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NEW CONCEPT

Fast-Track in Bariatric and Metabolic Surgery: Feasibility and Cost Analysis Through a Matched-Cohort Study in a Single Centre

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Abstract
Background Due to the rise in severe obesity in Western countries and the increase in bariatric surgery, enhanced recovery (ER) pathways should be developed and promoted.
Methods A monocentric prospective series of 103 bariatric surgery patients managed with the ER pathway (group ER) was compared with a retrospective and immediately previous series of 103 patients managed with standard care (group CS). The aim of the present study was to assess and compare the differences in terms of mean postoperative length of stay (LOS), costs for surgery and recovery, and the differences in terms of complications, readmission, and reoperation rate in the short term between the ER and CS groups.
Results The mean LOS was 4.18 days in group CS and 1.79 days in group ER ($p < 0.0001$). The mean operative time (OT) per patient was 190.20 min in the group CS and 133.54 min in the group ER, resulting in an average cost of 7272.57€ per patient in group CS and 5424.09€ per patient in group ER. The average recovery cost was 1809.94€ for the group CS series and 775.07 for the group ER one. Overall complications (Clavien-Dindo up to II) occurred in 6 patients (5.8 %) in group CS and in 2 patients (1.9 %) in group ER ($p = 0.149$) and specific complications (Clavien-Dindo IIIb) occurred for 9 patients (8.7 %) in Group CS and for 14 patients (13.5 %) in group ER ($p = 0.268$) after hospital discharge within 1-month of follow-up. Twelve patients (11.5 %) in group CS and 13 (12.5 %) in group ER were readmitted after discharge ($p = 0.831$) within 1-month of follow-up; 8 patients (7.7 %) in group CS versus 9 patients (8.8 %) in group ER needed to be reoperated ($p = 0.800$) within 1-month follow-up.
Conclusions Enhanced recovery pathway reduces significantly LOS in bariatric surgical patients and shortens the mean OT of the procedure, with no significant differences in terms of surgical outcomes. Furthermore, recovery charges were lower and operative time was shorter allowing for procedural cost reduction.

Keywords Laparoscopy · Bariatric surgery · RYGB · Enhanced recovery · ERAS

Introduction

The prevalence of obesity in Western countries has doubled since 1980 [1] and today more than half of the European population is overweight (body mass index (BMI) >25 and <30 kg/m^2) and up to 30 % is obese (BMI > 30 kg/m^2) [2]. The only effective and recommended long-term treatment for severe obesity is bariatric surgery [3], which gives better results than non-surgical therapy and management in terms of weight reduction and is also more cost-effective [4, 5]. This induces an increased number of bariatric surgeries, especially laparoscopic Roux-en-Y gastric bypass (LRYGB), considered as the gold standard (45 % of all bariatric operations worldwide 2013). IFSO data 2015 show however an increased number of laparoscopic sleeve gastrectomy (LSG) [6, 7].

Bariatric surgery is an advanced surgery and remains challenging for the surgeon. Complications are rare, but really catastrophic so many patients have to stay in hospital for several days following surgery, with impacts on recovery costs.

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Table 1 Comparative table of the two management protocols

Conventional series (CS group)	Enhanced recovery pathway (ER group)
Preoperative assessment (surgeon, anesthesiologist, endocrinologist, dietician, and psychologist)	
Hospitalization	Hospitalization
• Admission at D-1	• Admission at D-1(first patient)/D0 the rest
• Pneumatic stockings	• Information and planned discharge the day after
• Nursing	
• Planned discharge 3 days after	
Surgery	Surgery
• Premedication	• No premedication
• Transported in bed	• Patient walks into OR
• Checklist before entering OR	• Checklist during preparation of OR
• Positioning and draping after intubation	• Positioning, draping and intubation at the same time
• Operation	• Operation
• No abdominal drain	• Local anesthesia infiltration on trocart's site wound
	• Patient is able to change from operating table to bed after surgery
	• No drain, no nasogastric tube, no urinary catheter
Anesthesia	Anesthesia
• No standard protocol	• Standard protocol with short-time non opioid drugs
• No PCA pump	• No PCA pump
• Admission on medium care unit/OSAS in intensive care unit with nasogastric tube and urinary catheter	• Admission on medium care unit with IV peripheral access and oral analgesia
• Return to standard unit in the evening	• Return to standard unit 2 h later[a]
Postoperative	Postoperative
• IV fluid perfusion` and fast at D0	• No IV fluid perfusion
• 1 glass of water at D1	• Unlimited water the evening at D0
• Unlimited water at D2	• Blood count and CRP[b]
• Thick fluid diet for 3 weeks	• Thick fluid diet and dietary consult
• Discharge after dietary consult	• Discharge at D1 if correct parameters, adequate pain control and food intake
	• Telephoned 2 days later for a short health survey

[a] OSAS are placed in a special room equipped with the CPAP machine and supplies in standard care unit

[b] Discharge if white blood cells count >17,000 mg/dl and CRP >100

D-1 day before surgery, *D0* day of surgery, *D1–2-3* postoperative days 1–2-3, *OR* operating room, *PCA pump* patient-controlled analgesia pump, *IV* intravenous, *CRP* C-reactive protein

Fast-track, later enhanced recovery after surgery (ERAS) or rapid or accelerated recovery pathways, were first proposed by Kehlet 2002 [8] describing a systematic approach to control patient's perioperative pathophysiological reaction, to reduce surgical stress and complications, to enhance postoperative rehabilitation, and to improve prognosis. In 2010, the ERAS Society was founded, focusing more on enhancement than on speed, with publications of systematic guidelines in colorectal surgery [9] than the pancreas and gastric surgery [10–11]. These pathways include multimodal perioperative cares, which have been demonstrated to be safe and cost-effective in colorectal [12] and gastric surgery [13, 14].

ERAS guidelines for bariatric surgery are not published yet, but several surgical teams have developed their own enhanced recovery (ER) in bariatric surgery. First results appear promising, after an initial learning curve [15–19].

The goal of this new perioperative approach is an economic optimization without negative impact on surgical outcomes.

The present study aims at assessing the reliability of ER protocol compared to conventional approach.

Table 2 Main patient characteristics in the two groups

	(*n*)	Female sex (%)	Age, mean (years)	BMI D0 (kg/m2)
Group CS	103	72	41.5 SD 10.02	44.3 SD 5.81
Group ER	103	75	42.1 SD 11.84	44.8 SD 5.89
P value		0.526*	0.699**	0.556**

(*n*) number of patients, *D0* day of the operation

*Chi-squared test, $p > 0.05$; **Student's *t* test, $p > 0.05$

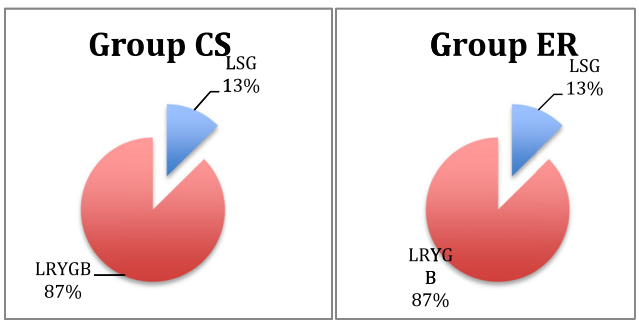

Fig. 1 Difference of type of intervention in the two groups

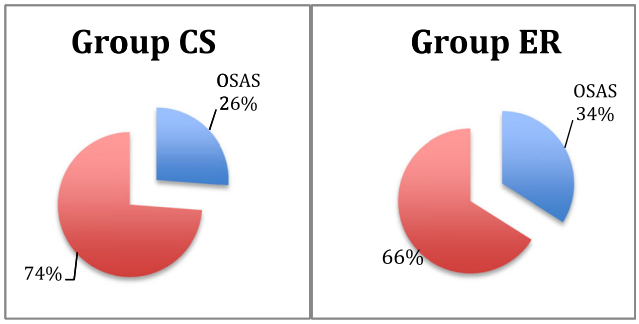

Fig. 2 Rate of respective obstructive sleep apnoea syndrome (OSAS) in the two groups

Materials and Methods

Prior to the start of ER protocol in our department, all members of the surgical team including surgeons, anesthesiologists, nurses, nurse team leader, supervisors, and operating room staff and management staff went to Rijnstate Hospital Arnhem (Netherlands) to train, update, and set up the project.

After 1 month of training necessary for us to set up this new pathway in our institution, a prospective data collection according to the research protocol for the matched-cohort study was started: a prospective series of 103 consecutive patients who underwent bariatric surgery (LRYGB and LSG) between May 2014 and June 2015 were included in the ER pathway (group ER) in our high-volume bariatric division of "Centre Hospitalier de Luxembourg" (Luxembourg City). This cohort was compared to a retrospective series of 103 consecutive patients operated previously from the same fully trained and experienced team between December 2012 and April 2014 and included in group CS. Data analyzed retrospectively were extracted from our prospective obesity database; the control series in group CS was immediately prior to ER series.

An ethical approval was not obtained for our study, but informed consent was signed from all individual participants included in ER series.

All patients met the validated international criteria for bariatric surgery [20].

Exclusion criteria for the enrolment in the two groups were:

1. Bad controlled type 2 diabetes mellitus (HbA1c >10 %)
2. Chronic heart failure
3. COPD in GOLD III or IV stages
4. Redo surgeries.

Preoperative factors including gender, age, preoperative BMI, and operative strategy were recorded.

Surgical Techniques

Laparoscopic Roux-En-Y Gastric Bypass The patients included in both groups received similar standardized procedure 5 trocarts retrocolic retrogastric LRYGB as previously described [21].

The biliary limb and the alimentary limb were respectively 50 and 120 cm long. The size of the gastric pouch was about 10 ml and the gastrojejunostomy was performed side-to-side with a linear 45-mm ECHELON FLEX™ ENDOPATH® Stapler (Ethicon Endo-Surgery (Europe) GmbH, Norderstedt, Germany) and completed with a 3-0 absorbable V-Loc™. The jejunojejunostomy was performed full mechanically side-to-side. All the mesenteric defects were closed with a 3-0, 15-cm-long, non-adsorbable V-Loc™ (Covidien, Mansfield, MA, USA), except for 10 patients in the ER group where the closure was performed with a single stapling line using the endoscopic multifeed stapler Endopath™ EMS (Ethicon Endo-Surgery (Europe) GmbH, Norderstedt, Germany). No leak test was performed, nor abdominal drain inserted at the end of the surgery.

Laparoscopic Sleeve Gastrectomy The Sleeve gastrectomy was performed using a classical 5 or 3 trocarts technique [22].

Dissection of the His angle and the greater curvature of the stomach was performed with a harmonic knife, beginning 6 cm from the pylorus. An Ethicon linear stapler with 60-mm cartridges was used during stomach resection, which was calibrated on a 34-fr gastric tube introduced into the patient's duodenum through the oral cavity. Staples from the last cartridge were applied resecting about 5–10 mm from the His

Table 3 Difference in terms of length of stay (LOS) and mean cost of total recovery between the two groups

	D-1, mean	LOS, mean	Total days of recovery, mean	Total recovery cost, mean (€)[a]
Group CS	1	3.18	4.18	1809.94
		SD 0.707	SD 0.707	
RYGB	1	3.16	4.16	1801.28
Sleeve	1	3.30	4.30	1861.90
Group ER	0.35	1.43	1.79	775.07
		SD 0.866	SD 0.978	
RYGB	0.36	1.4	1.76	762.08
Sleeve	0.30	1.69	1.99	861,67
P value*		<0.0001	<0.0001	
RYGB		<0.0001	<0.0001	
Sleeve		<0.0001	<0.0001	

D-1 patients recovered the day before surgery

[a] Flat fee per 1 day of recovery per patient: 433€

*Student's *t* test, $p < 0.01$

angle. No additional suture or leak test was performed, and no abdominal drain was inserted.

Conventional Management Series (group CS)

The characteristics of the conventional series are described in Table 1.

A multidisciplinary team comprising of surgeons, anesthetists, an endocrinologist, a dietician, and a psychologist preoperatively assessed patients.

All patients were admitted 1 day before surgery (D-1). All patients received pneumatic stockings and twice a day low molecular weight heparin (LMWH) 1 mg/kg of body weight to prevent thromboembolic complications during recovery.

Premedication was administered in the unit half an hour before the surgery. Patients were transported by bed to the operation room.

No standard anesthesia protocol was used in the CS group; anesthesia was administered according to the anesthesiologist's personal choice.

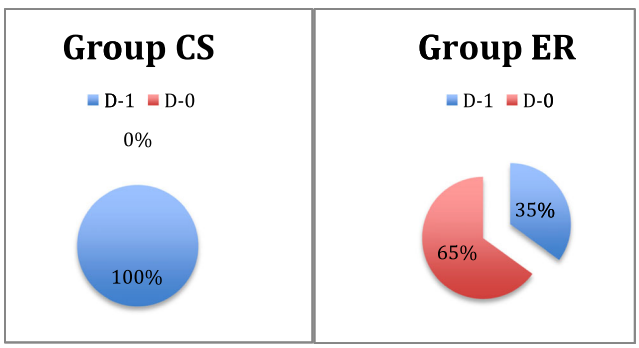

Fig. 3 Rate of patients admitted 1 day before surgery (*D-1*) versus day of surgery (*D-0*) in the two groups

No patient-controlled analgesia (PCA) pump was used for postoperative pain control.

The surgical team could start the positioning and sterile draping of the patient only after anesthesia and intubation were completed.

After surgery, all patients non-suffering from mild to severe obstructive sleep apnoea syndrome (OSAS) were planned for admission on the medium care unit for a few hours; patient affected by OSAS were planned for admission in the intensive care unit with nasogastric tube and urinary catheter for one night and they returned to the standard care unit at day 1 (D1).

In the standard care unit, all patients were allowed to drink one glass of water at D1, free water at day 2 (D2), and thick liquid diet at day 3 (D3). They were discharged after meal and dietary consultation at D3 if vital parameters, pain control, and oral intake were adequate.

Enhanced Recovery Pathway (group ER)

Our ER pathway is described in Table 1. The preoperative assessment program was identical to the conventional management pathway.

The first patient of the day was admitted to hospital the evening before surgery (D-1); all other patients were admitted the day of surgery (D0).

The patients were preoperatively prepared for planned discharge at D1.

The antithrombotic prophylaxis protocol was identical to the conventional management pathway.

No systemic premedication was used but all patients received an oral energetic drink (Oral Impact® or Aquarius®) 2 h before surgery.

The patients walked to the operating theater, sat on the table, and did their own checklist, enabling simultaneous

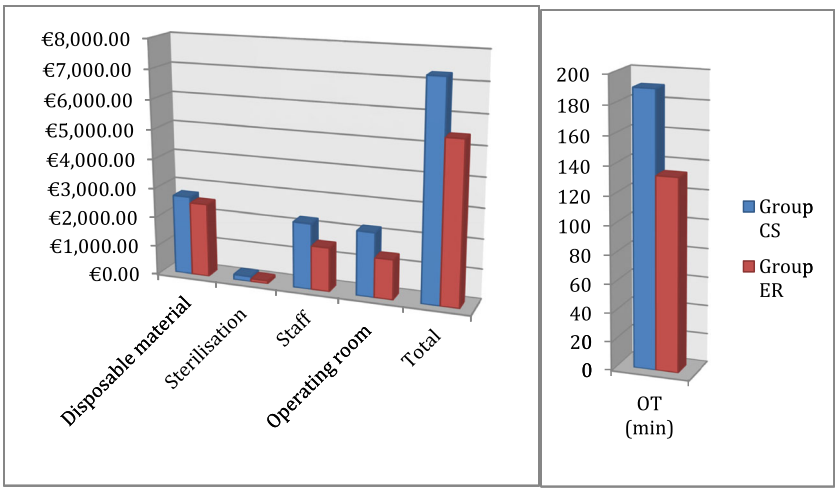

Fig. 4 Mean OT per patient from entry in the operating room to exit in the two groups and its relative impact on the mean cost of the surgery per patient with details

preparation by both surgical and the anesthesia team. Positioning and sterile draping of the patient started between the induction of general anesthesia and intubation.

A standardized anesthesia protocol [16] for bariatric surgery was used, based on short-acting agents and without opioid painkillers, enabling fast recovery, postoperative mobilization, reduced postoperative nausea, and enhanced bowel transit time. The skin at all port sites was infiltrated with ropivacaine hydrochloride 7.5 mg/ml before every incision to reduce postoperative pain [23]. No epidural analgesia or PCA pump was used in the protocol.

After the operation, patients were revived on the operating table without nasogastric tube nor urinal catheter, shifted bed, and were all planned for admission on the medium care unit for vital parameters control, with one single peripheral intravenous (IV) access only, and oral painkillers for 2 h, before going back to the standard care unit; no patient was planned for admission in the intensive care, and patients needing respiratory support (OSAS) were admitted in a special room in the standard care unit, equipped with a CPAP machine and supplies.

The patients were encouraged to mobilize and then to walk around 2 h after the operation and were allowed to drink in the evening of D0.

At D1, full blood count and serum C-reactive protein (CRP) was performed. Patients were allowed to have a thick liquid diet and were discharged after a dietary consult; white blood cells count <17,000 mg/dl and CRP <100 [15], no fever (temperature < 38°), no tachycardia (rate < 100 per minute), normal blood pressure (<160/90 mmHg), adequate pain control, and adequate oral intake were the formal criteria for discharge.

Patients were advised to come back to the hospital in case of any problem, and the chief nurse of the surgical unit phoned all the patients for a short general health survey 2 days after discharge.

For costs analysis, the billing department together with the operating theater supervisor compared the mean operating

Table 4 Difference in terms of general and specific complications of readmission rate and of reoperation rate between the two groups within 1 month of follow-up

	Mean follow-up time	General complications	Specific complications	Readmission rate	Reoperation rate
Group CS	1 month	6 (5.8 %)	9 (8.7 %)	12 (11.5 %)	8 (7.7 %)
RYGB		5	8	12	7
Sleeve		1	1	0	1
Group ER	1 month	2 (1.9 %)	14 (13.5 %)	13 (12.5 %)	9 (8.7 %)
RYGB		2	14	13	9
Sleeve		0	0	0	0
P value*		0.149	0.268	0.831	0.800
RYGB		0.247	0.172	0.829	0.27
Sleeve		0.307	0.307	1	1.04

*Chi-squared test, $p < 0.05$

Table 5 Details of complications needing readmission and reoperation in the two groups

	Readmitted		Reoperated	
	Group CS	Group ER	Group CS	Group ER
Internal hernia	4	6	4	6
Hemorrhage	0	0	2	2
Anastomotic leakage	1	1	1	1
Anastomotic stenosis	1	0	1	0
Nausea	4	5	0	0
Marginal ulcer	1	0	0	0
Chronic pain	1	1	0	0
Total	12	13	8	9

time (OT) per patient, from entry in the operating room through departure, in both protocols, and they calculated the mean price per patient with the details fees.

For the cost analysis of the postoperative length of stay (LOS) in both groups, the flat fee in euros for 1 day of recovery in our unit was considered, and multiplied by the respective mean LOS, calculated from admission to discharge.

Patients in both groups were followed-up 1 month after the operation to assess complications, readmission, and reoperation rates.

The primary endpoint of this study was the difference in total mean LOS, in surgery costs per patient, and in total recovery costs (TRC) between both groups (Student's t test, $p < 0.01$ statistically significant).

The secondary endpoint was the difference in general complications (Clavien-Dindo classification [24]), in specific complications (leakage, internal hernia), in readmission rate, and need for reoperation between both groups (chi-squared test, $p < 0.05$ statistically significant).

Results

The characteristics of the patients in groups CS and ER with 103 patients each are described in Table 2 and Fig. 1. Both groups were homogeneous for age, sex, BMI at the day of the operation ($p > 0.05$), and type of surgery received; 27 (26 %) patients in group CS and 35 (34 %) in group ER had mild to moderate OSAS ($p > 0.05$) (Fig. 2).

In group CS, the mean postoperative stay was 3.18 days (SD 0.707), but all patients were admitted on the day before surgery (D-1 mean = 1) that resulted in a total mean LOS of 4.18 days (SD 0.707); in group ER, the proportion of patients admitted at the D-1 was 0.35 and the mean postoperative stay was 1.47 days (SD 0.866), which resulted in a total mean LOS of 1.79 days (SD 0.978) (p value <0.0001 at Student's t test) (Table 3 and Fig. 3). Moreover, in the ER group, 72 of 103 patients (70 %) could be discharged at D1.

The mean OT per patient from entry in the operating room to exit was 190.20 min in group CS and 133.54 min in group ER, with a mean cost of 7272.57€ per surgery per patient operated in the conventional management pathway and 5424.09€ per surgery per patient operated in the ER pathway; the respective details of the surgery fees per patient are shown in Fig. 4.

A 1-day recovery flat fee in our unit was 433€ from admission to discharge, so the mean recovery overall cost was 1809.94€ for the CS and 775.07 for the ER series as shown in Table 3.

There was no perioperative death in either series.

General complications (Clavien-Dindo up to II) occurred in 6 patients (5.8 %) in group CS and in 2 patients (1.9 %) in group ER ($p = 0.149$) and specific complications (mostly internal hernias and hemorrhage, Clavien-Dindo IIIb) occurred in 9 patients (8.7 %) in group CS and in 14 patients (13.5 %) in group ER ($p = 0.268$) after 1 month of follow-up (Table 4).

Twelve patients (11.5 %) in group CS and 13 (12.5) in group ER were readmitted after discharge ($p = 0.831$) within 1 month of follow-up; 8 patients (7.7 %) in group CS versus 9 patients (8.8 %) in group ER needed to be reoperated ($p = 0.800$) within 1 month of follow-up (Table 4).

Patients in the two groups needed readmission and reoperation mostly for internal hernia and persistent nausea after discharge; the details of the types of complications needing readmission and reoperation in the two groups are listed in Table 5.

Discussion

The present study confirms that the ER pathway in bariatric surgery is feasible, safe, and cost-effective in high-volume obesity centers with well-trained surgeons as reported in previously published studies [17–19].

In order to develop a new ER protocol, a multidisciplinary and multimodal approach is required. It is therefore necessary to understand and apply the concept of "team-work." For this reason, all team members (including surgeons, anesthesiologists, nurses, nurse team leader supervisors, and operating room staff) and management staff have received adequate training in an experienced ER center. Afterwards, 1 month of learning curve was necessary for us to perform the implementation of the new protocol. Of note, our conventional management protocol was already easy to perform, even before the start of our ER pathway: no abdominal drains, no nasogastric tube, early feeding, and only 3 days of recovery. Furthermore, in our hospital, a surgeon or a surgical trainee is available on site 24 h a day. So in case of any problem after discharge, patients may come back directly to the surgical

ward skipping emergencies. Obtaining the same results could possibly take more time in a less experienced center, with fewer available surgeons.

Comprehensive and repetitive perioperative information of patients is essential to avoid complications due to erroneous behavior and encouraging patient self-reliance belongs to the essence of such a concept.

A standardized anesthesia protocol including short-term and non-opioid substances, no premedication, local anesthesia on port-site wounds, immediate extubation on the operating table, and early mobilization contribute to restore postoperative bowel transit and mitigates postoperative pain, nausea, and vomiting [25–27]. Furthermore, early mobilization prevents venous thromboembolic (VTE) complications [28]. Several studies suggest that the consumption of carbohydrate drinks prior to surgery promotes early recovery [29, 30]. Furthermore, early diet restoration following surgery is associated with lower mortality rate in colorectal surgery [31, 32].

Discharge at postoperative D1 should be allowed depending on white blood cells count <17,000 and serum CRP <100 [33, 34] as well as physiological vital parameters, absence of nausea and vomiting, adequate food intake, and adequate pain control [15].

In the present ER series, reducing the mean OT (from 190.20 to 133.54 min) was possible because the patient was not pre-medicated, so he could do his own checklist in the operating room, while sitting on the operating table, with both surgical and anesthesia team simultaneously preparing for the operation. Moreover, the time lapse between two operations was shorter, (almost 1 h on average per patient) resulting in cost reduction (about 2000€ on average per patient). This means that with ER protocol it was possible to operate one more patient per day, compared to the conventional management protocol. Cost reduction was basically due to shorter staff working time and shorter use of operating room (Fig. 4).

When compared to conventional management, the ER pathway allows reducing the mean LOS of 43 %, with a proportional reduction of total recovery costs. Unfortunately, it was not possible to obtain statistical data regarding the reduction in terms of mean recovery costs because the billing department calculates only flat fee for one recovery day in our unit.

Our study suggests that a significant shorter LOS in the ER group compared to the CS group did not translate in a significant difference in terms of complications, rehospitalization, and reoperation rates within 1 month of follow-up.

Nowadays, considering the “pandemic” rise of morbid obesity in Western countries and the resulting increased demand for bariatric surgery, new protocols like the present ER pathway aimed at optimizing management costs as well as new interesting scenarios for institutions in particular and for the National Health System in general.

Limitations

This present study was hindered by the lack of some retrospective data on the CS group. However, these preliminary results represent a promising starting point for implementation of ER pathways that deserve further investigations. Moreover, the present study shows the effect of the whole ER pathway compared to conventional management in bariatric surgery.

Conclusion

The present study suggests that the ER pathway reduces significantly the LOS of bariatric surgical patients, and shortens the mean OT per patient. It also entails obvious savings without worsening the surgical outcomes. Controlled randomized trials are needed to confirm this preliminary experience.

Compliance with Ethical Standards An ethical approval was not obtained for our study, but informed consent was signed from all individual participants included in ER series. All patients met the validated international criteria for bariatric surgery

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

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