluded from the analysis.

Between May and August 2014, economic and clinical data were prospectively collected on consecutive patients undergoing laparoscopic colorectal resection within ERP. They formed study group 1. Using ICD-10 diagnostic codes and ICD-9 procedure codes patients were matched by an independent administrative officer for age, sex and type of resection with two historical control groups. To avoid potential bias the officer was not aware of the study concept. Group 2 consisted of patients undergoing laparoscopic resection with traditional perioperative care (between January and May 2012) and group 3 comprised patients undergoing open resection with traditional care between January and April 2010. Each group consisted of 33 patients (Table I). There were no differences between groups in terms of sex, age, body mass index (BMI), ASA grade and type of surgery. A comparison of the two perioperative protocols (traditional vs. ERP) is presented in Table II.

We are a tertiary referral centre and university teaching hospital. All operations were performed by the same laparoscopic surgeon (AB) with extensive expertise in colorectal surgery (more than 250 open and 200 laparoscopic colorectal resections). Clinical and economic data were recorded in an electronic database up to 30 days after surgery. The primary outcome was cost analysis from the institutional perspective. It was carried out incorporating costs of hospital bed stay, anaesthesia, surgical procedure and equipment, drugs, complications and readmissions and potential reoperations. It was performed by the use of an integrated hospital cost management programme. We used a micro-costing technique in which the frequencies of each resource consumed were recorded and multiplied by their unit cost. All costs were presented per case and were converted to euro from original currency (1 euro = 4.17 Polish zloty, PLN). As patients were treated in different time frames, to avoid the potential bias in differences of medical costs between groups, they were adjusted for inflation and calculated according to the hospital price list at the time of study group 1. Secondary outcomes were length of stay, readmission and complication rate graded with the Clavien-Dindo scale [21].

The study obtained ethical approval from the local Ethics Review Committee (Approval number:

Table I. Demographic characteristics and types of surgery

Parameter	Group 1 (Laparoscopic + ERP)	Group 2 (Laparoscopic + traditional)	Group 3 (Open + traditional)	*P*-value
Number of patients, *n*	33	33	33	–
Females, *n* (%)	18 (54.5)	16 (48.5)	20 (60.6)	0.6132
Males, *n* (%)	15 (45.5)	17 (51.5)	13 (39.4)	
Age, mean ± SD [years]	66.2 ±11.7	64.0 ±11.4	65.8 ±10.9	0.9385
Body mass index, mean ± SD [kg/m^2]	26.8 ±6.3	26.2 ±3.9	26.3 ±6.1	0.9465
ASA 1, *n* (%)	2 (6)	5 (15)	4 (12)	0.7289
ASA 2, *n* (%)	21 (64)	19 (58)	22 (67)	
ASA 3, *n* (%)	10 (30)	9 (27)	7 (21)	
General anaesthesia time, mean ± SD [min]	210.2 ±45.1	204.2 ±55.9	155.7 ±70.1	0.0011
Right hemicolectomy, *n* (%)	15 (45.5)	15 (45.5)	16 (48.5)	0.9982
Left hemicolectomy, *n* (%)	4 (12.1)	3 (9.1)	3 (9.1)	
Sigmoid resection, *n* (%)	4 (12.1)	5 (15.2)	4 (12.1)	
Rectal resection + TME, *n* (%)	10 (30.3)	10 (30.3)	10 (30.3)	

KBET/53/B/2014) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all patients before surgery.

Statistical analysis

To detect a relevant difference of 15% in overall treatment costs with a two-sided significance level of 0.05 and a power of 80%, it was calculated that 33 patients per study arm would be required. Statistical analysis was performed using StatSoft Statistica v.10. Groups were compared using the χ^2 Pearson test for categorical variables. The Kruskal-Wallis test was used to assess non-normally distributed continuous data. Results were considered statistically significant when *p*-value was < 0.05.

Results

We observed that the general anaesthesia time was significantly shorter in group 3 (open surgery). Table III presents mean direct costs of treatment in analysed groups. Laparoscopic operations were significantly more expensive than open surgery. Due to shortening length of stay (LOS), costs of bed stay and drugs were lowest in group 1. Total cost per patient in group 1 was significantly lower than in groups 2 and 3 (EUR 1826 vs. EUR 2355.3 vs. EUR 2459.5, $p < 0.0001$).

Secondary outcomes are presented in Table IV. Median LOS was 3 days in group 1, 6 days in group 2 and 9 days in group 3 ($p < 0001$). Postoperative complications were noted in 5 (15.2%), 6 (18.2%) and 13 (39.4%) patients in groups 1, 2, 3 respectively ($p = 0.0435$).

In total, 3 patients required an intensive care unit (ICU) stay – 1 patient from group 1 (1 day) and 2 patients in group 3 (6 and 2 days, both due to cardiopulmonary failure) ($p = 0.3564$).

Reoperation was necessary in 1 patient (group 1) readmitted due to anastomotic leakage. This patient was our only mortality in all of the study groups. She died after 1 day in the ICU as a result of myocardial infarction during relaparotomy for anastomotic leakage 7 days after the primary surgery.

Readmission within 30 postoperative days was necessary in 2 patients from group 1 and 1 patient from group 2. There were no readmissions in group 3 ($p = 0.3564$). The reasons for readmissions were bleeding from the anastomotic suture line (2 patients) and anastomotic leakage on the 7th postoperative day (1 patient mentioned above).

Table II. Enhanced recovery after surgery protocol compared with standard care protocol

Variable	Standard care	Enhanced Recovery After Surgery Protocol
Before admission	Surgical and anaesthesia consultation Perioperative risk assessment Admission 1 day before surgery	Surgical and anaesthesia consultation Perioperative risk assessment Patient education including ERAS principles, treatment goals, discharge criteria and expected length of stay Smoking cessation Prehabilitation (30 min walks 2 weeks prior to surgery) Admission 1 day before surgery
Before surgery	Mechanical oral bowel preparation (Fortrans or Citrafleet) Clear fluids up to 8 h before surgery Antibiotic prophylaxis (preoperative cefuroxime 1.5 g + metronidazole 0.5 g ***i.v.*** 30–60 min prior to surgery)	No bowel preparation (excluding rectal resection with total mesorectal excision (TME) Solid meals up to 6 h and clear fluids up to 2 h before surgery Preoperative carbohydrate loading (400 ml of Nutricia preop. 2 h before surgery) Antibiotic prophylaxis (preoperative cefuroxime 1.5 g + metronidazole 0.5 g *i.v.* 30–60 min prior to surgery) Deep vein thrombosis (DVT) prophylaxis (clexane 40 mg *s.c.* starting in the evening prior to surgery)
Perioperatively	Open surgery (longitudinal incision) or laparoscopic approach (longitudinal minilaparotomy for specimen extraction) Non-balanced intravenous fluid therapy (2500–4500 ml intravenous crystalloids during the day of surgery – amount decided by anaesthetist and surgeon) Peritoneal drainage after each type of surgery Avoidance of prophylactic nasogastric tubes Anti-emetics according to instructions given by anaesthetist	Laparoscopic surgery (transverse minilaparotomy for specimen extraction) Balanced intravenous fluid therapy (< 2500 ml intravenous fluids during the day of surgery, sodium restriction) Avoidance of prophylactic nasogastric tubes and drains Postoperative nausea and vomiting prophylaxis (8 mg dexamethasone *i.v.*, ondansetron 8 mg *i.v.*)
Postoperatively	Analgesia decided by anaesthetist and surgeon Introduction of clear fluids on 2nd postoperative day Introduction of oral diet on 3rd postoperative day DVT prophylaxis (Clexane 40 mg *s.c.* starting on the 1st postoperative day) Mobilization on the 2nd day after surgery Removal of urinary catheter when patient fully mobilized	Non-opioid multimodal analgesia Transversus abdominis plane block Introduction of clear fluids 2 h after return to ward Oral nutritional supplement in the evening on the day of surgery (Nutricia Nutridrink) Postoperative oxygenation therapy Introduction of oral diet on 1st postoperative day Early mobilization 2 h after return to ward Early removal of urinary catheters (< 24 h postoperatively)
Discharge	Discharge at surgeon's decision when indicated clinically	Discharge after fulfilling discharge criteria
After discharge	7 day follow-up in outpatient clinic	Telephone call on the 1st and 3rd day after discharge 7 day follow-up in outpatient clinic

Discussion

The differences in national health care systems, reimbursement policies and human costs across the countries encouraged us to perform an analysis of economic outcomes of ERP implementation based on a publicly financed academic institution in Poland. In this study we found that laparoscopic surgery combined with ERP is a cost-effective treatment comparing to laparoscopic or open surgery with traditional perioperative care. Additionally it reduces length of stay and postoperative complications.

Table III. Cost analysis in subsequent groups

Parameter	Group 1 (Laparoscopic + ERP)	Group 2 (Laparoscopic + traditional)	Group 3 (Open + traditional)	*P*-value
Operative costs, mean ± SD [EUR]	1272.1 ±345.9	1318.1 ±329.2	941.3 ±245.2	< 0.0001
Costs of bed stay, mean ± SD [EUR]	491.4 ±177.0	874.8 ±235.9	1324.6 ±570.5	< 0.0001
Costs of drugs, mean ± SD [EUR]	17.0 ±4.6	42.4 ±8.6	53.2 ±20.7	< 0.0001
Other costs, mean ± SD [EUR]	45.5 ±60.7	120.0 ±31.8	140.4 ±267.4	0.0005
Total cost per patient, mean ± SD [EUR]	1826.0 ±397.7	2355.3 ±420.1	2459.5 ±575.7	< 0.0001

Table IV. Secondary outcomes

Parameter	Group 1 (Laparoscopic + ERP)	Group 2 (Laparoscopic + traditional)	Group 3 (Open + traditional)	*P*-value
Number of patients, *n* (%)	33 (33.3)	33 (33.3)	33 (33.3)	–
Length of stay, median (IQR) [days]	3 (2–4)	6 (5–7)	9 (7–10)	< 0.0001
Complication rate, *n* (%)	5 (15.2)	6 (18.2)	13 (39.4)	0.0435
Clavien-Dindo 1, *n* (%)	3 (9.1)	4 (12.1)	6 (18.2)	
Clavien-Dindo 2, *n* (%)	1 (3.0)	1 (3.0)	4 (12.1)	
Clavien-Dindo 3, *n* (%)	–	1 (3.0)	1 (3.0)	
Clavien-Dindo 4, *n* (%)	–	–	2 (6.1)	
Clavien-Dindo 5, *n* (%)	1 (3.0)	–	–	
Intensive care unit stay, *n* (%)	1 (3.0)	–	2 (6.1)	0.3564
Readmission, *n* (%)	2 (6.1)	1 (3.0)	–	0.3564

There is currently strong evidence for better short-term outcomes from minimally invasive surgery compared to open resections [1, 22, 23]. However, due to the false impression of higher costs of treatment, it is rarely performed in middle- and low-income countries with limited expenditure on health care [5]. Our paper is in line with previous results stating that the laparoscopic procedure alone is undoubtedly more expensive until LOS, costs of complications and recovery are factored in [24–26]. It is directly related to a longer operative time and increased number of disposable equipment. Therefore, we agree that in our environment it may also be associated with increased expenditure. According to our results, when including other treatment costs (LOS, drugs, complications) in the calculations, minimally invasive surgery turns out to be a cost-effective alternative. Although this has been previously confirmed in studies conducted in high-income countries, data on this topic in a different economic setting are sparse [27–29]. Thus, in the analysis we also included an intermediate group – patients operated on minimally invasively but managed traditionally. Interestingly, we noted that there were no significant differences in direct costs of treatment between laparoscopic and open groups in a traditional care protocol.

In the large multicentre randomized LAFA trial comparing laparoscopic and open techniques within and outside ERP, the authors did not find significant differences in in-hospital costs among the treatment groups [30]. Probably the most important result of our analysis is that a hospital may financially benefit from laparoscopic colorectal procedures only if they are combined with ERP. In our setting, the reduction of costs of hospital stay and drugs in the enhanced recovery after surgery environment overweighed operating room costs both in open and laparoscopic

groups. The mean difference in overall costs between traditional laparoscopic and ERP groups was EUR 529 (22.5%). It is smaller than presented in the recent reviews by Lee *et al.* and Lemanu *et al.* [16, 19]. It seems that this discrepancy reflects the total expenditure on the overall costs of treatment of a single patient, which in our case, due to socioeconomic conditions, was significantly lower. This proportion can be additionally enhanced if we take into consideration improved patient bed availability, shorter waiting lists for surgery, fewer cancelations due to the lack of ward capacity and, last but not least, higher total reimbursement due to a higher number of patients treated. The Polish Ministry of Health has recently implemented a new programme for all surgical cancer patients to improve clinical outcomes. It aims to shorten the time from diagnosis to treatment by providing surgeons with better and wider access to diagnostic tools. Moreover, increased financial resources on surgical oncology were allocated. Therefore shortened length of stay and a reduced complication rate increase the capacity of every surgical ward, thus indirectly enabling higher income. In Poland, health care is mostly public funded. Each year the National Health Fund signs individual contracts with Polish hospitals setting down the number and types of individual surgical procedures to be refunded by the state during the next year. The reimbursement for the surgical treatment of a patient depends on the type of surgery (ICD-9) and diagnostic code (ICD-10). The refund is equal regardless of the surgical approach (open/laparoscopic) or postoperative course (prolonged hospital stay, complications). Moreover, any readmission within 14 days after discharge is not refunded and therefore generates debt. For instance, the expenditure on a single colorectal resection is much lower than in other developed countries [16]. This is probably the most important factor which slows down wider implementation of laparoscopy in Poland (mistakenly considered as more expensive). Therefore ERP leading to real cost savings allows us to perform laparoscopic surgery practically in all patients. Further reduction of LOS maximizes hospital bed capacity, thus increasing the number of cases treated annually.

The primary outcome of this study was cost-analysis, but similarly to our previous analyses we also demonstrated that laparoscopy and ERP significantly reduce complications and length of stay [10, 31–34]. Previous large trials and meta-analyses clearly showed similar results in terms of both laparoscopy and ERP [6, 9, 35]. Moreover, they did not demonstrate any differences in readmission rates. We can therefore assume that further savings can be made as a result of reduced complications and improved postoperative recovery with no risk of additional costs of readmission.

Another important issue which should be mentioned is neglecting costs of staff training and the ERP implementation process. We have decided to deliberately ignore implementation costs since we believe that once protocols are implemented the training will become "training while working" with regular postgraduate education or refreshment courses. Those costs are the same no matter whether training includes traditional or modern multimodal perioperative care pathways. Obviously implementation of a new protocol may require a costly visit to a centre of excellence. Currently, there are already national symposia in Poland which teach necessary skills of how to implement ERP.

Our study has certain limitations typical for a single-centre non-randomized analysis. However, in our opinion conducting a randomized controlled trial in a centre which implemented ERP 3 years ago for all types of procedures (compliance with ERP in colorectal surgery > 80%) would not be possible. We cannot imagine how to convince our staff to take a step back and start using the traditional perioperative protocol. It would certainly result in low compliance with the traditional protocol and might create potential bias. Additionally, the costs of certain equipment and drugs as well as bed stay at our institution may be different from other hospitals in our country. Therefore it cannot be directly transferred to all hospitals but may very well serve as a model of a Polish hospital financed by the national health care system. The inclusion of a retrospective group of patients introduces the possibility of some differences in perioperative care, which were not assessed. Finally, we calculated only direct costs (and readmissions within 30 days after discharge), and did not include costs of postoperative care in primary health care after that period.

Conclusions

The implementation of ERP and laparoscopic colorectal surgery is associated with decreased risk of postoperative complications. Although clinical

outcomes are the most important measurements in modern surgery, cost analysis remains a significant argument in the discussion on new methods of treatment. Based on our analysis, modern perioperative care combined with minimally invasive surgery can be a cost-effective alternative to open surgery with traditional perioperative care.

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Conflict of interest

The authors declare no conflict of interest.

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