# The effect of an Enhanced Recovery Program in elective retroperitoneal abdominal aortic aneurysm repair

Carlo V. Feo, MD, FACS,[a] Mattia Portinari, MD,[a] Elpiniki Tsolaki, MD,[b] Giovanni Romagnoni, MD,[a] Marco Verri, MD,[c] Stefano Camerani, MD,[c] Carlo Alberto Volta, MD,[c] and Francesco Mascoli, MD,[b]
*Ferrara, Italy*

**Objective:** Enhanced Recovery Programs (ERPs) have been introduced to accelerate postoperative recovery and are mainly focused on decreasing the surgical stress response. Limited data are available regarding the implementation of ERPs in patients who undergo abdominal aortic aneurysm (AAA) repair using the retroperitoneal approach. The aims of this study were: (1) to evaluate the implementation of an ERP in patients who underwent elective retroperitoneal AAA repair; and (2) to define independent predictors of prolonged hospital length of stay (LOS) in these patients.

**Methods:** This was a retrospective cohort study on 221 patients who underwent elective AAA repair via a retroperitoneal approach from 2005 through 2013 at an Italian university hospital. Patients who received surgery from 2008 through 2013 and enrolled in an ERP (n = 130) were compared with those who received surgery from 2005 through 2007 and managed with traditional perioperative care (n = 91).

**Results:** Patient characteristics were comparable between groups. Intensive care unit admissions were prevalent among patients who received traditional care vs patients in the ERP ($P < .01$). ERP patients had fewer major ($P < .01$) and minor ($P = .019$) complications, and mortality was similar between groups. Complete functional recovery was achieved earlier in ERP patients vs controls ($P < .01$). Patients in the ERP group left the hospital earlier than controls ($P < .01$). No readmission ≤30 days were reported in the ERP group. Age ≥65 years and being in a conventional care protocol were found to be independent predictors of prolonged hospital LOS.

**Conclusions:** The implementation of an ERP after elective AAA repair using a retroperitoneal approach reduced postoperative intensive care unit admission, accelerated functional recovery, and decreased morbidity and LOS with no readmission ≤30 days. Age ≥65 years and conventional perioperative care were the only independent predictors of prolonged LOS. (J Vasc Surg 2016;63:888-94.)

Enhanced Recovery Programs (ERPs) (Enhanced Recovery After Surgery or fast-track surgery) have been recently introduced to accelerate the postoperative recovery of the surgical patient and are mainly focused on decreasing the surgical stress response.[1] ERPs incorporate several evidence-based principles of perioperative care into a multidisciplinary common pathway. These elements include preoperative patient counseling, epidural anesthesia, minimal surgical access, optimal pain control with multimodal analgesia with no side effects, early postoperative mobilization and oral feeding, and avoidance or early removal of drains and catheters.[1] ERP methodology has been successfully introduced in colorectal surgery, which is nowadays considered the standard of care,[2] and extended to other areas of general surgery as well as other surgical specialties.[3] In vascular surgery, ERPs have been applied to elective abdominal aortic aneurysm (AAA) repair, aortobifemoral bypass grafting, and carotid surgery, but the evidence supporting it relies mostly on uncontrolled studies that often included small groups of patients.[4] Minimally invasive surgery is considered an important component of ERPs; however, limited data are available regarding AAA repair using the retroperitoneal approach (less invasive than the transperitoneal approach) in combination with enhanced recovery methodologies.[5-7]

The aims of this study were: (1) to evaluate the effect of an ERP applied to patients who undergo elective retroperitoneal AAA repair on outcomes; and (2) to define the independent predictive factors of prolonged hospital length of stay (LOS) in these patients.

## METHODS

### Study design and population

This was a retrospective cohort study on 221 consecutive patients who underwent elective AAA repair via a retroperitoneal approach between January 2005 and June 2013 at the Unit of Vascular Surgery of the S. Anna

From the Department of Surgery, Unit of Clinica Chirurgica,[a] and Unit of Vascular Surgery,[b] and Department of Emergency Medicine, Unit of Anesthesiology and Intensive Care,[c] S. Anna University Hospital of Ferrara, and University of Ferrara.

Author conflict of interest: none.

Presented as an oral presentation at the American College of Surgeons (ACS) Clinical Congress, San Francisco, Calif, October 26-30, 2014.

Correspondence: Mattia Portinari, MD, Clinica Chirurgica, Azienda Ospedaliera Arcispedale S Anna di Ferrara, Via Aldo Moro, 8, Room 2 34 03 (1C2), 44124 Ferrara (Cona), Italy (e-mail: mattia.portinari@unife.it).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214



http://dx.doi.org/10.1016/j.jvs.2015.09.060

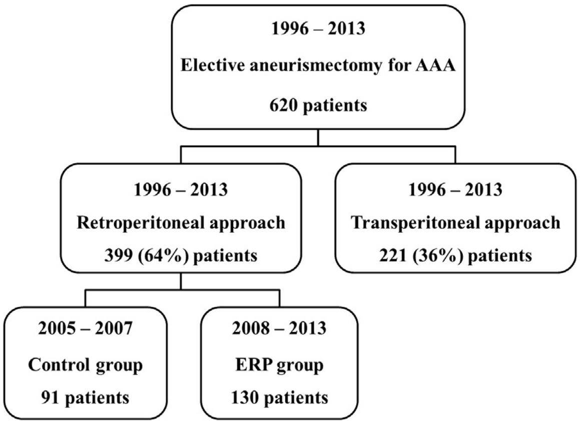


**Fig.** Flow chart of all patients who underwent open elective repair of abdominal aortic aneurysm (*AAA*) since the institution of the Unit of Vascular Surgery at the S Anna University Hospital of Ferrara (1996), including the study population (2005-2013). *ERP,* Enhanced Recovery Program.

University Hospital in Ferrara, Italy (Fig). The same surgery and anesthesiology teams treated all patients throughout the entire study period.

In January 2008, a vascular ERP to be applied to all patients who underwent elective AAA surgical repair using the retroperitoneal approach was implemented at our institution with the input of surgeons, anesthesiologists, and surgical nurses. All patients who received surgery between January 2008 and June 2013 were included in the study group (ERP group), and patients who received surgery between January 2005 and December 2007, before the introduction of the ERP, and who had been managed with traditional perioperative protocols of care, were included in the control group. The reason not to include patients who received surgery before 2005 among controls was twofold: (1) to exclude the learning curve period when the surgical team was perfecting its skills of retroperitoneal AAA repair; and (2) to optimize the quality of the data, considering the retrospective nature of the study and the availability of a surgical report electronic database since 2005.

### Variables and outcomes

A retrospective analysis was performed using a database that included demographic characteristics and clinical data, type of aneurysm and graft, and intra- and postoperative variables. Data on the outcome variables collected included morbidity and mortality, intensive care unit (ICU) admission rate and LOS, time to functional recovery (time to liquid diet, solid food, intestinal activity, and first bowel movement), pain scores with oral analgesics, indicators of independence in performing activities of daily living, day when the patient was ready for discharge, hospital LOS, and readmission rate ≤30 days from discharge. Postoperative complications were defined according to the Clavien-Dindo classification.[8]

**Table I.** Perioperative management of patients according to the study group

| *ERP element* | *ERP group* | *Control group* |
|---|---|---|
| Preoperative counseling | Extensive with illustrated booklet | Informed consent to surgery |
| Preoperative fasting | Two hours for clear liquids, 4 hours for solids | Since midnight |
| Preoperative CHO drinks | No | No |
| Anesthesia | Balanced (short-acting anesthetic drugs with thoracic epidural) | Opioid-based without thoracic epidural |
| Postoperative pain control | POD 0-2 thoracic epidural<br>POD ≥3 NSAIDs and paracetamol | POD 0-3 thoracic epidural or intravenous opioids<br>POD ≥4 NSAIDs or paracetamol on request |
| Retroperitoneal drain | Yes, removed on POD 1 | Yes, removed on POD 1 |
| Gastric tube | Removed on POD 0-1 | Removed when <300 mL per 24 hours |
| Start of enteral feeding | POD 1 | At bowel movements |
| Intravenous fluids abolition | POD 2 | At bowel movements |
| Removal of Foley catheter | POD 2 | At bowel movements |
| Mobilization | POD 1-2 | At patient's will |

*CHO,* Carbohydrate; *ERP,* Enhanced Recovery Program; *NSAID,* nonsteroidal anti-inflammatory drug; *POD,* postoperative day.

### Perioperative protocol

The perioperative management using most of the elements of the ERP and conventional care is detailed in Table I.

Preoperative carbohydrate drinks, which were introduced at our institution after a more recent iteration of our ERP, were not administered to the patients during the study periods.

A retroperitoneal abdominal drain was left in place and removed on the first postoperative day in both cohorts of patients.

All patients received clear liquids and then were advanced to liquid and solid food diets as tolerated.

Criteria for discharge were: (1) full recovery of intestinal function; (2) tolerated an unrestricted hospital diet with no nausea or vomiting; (3) good pain control (Numerical Rating Scale [NRS] ≤3) with oral analgesics; and (4) no clinical sign of infection.

### Anesthesia-analgesia protocol

No premedication was used. A peridural catheter was inserted at the T7 to 8 or T8 to 9 levels in all patients in the ERP groups as opposed to a selected number of patients in the control group.

**ERP group.** Patients in the ERP group had a combination of regional (epidural) and general anesthesia.

General anesthesia was induced either with fentanyl, 2 μg/kg, propofol, 1.5 to 2 mg/kg, or with remifentanil, 0.2 μg/kg/min, and propofol, 1.5 to 2 mg/kg according to the model from Schnider et al[9] (target controlled infusion). Vecuronium at the dosage of 0.1 mg/kg was administered to facilitate tracheal intubation in all patients and additional 10-mg boluses were given as needed to maintain adequate muscle relaxation during surgery.

Anesthesia was maintained either with isoflurane and fentanyl, or with a continuous infusion of remifentanil and propofol. The lungs were ventilated using controlled ventilation with a tidal volume of 6 to 8 mL/kg ideal body weight, a positive end expiratory pressure of 5 cm $H_2O$, an inspiratory oxygen fraction and respiratory rate adjusted to obtain a peripheral oxygen saturation >96% and end-tidal $CO_2$ ($EtCO_2$) between 35 and 45 mmHg. Intraoperative fluid administration was on the basis of a restrictive protocol that relied mainly on crystalloids (approximately 7 mL/kg/h). Epidural anesthesia was maintained with an infusion of levobupivacaine (0.375%; 5-10 mL/h) that was started after the induction of general anesthesia. Postoperative epidural analgesia was obtained via a continuous infusion of levobupivacaine 0.15% to 0.2%, 5 to 7 mL/h until the second postoperative day. In presence of persistent pain, nonsteroidal anti-inflammatory drugs (NSAIDs) and paracetamol were used starting from the third postoperative day.

**Control group.** Induction of anesthesia was achieved in a similar fashion, however, fentanyl was used for maintenance (3-5 μg/kg/h) and the epidural catheter, if present, was activated only at the end of the procedure for postoperative analgesia (levobupivacaine, 0.15%-0.2%; 5-7 mL/h) until the third postoperative day; NSAIDs or paracetamol were administered only on the patient's request. If a peridural catheter was not placed, postoperative analgesia was obtained with intravenous morphine infusion (0.01-0.02 mg/kg/h) until the third postoperative day; NSAIDs or paracetamol were administered on request. Finally, a more liberal strategy of fluid administration in terms of quantity and quality was used.

### Surgical technique

Vascular fellowship-trained surgeons performed all surgical procedures; approximately 90% were performed by a single experienced surgeon (F.M.) who supervised the remaining procedures. At our institution, the retroperitoneal approach is preferred over the transperitoneal approach for AAA repair (Fig); indications for the transperitoneal approach include patients in whom the right external iliac axis has to be substituted because of obstructive or aneurysmal disease.

The patient is positioned with the hips parallel to the table and the left shoulder and trunk rotated 45° to the right. An oblique incision of 9 to 13 cm from the anterior margin of the 11th left rib to the lateral margin of the rectus abdominis muscle is performed. The external and internal oblique, and the transversus abdominis muscles are divided, and the rectus muscle and the peritoneal sac are mobilized laterally to the right. This maneuver allows access to the retroperitoneal space and subsequent exposure of the left ureter, gonadic vessels, left renal vein, and proximal aortic neck, and maintains the left kidney in its anatomic position (ie, kidney down). Exposure of the distal aortic neck and iliac arteries is finally completed, helped by the division of the posterior fascia of the rectus muscle.

The institutional review board granted an exemption from requiring ethics approval for this study. All patients provided preoperative written informed consent. Data collection and analyses were performed in compliance with the Declaration of Helsinki of 1975.

### Statistical analysis

Data are expressed as median (interquartile range, 25th-75th) and mean ± standard deviation according to the distribution. The Shapiro-Wilk test was used to assess the assumption of normality. Categorical data are presented as number (%). Data were analyzed using the $\chi^2$, analysis of variance, and Mann-Whitney tests as appropriate. The Kaplan-Meier method was been used for analysis of duration of the surgical procedure, ICU LOS, and hospital LOS. The log-rank test was used to compare duration of the surgical procedure, ICU LOS, time to functional recovery, and hospital LOS for patients in the ERP group vs patients included in the traditional perioperative care group. We assessed the association of different baseline characteristics with the duration of hospital LOS in the univariate analysis and used time to hospital discharge of patients as the end point of interest. For the time to event analyses, patients were censored at the time of hospital discharge. We then calculated multivariate Cox regression analyses adjusted for potential confounders to assess independent predictors of prolonged hospital LOS. Of note, hazard ratios <1 corresponded to an association of the factor with prolonged hospital LOS, and hazard ratios >1 corresponded to earlier discharge. Significance was considered for values of $P < .05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, version 20.0 (IBM Corp, Armonk, NY).

This report complies with the reporting standards established by Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting observational studies.[10]

## RESULTS

Between January 2005 and June 2013, 221 patients underwent elective retroperitoneal AAA repair at the Unit of Vascular Surgery of the S. Anna University Hospital in Ferrara, Italy. Of these 221 patients, 91 (41.2%) received surgery from January 2005 to December 2007 following traditional perioperative care principles (control group), and 130 (58.8%) received surgery from January 2008 to June 2013 following an ERP regimen (ERP group; Fig).

Demographic and baseline characteristics of all patients are shown in Table II. Demographic data, body mass index, American Society of Anesthesiologists score, and

**Table II.** Demographic and baseline characteristics

| *Variable* | *ERP group (n = 130)* | *Control group (n = 91)* | P |
|---|---|---|---|
| Age ± SD, years | 69.9 ± 8.6 | 71.1 ± 8.2 | .296 |
| Sex | | | .271 |
| Male | 119 (91.5) | 79 (86.8) | |
| Female | 11 (8.5) | 12 (13.2) | |
| BMI[a] | | | .161 |
| <25 | 45 (34.9) | 32 (37.2) | |
| 25-29.9 | 49 (38.0) | 40 (46.5) | |
| ≥30 | 35 (27.1) | 14 (16.3) | |
| ASA[b] | | | .375 |
| I-II | 21 (16.4) | 19 (21.6) | |
| III-IV | 107 (83.6) | 69 (78.4) | |
| Diabetes | 16 (12.3) | 8 (8.8) | .512 |
| Hypertension | 103 (79.2) | 76 (83.5) | .488 |
| Ischemic heart disease | 47 (36.2) | 32 (35.2) | .888 |
| COPD | 19 (14.6) | 16 (17.6) | .578 |

*ASA,* American Society of Anesthesiologists; *BMI,* body mass index; *COPD,* chronic obstructive pulmonary disease; *ERP,* Enhanced Recovery Program; *SD*, standard deviation.
Data are presented as number (%) unless otherwise indicated.
[a]BMI was not available in one patient of the ERP group and in five patients of the control group.
[b]ASA score was not available in two patients of ERP group and in three patients of the control group.

comorbidity distribution at admission to the surgical ward were comparable between groups ($P > .05$).

No difference between groups was found in term of size of AAA, type of AAA, type of graft, and surgical time, and intraoperative blood loss ($P = .007$) and number of patients who required blood transfusion ($P = .022$) were lower in the ERP group. Admission rate to the ICU was higher among patients in the control group compared with that of patients in the ERP group (36.2% vs 67.0%; $P < .0001$), but ICU LOS was similar in both groups (Table III).

Patients in the ERP group developed fewer major (Clavien-Dindo grade III-IV; $P < .0001$) and minor (Clavien-Dindo grade I-II; $P = .019$) complications, and mortality did not statistically differ between groups (Clavien-Dindo grade V; $P = .480$; Table IV). Patients in the ERP group had fewer cardiac (6 [4.6%] vs 12 [13.2%]; $P = .022$) and pulmonary complications (13 [10.0%] vs 19 [20.9%]; $P = .021$), and no difference could be detected in wound (3 [2.3%] vs 2 [2.2%]; $P = .660$) and urinary tract (3 [2.3%] vs 1 [1.1%]; $P = .451$] infection rates.

Complete functional recovery and pain control with oral analgesics were achieved earlier in the ERP group compared with the control group (Table IV). Patients in the ERP group were deemed ready for discharge and actually left the hospital before those who received conventional care, with no readmission to the hospital within 30 days from discharge (Table IV). The difference in functional recovery (solid food, bowel movements) and LOS were the same also when ERP patients with a functioning epidural (n = 119; in 11 patients it was not possible either to place the catheter or it was displaced in the early postoperative period) were compared with control patients with an epidural catheter (n = 85) used only for postoperative analgesia.

**Table III.** Perioperative variables

| *Variable* | *ERP group (n = 130)* | *Control group (n = 91)* | P |
|---|---|---|---|
| Size of AAA, cm | 5.3 (5.0-6.1) | 5.5 (4.9-6.5) | .482 |
| Type of AAA | | | .098 |
| Aortic | 120 (92.3) | 78 (85.7) | |
| Aortoiliac | 10 (7.7) | 13 (14.3) | |
| Type of graft | | | .525 |
| Aorto-aortic | 104 (80) | 72 (79.1) | |
| Aortoiliac | 26 (20) | 19 (20.9) | |
| Operative time, minutes | 271 (235-313) | 282 (255-345) | .144[a] |
| Intraoperative blood loss, mL | 50 (50-450) | 200 (50-1147) | .007 |
| Intraoperative blood transfusion | 42 (32.3) | 42 (46.2) | .022 |
| Admission in ICU | 47 (36.2) | 61 (67.0) | <.0001 |
| ICU LOS, days | 2 (1-4) | 2 (1-3) | .639[a] |

*AAA,* Abdominal aortic aneurysm; *ERP,* Enhanced Recovery Program; *ICU,* intensive care unit; *LOS,* length of stay.
Data are presented as number (%) or median (range).
[a]Log-rank test for ICU LOS and operative time.

**Table IV.** Postoperative outcomes

| *Variable* | *ERP group (n = 130)* | *Control group (n = 91)* | P |
|---|---|---|---|
| Complications (Clavien-Dindo) | | | <.0001 |
| Minor complications (grade I-II) | 20 (15.4) | 52 (57.1) | |
| Major complications (grade III-IV) | 4 (3.1) | 10 (11.0) | |
| In-hospital mortality (grade V) | 3 (2.3) | 3 (3.3) | |
| Time to liquid diet, days | 2 (1-3) | 2.5 (2-3) | .008[a] |
| Time to solid food, days | 3 (2-4) | 4 (3-5) | <.0001[a] |
| Time to intestinal activity, days | 2 (1-3) | 2 (2-3) | <.0001[a] |
| Time to bowel movements, days | 3 (2-4) | 4 (3-5) | <.0001[a] |
| Good pain control on oral analgesics, days | 2 (2-3) | 3 (2-4) | .001[a] |
| Full mobility and autonomy, days | 4 (3-6) | 5 (4-7) | <.0001[a] |
| Day fit for discharge, days | 4 (3-7) | 6 (5-8) | <.0001[a] |
| Hospital LOS, days | 5 (4-7) | 7 (6-9) | .002[a] |
| Readmission ≤30 days) | 0 | 3 (3.3) | .07 |

*ERP,* Enhanced Recovery Program; *LOS,* length of stay.
Data are presented as number (%) or median (range).
[a]Log-rank test for time to recovery.

Unadjusted and adjusted Cox regression analysis showed that age ≥65 years and receipt of the conventional perioperative care protocol were found to be predictive factors of prolonged hospital LOS (Table V).

**Table V.** Association between baseline characteristics, intraoperative outcomes, type of perioperative protocol, and length of hospital stay according to Cox regression analysis adjusted for potential confounders

| | *Prolonged hospital LOS* | | | |
|---|---|---|---|---|
| | *Unadjusted model* | | *Full adjusted model* | |
| *Variable* | *HR (95% CI)* | P | *HR (95% CI)* | P |
| Sex (ref: female) | | | | |
| Male | 1.34 (0.86-2.09) | .197 | 0.86 (0.53-1.41) | .549 |
| Age (ref: <65 years) | | | | |
| 65-74 | 0.67 (0.47-0.94) | .020 | 0.66 (0.46-0.94) | .022 |
| ≥75 | 0.47 (0.33-0.68) | <.0001 | 0.47 (0.32-0.70) | <.0001 |
| BMI (ref: <25) | | | | |
| 25-29.9 | 1.11 (0.81-1.52) | .499 | 1.09 (0.79-1.51) | .618 |
| ≥30 | 1.08 (0.75-1.57) | .667 | 0.85 (0.58-1.27) | .431 |
| Diabetes (ref: absence) | | | | |
| Presence | 0.94 (0.61-1.43) | .758 | 1.01 (0.65-1.55) | .977 |
| Hypertension (ref: absence) | | | | |
| Presence | 1.17 (0.83-1.65) | .358 | 1.13 (0.79-1.62) | .495 |
| Ischemic heart disease (ref: absence) | | | | |
| Presence | 1.05 (0.80-1.40) | .712 | 0.96 (0.71-1.29) | .781 |
| COPD (ref: absence) | | | | |
| Presence | 1.35 (0.93-1.96) | .117 | 1.11 (0.72-1.70) | .245 |
| Perioperative protocol (ref: ERP) | | | | |
| Traditional | 0.69 (0.52-0.90) | .007 | 0.69 (0.52-0.92) | .012 |

*BMI,* Body mass index; *CI,* confidence interval; *COPD,* chronic obstructive pulmonary disease; *ERP,* Enhanced Recovery Program; *HR,* hazard ratio; *LOS,* length of stay; *ref,* reference.

## DISCUSSION

The results of our study show that the implementation of an ERP in patients who undergo elective repair of AAAs with the retroperitoneal approach is associated with a reduced number of postoperative ICU admissions, earlier functional recovery, decreased morbidity, and shorter hospital LOS, with no readmission within 30 days from discharge. In regression analysis, age ≥65 years and conventional perioperative care management were found to be the only independent factors that predicted prolonged hospital LOS.

There is evidence in the literature that the retroperitoneal approach for repair of AAAs reduces postoperative morbidity and hospital LOS compared with the transperitoneal approach; however, this approach is technically more challenging and requires a longer learning curve.[7]

The use of minimally invasive surgical techniques is considered an important element of ERPs because they contribute to a decrease of the surgical stress response.[1] At our institution we have decided to use the retroperitoneal approach for the elective repair of AAAs, because it is associated with a smaller surgical incision and minimal bowel manipulation compared with the transperitoneal approach, similar to that observed when video-assisted (ie, laparoscopic) over open techniques are used in patients who undergo colorectal surgery.[2]

**ERPs might decrease the need for postoperative ICU admissions.** In 2009, Muehling et al, from the University of Ulm (Germany) published the only randomized trial of a comparison of traditional (n = 50) vs enhanced recovery (n = 49) protocols in patients who underwent elective open AAA repair. The surgical approach was either retroperitoneal (n = 56) or transperitoneal (n = 43). Patients in the enhanced recovery group were nourished with enteral feeding earlier (5 vs 7 days; $P > .0001$), had reduced morbidity (16% vs 36%; $P = .039$), and shorter hospital LOS (10 vs 11 days; $P = .016$).[11] Although the primary end point for sample size calculation was not indicated, the authors specified that the main goal of the study was the improvement of patient recovery and reduction of morbidity. All patients were admitted to the ICU postoperatively, however, the patients in the ERP group had a shorter length of ICU stay, even though that difference was not statistically significant (32 [12-293] vs 20 hours [14-336]; $P = .183$).[11]

At our institution the patients were admitted to the ICU only if postoperative mechanical ventilation was necessary; the ICU admission rate was lower in the ERP group compared with the control group (36.2% vs 67.0%; $P < .0001$), although no difference in the ICU LOS could be detected (2 [1-4] vs 2 days [1-3]; $P = .639$). Interestingly, a subgroup analysis involving the last tertile of patients in the ERP group (n = 45) revealed that 12 patients (26.7%) were admitted to the ICU with a median LOS of 1 day (1-2).

**ERPs might decrease morbidity, accelerate functional recovery, and decrease hospital LOS.** Brustia et al, from Italy, published a retrospective, uncontrolled study on 323 unselected patients who underwent abdominal aortic repair for aneurysm or obstructive disease via a left subcostal minilaparotomy.[12] Patients were admitted to the surgical ward at the end of the procedure and encouraged to ambulate and start oral feeding on the same day. On the first postoperative day patients assumed an oral diet of 1583.1 Kcal (± 95% confidence interval [CI], 105.2) and 2127 mL (± 95% CI, 102.6) and ambulated a mean of 2544 m (± 95% CI, 208.9). The first bowel movement occurred at a mean of 41.6 hours after surgery (± 95% CI, 2.4). Postoperative morbidity was insignificant and the mortality rate was 2.5%. The median hospital stay was 3 days (range, 2-21 days), all patients were discharged home, and 5 patients (1.6%) were readmitted to the hospital within 30 days.[12] Although the study was not controlled, the excellent results achieved on a large unselected population suggest that the use of ERPs, a minimally invasive surgical approach, optimal anesthesia and/or analgesia, and intensive, goal-oriented postoperative care might decrease morbidity and hospital LOS in patients who undergo elective AAA surgical repair.

Most recently, because of the paucity of data from randomized trials, a pooled analysis of proportions from different case series was conducted with a comparison of patients managed with ERPs (n = 1250) vs conventional protocols (n = 1429) of perioperative care.[4] Data of patients included in the conventional perioperative care arm were obtained by pooling the data from the surgical arm of six randomized trials published between 2004 and 2011 that compared endovascular repair with open surgical repair without an enhanced recovery strategy. The pooled analysis of proportions showed that patients managed with ERPs and conventional perioperative care management strategies had similar 30-day mortality and overall complication rates. In our study, the implementation of the ERP reduced minor and major complications and accelerated functional recovery (time to liquid and solid diets, time to first bowel movement, full mobility, and autonomy) by a median of 1 day compared with controls ($P$ = .01). Although mortality rates were similar between groups ($P$ = .480), the reduction in morbidity strongly supports the reported safety of ERPs.[4] Patients in the ERP were ready for discharge (4 [3-7] vs 6 days [5-8]; $P < .0001$) according to predefined standardized criteria and actually left the hospital (5 [4-7] vs 7 [6-9] days; $P$ = .002) 2 days earlier than the patients in the control group. Moreover, considering the last tertile of patients the ERP group (n = 45), a further decrease of 1 day in the hospital LOS (4 days [4-6]) was detected. These data suggest that after mastering the implementation of the multidisciplinary, interprofessional, and multimodal ERP, patients were actually sent home as soon as they were ready to be discharged with further reduction in hospital LOS. It is of great importance that no 30-day readmissions after discharge were detected among patients who followed the ERP, which confirms the safety of the enhanced recovery methodology.

The difference in functional recovery (time to solid food and bowel movements) and LOS was maintained when ERP patients with a functioning epidural for blended anesthesia and postoperative analgesia were compared with control patients with an epidural catheter to control postoperative pain. This suggests that the combination of epidural and general anesthesia (blended anesthesia) plays an important role in the ERP.

**Older age and receipt of conventional perioperative care predicted prolonged hospital stay.** Several factors (eg, age >75 years, chronic obstructive pulmonary disease) have been shown to influence the hospital LOS when enhanced recovery care protocols are adopted in aortic surgery[13]; therefore, we decided to perform an adjusted Cox regression analysis to investigate factors, including being in an ERP, that might be associated with prolonged hospital LOS. Age ≥65 years and being in a conventional perioperative care protocol were the only independent factors found to be predictive of prolonged hospital LOS in our study.

**Strengths and limitations of the study.** Our study represents one of the largest cohorts of patients who underwent elective AAA repair using the retroperitoneal approach and managed with an ERP. All of the surgeries were completed in a single center, by the same surgical team who had fully mastered the technique before the study period (Fig). One-hundred seventy-eight retroperitoneal AAA surgical repairs had been performed by the operating surgeon (F.M.) before the first patients of the study received surgery in 2005. The surgeon's experience certainly affects perioperative morbidity and mortality and, therefore, surgeons' variability is an important confounder. In this study the same surgeon performed all surgeries in both groups, which reduced bias and allowed better evaluation of the real effect of the ERP on clinical outcomes and functional recovery. Although a wide study period was encompassed (2005-2013), the surgical technique was already standardized at the beginning of the study (2005) and did not change throughout the study period. This was a retrospective study with a historical control group used for comparison and, therefore, the results must be interpreted with caution.

ERPs have been shown to reduce direct and indirect costs in colorectal surgery as well as in-hospital costs in cohorts of patients who received an open transperitoneal AAA repair.[14,15] Unfortunately, because of the retrospective design of our study, the cost-analysis could not be performed. However, the decrease in the postoperative admission to the ICU (−30%), postoperative complications (−50%), and hospital LOS (2 days shorter than in the control group) might well suggest a reduction for institutional costs.

## CONCLUSIONS

An ERP applied to patients who underwent elective retroperitoneal AAA repair reduced the rate of postoperative ICU admissions, accelerated functional recovery, and decreased morbidity and hospital LOS. No patient in the ERP group was readmitted to the hospital within 30 days from discharge. Age ≥65 years and conventional perioperative care management were the only independent factors associated with prolonged hospital LOS.

The authors thank Dr Franco Carli and Dr Mario De Pinto for their substantial contribution to the revision of the report; and Dr Simone Targa, who helped in the data collection.

## AUTHOR CONTRIBUTIONS

Conception and design: CF, MP, SC, CV, FM
Analysis and interpretation: CF, MP, ET, MV
Data collection: GR
Writing the article: CF, MP, MV, SC
Critical revision of the article: ET, GR, CV, FM
Final approval of the article: CF, MP, ET, GR, MV, SC, CV, FM
Statistical analysis: MP
Obtained funding: Not applicable
Overall responsibility: CF
CF and MP contributed equally to this article and share co-first authorship.

## REFERENCES

1. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg 2008;248:189-98.
2. Gustafsson UO, Scott MJ, Schwenk W, Demartines N, Roulin D, Francis N, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations. World J Surg 2013;37:259-84.
3. Kehlet H. Multimodal approach to postoperative recovery. Curr Opin Crit Care 2009;15:355-8.
4. Gurgel SJ, El Dib R, do Nascimento PJ. Enhanced recovery after elective open surgical repair of abdominal aortic aneurysm: a complementary overview through a pooled analysis of proportions from case series studies. PLoS One 2014;9:e98006.
5. Rigberg DA, Dorafshar A, Sridhar A, Quinones-Baldrich W, Moore WS. Abdominal aortic aneurysm: stent graft vs clinical pathway for direct retroperitoneal repair. Arch Surg 2004;139:941-4; discussion: 945-6.
6. Mukherjee D, Becker TE. An update on the 'fast-track' abdominal aortic aneurysm repair. Int J Angiol 2008;17:93-7.
7. Twine CP, Lane IF, Williams IM. The retroperitoneal approach to the abdominal aorta in the endovascular era. J Vasc Surg 2012;56:834-8.
8. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187-96.
9. Schnider TW, Minto CF, Gambus PL, Andresen C, Goodale DB, Shafer SL, et al. The influence of method of administration and covariates on the pharmacokinetics of propofol in adult volunteers. Anesthesiology 1998;88:1170-82.
10. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg 2014;12:1495-9.
11. Muehling B, Schelzig H, Steffen P, Meierhenrich R, Sunder-Plassmann L, Orend KH. A prospective randomized trial comparing traditional and fast-track patient care in elective open infrarenal aneurysm repair. World J Surg 2009;33:577-85.
12. Brustia P, Renghi A, Fassiola A, Gramaglia L, Della Corte F, Cassatella R, et al. Fast-track approach in abdominal aortic surgery: left subcostal incision with blended anesthesia. Interact Cardiovasc Thorac Surg 2007;6:60-4.
13. Chang JK, Calligaro KD, Lombardi JP, Dougherty MJ. Factors that predict prolonged length of stay after aortic surgery. J Vasc Surg 2003;38:335-9.
14. Lee L, Mata J, Ghitulescu GA, Boutros M, Charlebois P, Stein B. Cost-effectiveness of enhanced recovery versus conventional perioperative management for colorectal surgery. Ann Surg 2015;262:1026-33.
15. Tatsuishi W, Kohri T, Kodera K, Asano R, Kataoka G, Kubota S, et al. Usefulness of an enhanced recovery after surgery protocol for perioperative management following open repair of an abdominal aortic aneurysm. Surg Today 2012;42:1195-200.

Submitted Aug 10, 2015; accepted Sep 30, 2015.