



Enhanced recovery protocols in colonic surgery: retrospective cohort analysis of economic impact from an institutional point of view

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Abstract

Background Despite increasing evidence supporting the beneficial effects of enhanced recovery protocols (ERPs), their accurate economic impact on institutions remains lacking. The aim of this study was to analyze ERP economic impact in a French center in order to further encourage implementation.

Methods All patients who underwent elective laparoscopic right or left colectomy for benign or malignant pathology from 2014 to 2017 in a single center were retrospectively reviewed. ERP according to national recommendations was effective starting November 2015. Perioperative data and all direct costs borne by the institution were collected for each patient. Patients who underwent colectomy before and after ERP implementation were compared.

Results Overall, 288 patients were included of which 144 received conventional perioperative care (CC) and 144 received ERP. There were 161 (56%) men, median age was 71 (28–92) years, and 242 (84%) patients underwent surgery for malignant disease. Operative time, intraoperative blood loss, and severe postoperative complications were similar between both groups. ERP was associated with reduced Clavien-Dindo I–II postoperative complications (15% vs. 28%, $p = 0.010$) and overall in-hospital stay (6 vs. 7 days, $p = 0.003$). Overall institutional costs were lower in the ERP group although difference was not statistically significant (7022 vs. 7501 euros, $p = 0.098$). Estimated savings per patient reached a mean of 480 euros.

Conclusions In a tertiary French center, ERP was associated with reduced postoperative morbidity and in-hospital stay resulting in considerable cost savings. Although not significant, ERP resulted in positive economic impact even in an early implementation phase.

Keywords Colorectal surgery · Postoperative outcome · Enhanced recovery following surgery · Economical impact · In-hospital stay · Perioperative management

Introduction

With over 40,000 surgical interventions per year in France [1], colorectal surgery represents an important healthcare burden. Almost 80% of procedures are performed electively, and guidelines for enhanced recovery programs (ERPs) are now established [2, 3]. First described in the early 1990s in order to improve postoperative outcomes and recovery following colorectal surgery [4], these programs include a series of evidence-based measures and treatments covering the entire perioperative period, all of which aim to reduce surgical stress response, maintain physiological function, and enhance mobilization following surgery [3]. Since then, countless studies have established ERP efficiency in terms of length of stay reduction and accelerated postoperative recovery and most have also found an associated reduction of postoperative morbidity

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[5–9]. Despite high-quality evidence, widespread dissemination of ERP has not occurred [10–12]. ERP implementation has been uneven between countries worldwide, as well as between centers within the same country, with various factors perceived as obstacles [13]. Indeed, adapting to change, interdisciplinary coordination efforts, and limited resources are just some of the barriers for successful clinical implementation [14].

Cost saving obtained through ERP could further encourage implementation. Although clinical outcome should always remain the primary focus of ERP, economic evaluations are an essential part of assessments of new health technologies and are important for funding decisions, especially in an era where health costs are rising and government resources are limited. Health-related costs vary according to countries (based on different health policies and practices) and studies analyzing ERP economic impact are sparse and heterogeneous, especially those reporting exhaustive cost data [8, 15]. The objective of this study was to assess the economic impact of implementing an ERP for colonic surgery in a French tertiary referral center, through an exhaustive analysis of all direct costs related to perioperative management.

Methods

Study population

From March 2014 to May 2017, all consecutive patients who underwent right or left colectomy at Institut Mutualiste Montsouris (Paris, France) were identified. Patients included were electively operated on for malignant and benign colonic pathology alike, had laparoscopic procedures, and had an ASA score ≤ 3 . Patients were excluded if they underwent rectal or colonic resections other than standard right or left colectomy, had stoma placement; presented with immunodeficiency and unstable diabetes mellitus, or had corticosteroid therapy or if surgical procedure extended beyond right or left colectomy (adjacent organs). Patient isolation and pregnancy were also considered as exclusion criteria. All procedures were performed using standardized surgical techniques for right hemicolectomy and left hemicolectomy, respectively. Surgical team included six senior colorectal surgeons, and techniques were unchanged during the entire study period. The decision for colectomy was taken by a multidisciplinary board that included surgeons, medical oncologists, and radiologists. Patients who underwent colectomy before and after implementation of ERP were compared. This study was approved by the local institutional review board.

Perioperative management and enhanced recovery protocol application

Starting November 2015, effective ERP was established through collaboration between local surgical and anesthetic teams, and

was based on national recommendations [2]. Implementation was performed with the same number of physicians and other allied health professionals, and all different ERP items (listed in Table 1) were established following a 1-month application phase. Perioperative management thus consisted of conventional care (CC group) between March 2014 and November 2015 and ERP between November 2015 and May 2017 (ERP group). Detailed perioperative management of both groups is reported in Table 1. In both groups, oral bowel preparation was performed only in the case of left colectomy. Laparoscopy was considered as the standard approach in both groups.

Postoperative outcomes

Systematic blood tests, including white blood cells' (WBC, cutoff set at $> 14,000/\text{mm}^3$) count and C-reactive protein (CRP, cutoff set at $> 150 \text{ mg/l}$), were performed in all patients at postoperative day 4 in search for postoperative complications [16]. Postoperative morbidity and mortality were assessed at 90 days after surgery using Clavien-Dindo classification [17]. Severe postoperative complications were defined as Clavien-Dindo > 2 . Medical and surgical complications were distinctively recorded as well as total in-hospital stay. Although the distinct readmission rate was not recorded, it was taken into account for each patient in terms of increased costs (readmission-related costs were included in overall patient cost in Syame®).

Clinical data and costs

The data for patients were retrospectively retrieved from a prospectively collected database. Clinical and demographic characteristics as well as intraoperative and postoperative data were recorded. Synchronous metastases and preoperative chemotherapy requirement were recorded. All direct in-hospital costs borne by the institution were collected (Table 4). Included costs were related to operating room, ward and total in-hospital stay, pharmacy, transfusion requirements, laboratory, radiology, physician and allied health professional remuneration, and pathology department. Furthermore, costs were analyzed according to ASA groups (ASA grades I and II compared with grades III and IV) in order to determine whether or not ERP was beneficial in healthy and frail patients alike. All costs were recorded using Syame® platform and analyzed on an institutional level. ERP entailed negligible implementation costs having been performed with the same number of personnel (physicians and other allied health professionals). These latter costs were related to all time-consuming reunions that took place in order to develop, implement, and maintain enhanced recovery protocols. In the French healthcare model, hospitals are funded by activity-based payment and are reimbursed for each patient based on rates that are determined for each hospital stay and that depend on the severity of underlying pathology and/or complexity of care (four severity categories). Reimbursement is thus determined yearly for each

Table 1 Perioperative management in CC and ERP groups

| | CC | ERP |
|---------------------------|--|---|
| Preoperatively | | |
| Patient education | No patient education | Oral and written explanation of perioperative pathway |
| Physical education | No | Physical preparation at home |
| Immunonutrition | No | Yes if cancer |
| Oral intake | Nil starting midnight before surgery | Carbohydrate loading* |
| Sedation | Yes | No routine sedation |
| Intraoperatively | | |
| Antibiotics and DTP | Yes | Yes |
| Normothermia | Yes | Yes |
| IV infusion | Non standardized | Avoid overhydration (guided infusion) |
| Prophylactic antiemetics | Yes | Yes |
| Routine abdominal drain | No | No |
| Routine nasogastric tube | No | No |
| Laparoscopy | Yes | Yes |
| Postoperatively | | |
| Multimodal analgesia** | No | Yes |
| Oral intake | Clear fluids starting after flatus with daily progression according to tolerance | Fluids on POD0 Regular diet on POD1 according to tolerance |
| Mobilization | No standardized mobilization plan | Sit in a chair on POD0 Walking on POD1 |
| Urinary drainage catheter | Removed on POD2 | Removed on POD0 |
| IV fluids discontinued | Upon oral intake resumption | POD1 |

CC, conventional care; ERP, enhanced recovery program; DTP, deep thrombosis prophylaxis; IV, intravenous; POD, postoperative day

*Patients who presented with diabetes mellitus or delayed gastric emptying were not given preoperative carbohydrate loading

**Includes opioid-free-based anesthesia with intravenous ketamine-lidocaine infusion and trocar site local anesthetic infiltration

of the four grades of patient severity. In this study, national healthcare reimbursement represented institution income.

Statistical analysis

Continuous variables were compared using Student's *T* test or Mann-Whitney test when appropriate, and presented as mean (\pm standard deviation). Categorical variables were compared using χ^2 test or Fisher's exact test when appropriate, and presented as absolute numbers (percentage). All statistical analyses were performed using SPSS version 20.0 (SPSS Inc., Chicago, IL) and statistical significance was accepted at the 0.05 level.

Results

Studied population

During the study period, 288 patients were included for analysis. All consecutive patients who underwent elective colectomy during the first 19 months following implementation of ERP (ERP

group, $n = 144$) were compared with the same number of consecutive patients treated before its introduction (CC group, $n = 144$), spanning over 19 months as well. There were 161 (55.9%) men and median age was 71 (28–92) years. Overall, 242 (84.0%) patients were operated on for malignant disease and 137 (47.6%) underwent right colectomy. All patients in both groups underwent laparoscopic colectomy with an overall conversion rate of 3%. The ERP group had significantly better compliance to all protocol elements than the CC group (90% vs. 25%, $p < 0.001$), although several elements were already in use in the CC group (Table 1). Both groups were similar in terms of demographic and clinical characteristics (such as age, gender, BMI, ASA score, comorbidities, and malignant underlying disease) as well as type of surgical procedure. Operative time, intraoperative blood loss, and red blood cell transfusion requirement were similar between both groups (Table 2).

Postoperative outcomes

Detailed postoperative morbidity is presented in Table 3. Overall, 90 (31.3%) patients presented with postoperative

Table 2 Patients' clinical and demographic characteristics and intraoperative course in CC and ERP groups

| | CC (N = 144) | ERP (N = 144) | p |
|--|--------------|---------------|-------|
| Demographic and clinical characteristics | | | |
| Age (years) | 71.0 (11.8) | 70.0 (11.1) | 0.181 |
| Sex ratio (M/F) | 84/60 | 77/67 | 0.476 |
| ASA score > 2, n (%) | 11 (7.6%) | 9 (6.3%) | 0.754 |
| BMI (kg/m ²) | 25.4 (4.2) | 25.4 (4.6) | 0.941 |
| Smoker, n (%) | 11 (7.6) | 14 (9.7) | 0.676 |
| Diabetes mellitus, n (%) | 27 (18.8) | 20 (13.4) | 0.516 |
| Elevated blood pressure, n (%) | 57 (39.6) | 63 (43.8) | 0.550 |
| Dyslipidemia, n (%) | 32 (22.2) | 38 (26.4) | 0.492 |
| Chronic renal failure, n (%) | 7 (4.9) | 2 (1.4) | 0.176 |
| Cardiac comorbidity, n (%) | 14 (9.7) | 15 (10.4) | 0.873 |
| COPD, n (%) | 2 (1.4) | 2 (1.4) | 0.873 |
| Malignant disease, n (%) | 124 (86.1) | 118 (81.9) | 0.421 |
| Synchronous liver metastases, n (%) | 10 (6.9) | 9 (6.3) | 0.873 |
| Intraoperative course | | | |
| Right colectomy, n (%) | 67 (46.5) | 70 (48.6) | 0.813 |
| Operative time (min) | 188.5 (68.5) | 173.2 (61.3) | 0.057 |
| Blood loss (ml) | 40.6 (75.7) | 38.2 (61.8) | 0.778 |
| RBC transfusion, n (%) | 4 (2.8) | 2 (1.4) | 0.680 |

CC, conventional care; ERP, enhanced recovery program; ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; RBC, red blood cells

complications with no significant difference found between both groups ($p = 0.162$) and 90-day mortality rate was nil. Conventional care patients presented with more Clavien-Dindo I–II postoperative complications (28.4% vs. 15.3%, $p = 0.010$), whereas severe postoperative complications were comparable between both groups ($p =$

0.808). Overall, 8 (2.8%) patients presented with anastomotic fistula, 12 (4.2%) required redo surgery, and 6 (2.1%) were admitted to intensive care unit. Postoperative ileus occurred in 41 patients overall with no significant difference between both groups ($p = 0.180$) or between patients who underwent right ($n = 24$, 17.5%) or left

Table 3 Detailed postoperative course in CC and ERP groups

| | CC (N = 144) | ERP (N = 144) | p |
|--|--------------|---------------|-------|
| Overall postoperative complications, n (%) | 51 (35.4) | 39 (27.0) | 0.162 |
| Clavien-Dindo I–II, n (%) | 41 (28.4) | 22 (15.3) | 0.010 |
| Postoperative ileus, n (%) | 24 (16.7) | 17 (11.8) | 0.180 |
| Urinary retention, n (%) | 7 (4.9) | 3 (2.1) | 0.340 |
| Pneumonia, n (%) | 1 (0.7) | 3 (2.1) | 0.615 |
| Acute renal failure, n (%) | 0 | 2 (1.4) | 0.478 |
| Urinary tract infection, n (%) | 0 | 1 (0.7) | 0.873 |
| Clavien-Dindo III–IV, n (%) | 8 (5.6) | 10 (6.9) | 0.808 |
| Anastomotic fistula, n (%) | 3 (2.1) | 5 (3.5) | 0.720 |
| Hemorrhage, n (%) | 4 (2.8) | 5 (3.5) | 0.873 |
| SBO, n (%) | 5 (3.5) | 5 (3.5) | 0.873 |
| Wound dehiscence, n (%) | 2 (1.4) | 2 (1.4) | 0.873 |
| Deep surgical site infection, n (%) | 2 (1.4) | 2 (1.4) | 0.873 |
| Redo surgery, n (%) | 4 (2.8) | 8 (5.6) | 0.376 |
| In-hospital stay | | | |
| ICU requirement, n (%) | 5 (3.5) | 1 (0.7) | 0.216 |
| Overall in-hospital stay duration (days) | 7 (3.5) | 6 (3.0) | 0.003 |

CC, conventional care; ERP, enhanced recovery program; SBO, small bowel occlusion; ICU, intensive care unit

colectomy ($n = 17$, 11.3%), $p = 0.236$. Postoperative in-hospital stay was significantly shorter in the ERP group (6 vs. 7 days, $p = 0.003$). Detailed in-hospital stay in both groups is reported in Fig. 1.

Cost analysis

Detailed institutional costs' analysis in both groups is presented in Table 4. Institutional costs were not surgeon dependent ($p = 0.735$). Overall institutional costs were lower in the ERP group although difference did not reach statistical significance (7022 (1798) vs. 7501 (2964) euros, $p = 0.098$) while overall budget was similar between both groups ($p = 0.904$). This resulted in savings estimated at a mean of 480 euros per patient. ERP was favorable in terms of surgical ward hotel ($p = 0.013$), pharmacy ($p < 0.001$), laboratory ($p < 0.001$), allied health professionals ($p < 0.001$), and depreciation expenses ($p < 0.001$). Based on different ASA groups, ERP resulted in savings estimated at 382 euros per patient in ASA I–II group ($p = 0.182$) and 2363 euros in ASA III–IV group ($p = 0.048$).

Discussion

Although it is now established that ERPs improve postoperative outcomes (overall postoperative complications rate and time to first passage of flatus and stool) and reduce in-

hospital stay [5–9], many institutions are reluctant to implement them due to the investment and considerable practice change they represent [18]. A beneficial economic impact on an institution level might therefore increase implementation. The current study confirms that implementation of ERP in a tertiary French center was associated with improved postoperative outcomes following elective colectomy (in terms of Clavien-Dindo grade I–II complications, $p = 0.010$), reduced overall in-hospital stay ($p = 0.003$), and reduced overall costs, although the latter was not significant. Nevertheless, the economical advantage seems to have a greater impact on patients with comorbidities (ASA III–IV).

Implementation requirements

Enhanced recovery protocol implementation requires constant efforts in order to efficiently change original practice. It is a gradual process, which requires regular auditing and result analysis [19]. In this study, because ERP was implemented without increasing personnel (medical and allied health professionals), direct costs that were taken into consideration included time that was spent developing, implementing, and maintaining protocols during the 1-month application period; time dedicated for continuous result analysis; overall personnel activity related to postoperative patient mobilization; information booklet manufacturing; supplement drinks; and additional analgesia [8]. Healthcare system and societal costs

Fig. 1 Detailed in-hospital stay

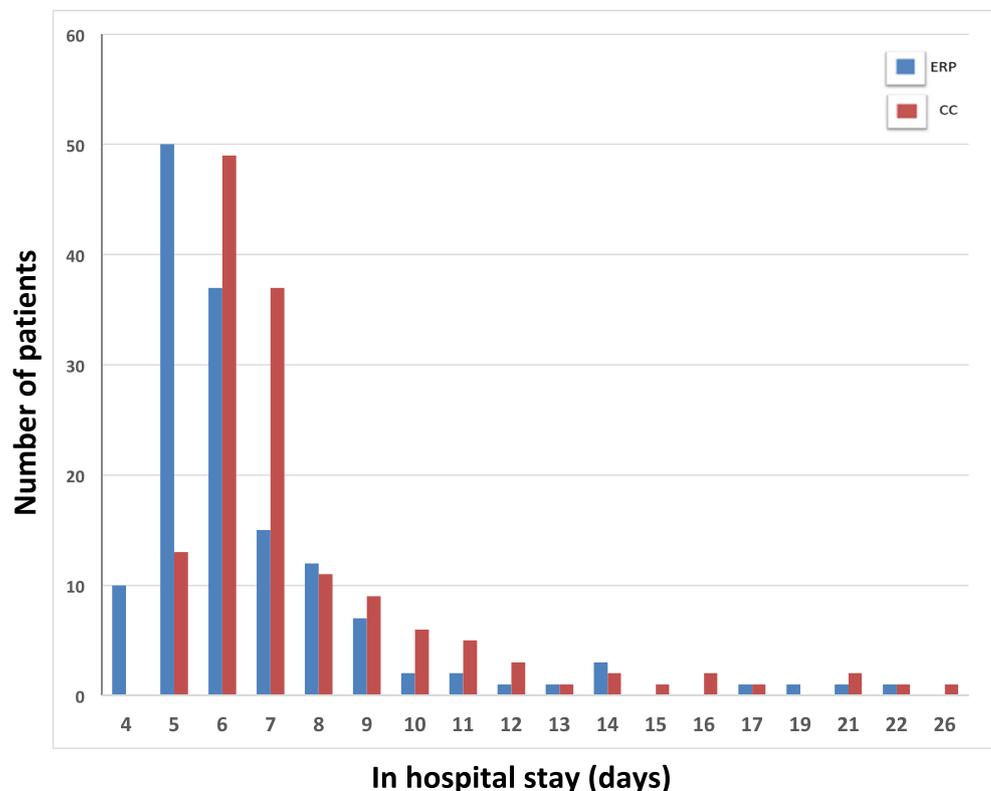


Table 4 Comparison of institutional costs between CC and ERP groups, expressed as cost per patient

| Costs | CC (N = 144) € (SD) | ERP (N = 144) € (SD) | Mean difference | p |
|-------------------------------|------------------------|-------------------------|-----------------|--------|
| Operating room | 883 (299) | 835 (230) | − 48 (403) | 0.130 |
| Anesthesia | 1024 (308) | 1021 (285) | − 4 (414) | 0.919 |
| Surgical ward hotel | 1593 (586) | 1411 (637) | − 182 (906) | 0.013 |
| Blood transfusion and testing | 47 (250) | 26 (85) | − 21(266) | 0.601 |
| Disposable materials | 1217 (545) | 1127 (406) | − 610 (6189) | 0.114 |
| Intensive care unit | 265 (1716) | 29 (347) | − 236 (1755) | 0.108 |
| Radiology | 54 (127) | 61 (139) | 7 (195)22 | 0.652 |
| Laboratory | 60 (47) | 42 (39) | − 19 (65) | <0.001 |
| Pharmacy | 40 (28) | 16 (21) | − 24 (36) | <0.001 |
| Allied health professionals | 165 (67) | 87 (116) | − 78 (120) | <0.001 |
| Pathology | 240 (113) | 299 (139) | 59 (178) | <0.001 |
| Physician billing | 1792 (708) | 1955 (897) | 163 (1184) | 0.089 |
| Depreciation expenses | 56 (18) | 48 (16) | − 7 (26) | <0.001 |
| Other* | 66 (24) | 66 (31) | 0.4 (45) | 0.909 |
| Overall costs | 7501 (2964) | 7022 (1798) | − 480 (3527) | 0.098 |
| Overall budget | 8574 (3064) | 8530 (3117) | − 44 (4425) | 0.904 |
| Overall income | 1073 (3547) | 1508 (2450) | + 436 (4321) | 0.226 |

CC, conventional care; ERP, enhanced recovery program

*Represents expenses related to information technology supplies, office supplies, laundry, office maintenance, and documentation resources

were not included in this analysis, which represents one of the limits of this study. Indeed, data regarding postoperative activity and functional recovery was lacking. However, because implementation of ERPs requires time and financial investment on an institutional level, focus was maintained on institutional costs in order to determine whether or not ERP is cost-effective on the same level. Although direct costs were thoroughly taken into consideration, other indirect costs such as loss of productivity, wages, and burden on families were therefore left out. This point needs to be underlined but remains of limited relevance on an institutional level.

Financial impact

ERP implementation resulted in savings estimated at almost 500 euros per patient, although not statistically significant ($p = 0.098$). Most published series have reported ERP cost-effectiveness (ERP cost–CC cost) varying from no difference to more than 10,000 US dollars per patient [20]. In the current study, overall in-hospital stay in the CC group (before implementation of ERP) was already lower than reported series of conventionally managed patients (ranging between 8 and 10 days) [9, 14, 15] and comes even close to results reported by teams that adhere to enhanced rehabilitation after surgery [9, 21]. Furthermore, compared with present results, significantly shorter length of in-hospital stay was reported by other authors in ERP groups [15]. However, it is well known that in-hospital stay varies between countries due to different

professional and cultural norms, differing payment schemes, and access to long-term care facilities [22]. Both these points might further explain why statistically significant results were not found in terms of cost savings and analysis of future results should shed light on the matter. Another possible explanation for these results would be that some elements in ERP have a bigger impact on patient recovery than others. Out of the 17 items applied in ERP, 6 (35%) were already performed in the CC group. Among these elements, laparoscopic approach, which was performed in all patients in both groups, probably made it more difficult to find a significant difference in terms of recovery benefit. The lack of significant cost savings could also reside in the fact that a certain learning curve is probably required following ERP implementation before reaching efficient results in terms of postoperative recovery. Current results represent the first 18 months of ERP implementation. Some authors have reported that at least 5 to 6 months is required before ERP efficiency is reached [19].

Limits

This study has focused on the financial implications of ERP implementation on an institutional level. Current results show that not only did ERP improve postoperative outcome and reduce in-hospital stay, but financial impact was beneficial as well, even in an early development stage. There are however some limits that need to be taken into consideration, such as the retrospective nature of the study (although data collection was

prospective) and the timeline difference between both groups (ERP patients were compared with historical CC patients).

Conclusions

Implementation of ERP was successful in significantly reducing postoperative morbidity and in-hospital stay. This resulted in considerable cost savings, although not significant. Longer financial analysis following implementation should shed light on this point, but it seems that ERPs have a positive economic impact.

Compliance with ethical standards

This study was approved by the local institutional review board.

Conflict of interest The authors declare that they have no conflict of interest.

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