Original Research

Enhanced Recovery Implementation in Major Gynecologic Surgeries

Effect of Care Standardization

Susan C. Modesitt, MD, Bethany M. Sarosiek, RN, Elisa R. Trowbridge, MD, Dana L. Redick, MD, Puja M. Shah, MD, Robert H. Thiele, MD, Mohamed Tiouririne, MD, and Traci L. Hedrick, MD, MS

OBJECTIVE: To examine implementing an enhanced recovery after surgery (ERAS) protocol for women undergoing major gynecologic surgery at an academic institution and compare surgical outcomes before and after implementation.

METHODS: Two ERAS protocols were developed: a full pathway using regional anesthesia for open procedures and a light pathway without regional anesthesia for vaginal and minimally invasive procedures. Enhanced recovery after surgery pathways included extensive preoperative counseling, carbohydrate loading and oral fluids before surgery, multimodal analgesia with avoidance of intravenous opioids, intraoperative goal-directed fluid resuscitation, and immediate postoperative feeding and ambulation. A before-and-after study design was used to compare clinical outcomes, costs, and patient satisfaction. Complications and risk-adjusted length of stay were drawn from the American College of Surgeons' National Surgical Quality Improvement Program database.

RESULTS: On the ERAS full protocol, 136 patients were compared with 211 historical controls and the median length of stay was reduced (2.0 compared with 3.0 days; $P=.007$) despite an increase in National Surgical Quality Improvement Program-predicted length of stay (2.5 compared with 2.0 days; $P=.009$). Reductions were seen in median intraoperative morphine equivalents (0.3 compared with 12.7 mg; $P<.001$), intraoperative (285 compared with 1,250 mL; $P<.001$) and total intravenous fluids (−917.5 compared with 1,410 mL; $P<.001$), immediate postoperative pain scores (3.7 compared with 5.0; $P<.001$), and total complications (21.3% compared with 40.2%; $P=.004$). On the ERAS light protocol, 249 patients were compared with 324 historical controls and demonstrated decreased intraoperative and postoperative morphine equivalents (0.0 compared with 13.0 mg; $P<.001$ and 15.0 compared with 23.6 mg; $P<.001$) and decreased intraoperative and overall net intravenous fluids ($P<.001$). Patient satisfaction scores showed a marked and significant improvement on focus questions regarding pain control, nurses keeping patients informed, and staff teamwork; 30-day total hospital costs were significantly decreased in both ERAS groups.

CONCLUSION: Implementation of ERAS protocols in gynecologic surgery was associated with a substantial decrease in intravenous fluids and morphine administration coupled with reduction in length of stay for open procedures combined with improved patient satisfaction and decreased hospital costs.

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The "enhanced recovery" after surgery concept emerged as a multimodal approach directed at optimizing the patient experience, standardizing perioperative care, and improving surgical outcomes.[1] Subsequent work has refined these concepts in multiple surgical fields including both colorectal and gynecologic.[2–6] Key components of enhanced recovery protocols include 1) comprehensive patient education including patient goals and expectations around surgery, 2) markedly diminished duration of the fasting period preoperatively and active use of oral carbohydrate and electrolyte fluids up

From the Thornton Gynecologic Oncology Service, the Division of Urogynecology, and the Division of Gynecologic Oncology, Department of Obstetrics and Gynecology, the Department of Anesthesia, and the Department of Surgery, Section of Colorectal Surgery, University of Virginia Health System, Charlottesville, Virginia.

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Corresponding author: Susan C. Modesitt, MD, Professor and Division Director, Gynecologic Oncology Division, Department of Obstetrics and Gynecology, University of Virginia Health System, PO Box 800712, Charlottesville, VA 22908; e-mail: scm6h@virginia.edu.

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until presentation for surgery, 3) multimodal pain control regimen including nonopioid analgesic agents and regional anesthesia to reduce opioid use, and 4) quick resumption of a normal diet and activity. Trials of these protocols have been performed in a myriad of surgical settings and have shown, almost uniformly, improved results such as decreased length of stay and improved surgical outcomes.[7–13]

The enhanced recovery after surgery (ERAS) model at the University of Virginia was piloted on our colorectal surgery service with outstanding results.[3] As part of a quality initiative project, the ERAS program was then modified for the gynecologic surgical population. This encompassed all women undergoing major gynecologic surgeries (gynecologic oncology, urogynecology, and general gynecology) and included a full pathway (for open procedures with the use of a neuraxial analgesic adjuvant) and a light pathway (for minimally invasive procedures; identical except for no neuraxial analgesia). The objectives of the present study were to assess and to compare surgical outcomes, costs, and patient satisfaction before and after implementation of an ERAS protocol for patients undergoing major gynecologic surgery.

MATERIALS AND METHODS

The institutional review board at the University of Virginia determined that this quality initiative project was exempt and provided documentation and approval for publication. All consecutive patients undergoing elective major gynecologic surgery with an overnight admission from January 2, 2014, to December 17, 2014 were included in the pre–ERAS control group. The post–ERAS group included all consecutive patients undergoing elective major gynecologic surgery during the timeframe from March 17, 2015, to October 31, 2015 after ERAS implementation; both groups also underwent American College of Surgeons' National Surgical Quality Improvement Program data abstraction. The 3-month period of time immediately before ERAS initiation was omitted from analysis to decrease the confounding effects of protocol development on clinical practice.

The primary outcome was actual length of stay as well as the risk-adjusted length of stay that was calculated using the National Surgical Quality Improvement Program Surgical Risk Calculator. Standard postoperative complications within National Surgical Quality Improvement Program data collection included: superficial, deep, and organ space surgical site infections; unplanned intubation; thromboembolic events; renal insufficiency or failure; urinary tract infection; myocardial infarction; transfusion; sepsis; pneumonia; unplanned return to the operating room; 30-days readmission rates; and all-cause mortality. Dedicated surgical clinical nurse reviewers abstracted all procedures included in the gynecology module in the Targeted Procedure Program; definitions located at http://www.facs.org/~/media/files/quality%20programs/nsqip/nsqip_puf_userguide_2014.ashx. Risk stratification was performed using the National Surgical Quality Improvement Program risk calculator to calculate the predicted length of stay based on 23 demographic and procedure-related variables. Additional variables specific to the ERAS pathway were collected prospectively in a separate quality improvement database including morphine equivalents, intravenous fluid amounts (mL), numeric pain scores (1–10), and compliance with protocol measures.

Patient satisfaction was measured using the Press Ganey infoEDGE database to analyze all gynecology patients discharged during the study periods. For the entire institution, 54% of discharged patients received surveys (24% response rate) and mean scores tallied and compared with other facilities to obtain percentiles. Financial data were obtained from the Clinical Data Repository at the University of Virginia and combined electronic medical record data, billing data, and cost accounting along with university physician practice group data. We report total cost (direct–indirect and fixed–variable costs) of the index hospitalization plus any readmission or outpatient visit up to 30 days postoperatively.

Before ERAS initiation, perioperative care was at the discretion of the health care providers. Patients were instructed to have nothing by mouth (after midnight). The vast majority of patients did not receive a mechanical bowel preparation; for those receiving a mechanical bowel preparation, 4 L of GoLytely (peg 3350-electrolytes) alone were given. The patients received varying preoperative education and were generally told that they would be hospitalized for 1–2 days for laparoscopic, vaginal, or robotic procedures and 2–5 days for open procedures. Prophylactic antibiotics included predominantly cephalosporins and were administered before skin incision. One fourth of patients undergoing open surgical procedures received epidurals. Intraoperative fluid administration was left to the discretion of the anesthesiologist. Postoperative fluids were given until the patients tolerated a diet, which was typically a clear liquid diet on the morning of postoperative day 1 and then advanced as tolerated. Epidurals and patient-controlled analgesia regimens were continued until patients were tolerating a regular diet and oral pain medications.

Over an 8-month period, a multidisciplinary team was constructed from the entire surgical care

team who planned the ERAS gynecologic protocol that was standardized and agreed on by anesthesia, nursing, and surgeon colleagues. Key protocol elements are summarized in Table 1 and patient educational information is available at www.uvaeras.com.

Univariate analysis compared baseline demographic and clinical variables between groups. Continuous variables were analyzed using Student *t* test for normally distributed data and Wilcoxon's rank sum as a nonparametric analog. Mean and standard deviations describe normally distributed data, and medians and interquartile ranges describe nonnormal data. Categorical variables were analyzed using χ^2 or Fisher exact test, as appropriate, and are described as frequencies and percentages.

RESULTS

A total of 136 patients went on the ERAS full pathway (Tables 2 and 3), with a mean age of 51 years (range 19–84 years); the mean body mass index (calculated as weight (kg)/[height (m)]^2) was 31.5, and the majority underwent total abdominal hysterectomy with or without bilateral salpingo-oophorectomy, staging, or urogynecologic procedures, and this was unchanged from pre–ERAS (59.7% compared with 56.6%; P=.58). A total of 249 patients went on the light pathway (Table 4), with a mean age of 56 years (range 20–90 years); the mean body mass index was 32.0 kg/m^2. The majority underwent laparoscopic hysterectomy with or without bilateral salpingo-oophorectomy, staging, or urogynecologic procedures (decreased compared with the pre–ERAS group 56.6% compared with 68.8%; P=.003) followed by total vaginal hysterectomy (22.2% compared with 20.5%; P=.68) and laparoscopic colpopexy (increased 0.3–6.8%; P<.001). There were no differences in mean operative times (from anesthesia start to anesthesia stop time) for the full pathway patients (222.2 minutes pre–ERAS to 228.1 minutes post–ERAS P=.42) or the light pathway patients (236.6 minutes pre–ERAS to 220.8 minutes post–ERAS; P=.05).

The median length of stay was significantly reduced after implementing ERAS in the ERAS full group (3.0 compared with 2.0 days; P=.007), despite increased National Surgical Quality Improvement Program-predicted length of stay (pre–ERAS 2.0 compared with post–ERAS 2.5 days; P=.009). Before ERAS, the actual median length of stay was 1 day longer than the National Surgical Quality Improvement Program-predicted median length of stay but after ERAS the actual median length of stay was 0.5 days below the predicted length of stay, which corresponded to a 1.5-day reduction in adjusted length of stay. Epidural rates were higher before implementation of ERAS (24.6% compared with 4.4%; P<.001) and spinal rates were higher after implementation of ERAS (12.3% compared with 86.8.%; P<.001). Substantial reductions in the ERAS full group were seen in median intraoperative morphine equivalents (12.7 compared with 0.3 mg; P<.001) but not in total morphine equivalents (25.2 mg pre–ERAS compared with 27.2 mg post–ERAS P=.46). Median intraoperative net fluid was also less in the ERAS patients (1,250.0 compared with 285.0 mL; P<.001) along with total intravenous fluid balance (1,410.0 compared with −917.5 mL; P<.001). The median pain scores were essentially identical on every day except on postoperative day 0, which was decreased in ERAS patients (5.0 compared with 3.7; P<.001) and on postoperative day 2 when it was increased in the ERAS patients (3.0 compared with 4.0; P<.001). Overall rate of complications decreased from 40% to 21% (P<.001) after implementing ERAS specifically related to higher rate of transfusion or bleeding (19% compared with 4%; P<.001) in the pre–ERAS group. If transfusion was omitted, the complication rates were not different (21.3% compared with 16.9%; P=.53).

Subset analysis of gynecologic oncology patients (96 historical controls and 45 ERAS full) was similar (Table 3). Although the median length of stay was 3.0 days in both pre–ERAS and ERAS patients, the majority of ERAS patients had shorter lengths of stay as demonstrated by the smaller interquartile range spread (1.5 compared with 1.0 in ERAS; P=.03). The mean length of stay for pre–ERAS and ERAS patients was 3.68 compared with 3.00, respectively (P=.02) despite a 1.3-day increase in the median National Surgical Quality Improvement Program-predicted length of stay. Similar reductions were seen in median intraoperative morphine (13.3 compared with 0.3 mg; P<.001), intraoperative net fluids (1,105.0 compared with 280.0 mL; P<.001), and total net fluids (1,302.6 compared with −769.2 mL; P<.001). There were no differences in overall complications if bleeding and transfusions were excluded; there was a decrease in bleeding and transfusion after enhanced recovery after surgery implementation (28.1% compared with 6.5%; P=.004).

On the light ERAS pathway, 324 consecutive historical controls were compared with 249 ERAS patients (Table 4); the only differences were decreased median intraoperative morphine equivalents (13.0 compared with 0.0 mg; P<.001), decreased total morphine equivalents (23.6 compared with 15.0 mg; P=.002), intraoperative net fluid balance (932.5 compared with 250.0 mL; P<.001), and overall total net fluid (1,381.5 compared with 171.1 mL; P<.001). After ERAS implementation, the actual median length of stay

Table 1. University of Virginia Enhanced Recovery After Surgery Gynecology Protocol Summary

Major Tenet	Phase of Care	ERAS Intervention
Preoperative education and patient expectations	Preoperative	1. Patient receives ERAS handbook describing pathway (www.uvaeras.com) 2. Patient receives one-on-one teaching with clinic nurse about ERAS pathway, patient's role in her recovery, and expectations surrounding surgery 3. Expectations set for expected date of discharge after surgery
Bowel preparation	Preoperative	1. Patient uses polyethylene glycol daily for 5 days before surgery 2. If MBP was ordered (less than 5% of patients), it included peg 3350-electrolytes GoLytely 4 L, erythromycin 1 g×3 doses, neomycin 1 g×3 doses, and metoclopramide 10 mg×3 doses
Diet and carbohydrate loading	Preoperative	1. Patient ceases regular diet at midnight (if no MBP) and 6 PM (if MBP) on the night before surgery; clear liquids could be consumed ad libidum 2. Patient drinks 20 oz of Gatorade 2 h before anesthesia induction
Multimodal pain management	Preoperative	Patient receives multimodal analgesic in preoperative surgical admissions suite, which includes celecoxib 200 mg PO, gabapentin 600 mg PO, and acetaminophen 975 mg PO Full pathway only: patient has neuraxial anesthesia placed preoperatively using morphine sulfate injection of 250 micrograms
	Intraoperative	Patient receives lidocaine continuous infusion 40 micrograms per kg/min IV intraoperatively
	Postoperative	1. Patient receives lidocaine continuous infusion 0.5–1.0 mg/min postoperatively for the first 48 h after the procedure 2. Patient receives scheduled acetaminophen 1 g IV×2 doses before transitioning to 975 mg PO and celecoxib 200 mg PO 3. Patient can receive oxycodone 5/10 mg for additional pain; additional opioids are purposefully avoided
Antibiotics	Intraoperative	Patient receives cefazolin (1 g or 2 g IV) before skin incision
Venous thromboembolism	Intraoperative	Full pathway only: unfractionated heparin 5,000 units SQ after spinal with sequential compression devices Light pathway only: enoxaparin 40 mg SQ with sequential compression devices
	Postoperative	Enoxaparin 40 mg SQ with sequential compression devices
Anesthesia or induction	Intraoperative	Patient receives NMDA antagonists at induction using magnesium 30 mg/kg IV and ketamine 0.5 mg/kg IV; ketamine infusion continues intraoperatively at 5–10 micrograms per kg/min
Fluid management	Preoperative	Patient has IV started in surgical admissions suite but no IV fluids are administered
	Intraoperative	Patient fluid resuscitation guided by a goal-directed fluid algorithm using the Masimo Pleth Variability Index
	Postoperative	Patient has IV fluids decreased to 40 mL/h on POD 0; fluids stopped at 8:00 AM on POD 1
Early mobility	Postoperative	1. Patient is OOB in the recovery room to stand for weight 2. Patient is OOB and in a chair on the night of surgery 3. Patient is OOB to walk at least 3 times each postoperative day
Early feedin	Postoperative	1. Patient receives clear fluids in the recovery room, as tolerated 2. Patient receives a soft diet on POD 1 and transitions to general diet as tolerated
Discharge criteria	Postoperative	Patient discharge criteria remained the same for ERAS protocol implementation; criteria included tolerating diet, ambulatory, and pain well controlled on oral analgesia

ERAS, enhanced recovery after surgery; MBS, mechanical bowel preparation; PO, orally; IV, intravenous; SQ, subcutaneous; NMDA, N-methyl-D-aspartate; POD, postoperative day; OOB, out of bed.

Table 2. Characteristics and Comparison of Population Before and After Enhanced Recovery After Surgery Implementation on Full Pathway for Open Surgical Procedures

	Pre-ERAS (n=211)	Post-ERAS (n=136)	*P*
Demographics			
Age (y)	51.1±14.5	51.8±13.3	.65
Race			
White or Caucasian	151 (71.6)	95 (69.9)	.81
African American	50 (23.7)	31 (22.8)	.90
Other	10 (4.7)	10 (7.4)	.35
BMI (kg/m^2)	31.3±7.9	31.5±10.5	.82
Procedures			
TAH±BSO, staging or urogynecologic	126 (59.7)	77 (56.6)	.58
Ovarian cancer debulking	52 (24.6)	27 (19.9)	.36
ERAS protocol elements			
Neuraxial analgesia			
Epidural	52 (24.6)	6 (4.4)	<.001
Spinal	26 (12.3)	118 (86.8)	<.001
Opioid consumption			
Morphine equivalents—intraoperative (mg)	12.7 (6.7, 22.7)	0.3 (0.25, 0.25)	<.001
Morphine equivalents—total, mg	25.2 (15, 43.3)	27.5 (12, 41.3)	.46
Pain score			
Highest	8.0 (7, 10)	8.0 (7, 10)	.06
POD 0	5.0 (3.3, 6.6)	3.7 (1.6, 5.5)	<.001
POD 1	3.8 (2.4, 5.1)	4.1 (2.6, 5.4)	.21
POD 2	3.0 (0.9, 4.8)	4.0 (2.3, 5.0)	<.001
Fluid administration			
Intraoperative net fluid balance (mL)	1,250.0 (890, 1,650)	285.0 (25, 550)	<.001
Total hospital net fluid balance (mL)	1,410.0 (−284, 2,972)	−917.5 (−2,489, 247.6)	<.001
Preoperative carbohydrate loading	—	120 (88.2)	NA
Ambulation			
Day of surgery	11 (5.2)	20 (14.7)	.004
More than 2 times on POD 1	114 (54.0)	119 (87.5)	<.001
LOS and financial outcomes			
LOS (d)	3.0 (2, 3)	2.0 (2, 3)	.007
NSQIP-predicted LOS	2.0 (1.5, 3)	2.5 (2, 3)	.009
30-d total hospital cost/patient*	$11,172 (8,953, 15,145)	$9,899 (8,382, 12,269)	.004
NSQIP outcomes*			
Surgical site infection	9 (4.3)	10 (7.4)	.23
Urinary tract infection	3 (1.4)	2 (1.5)	1.00
Transfusion	40 (19.0)	6 (4.4)	<.001
Unplanned return to OR	1 (0.5)	2 (1.5)	.56
Pneumonia	5 (2.3)	0 (0.0)	.16
Pulmonary embolism	2 (0.9)	0 (0.0)	.52
Unplanned intubation	2 (0.9)	0 (0.0)	.52
Acute renal failure	2 (0.9)	0 (0.0)	.52
Cardiac arrest	1 (0.5)	0 (0.0)	1.00
Sepsis or septic shock	5 (2.4)	2 (1.5)	.71
Death within 30 d	2 (0.9)	0 (0.0)	.52
Readmission	13 (6.2)	7 (5.1)	.82
Total complications	85 (40.2)	29 (21.3)	.004
Total complications (excluding postoperative transfusions)	45 (21.3)	23 (16.9)	.53

ERAS, enhanced recovery after surgery; BMI, body mass index; TAH, total abdominal hysterectomy; BSO, bilateral salpingo-oophorectomy; POD, postoperative day; NA, not applicable; LOS, length of stay; NSQIP, National Surgical Quality Improvement Program; OR, operating room.

Data are mean±standard deviation, n (%), or median (interquartile range) unless otherwise specified.

* Costs include both direct and indirect hospital costs.

was unchanged (1.0 compared with 1.0 days; *P*=.33). There was a slight decrease in the median predicted length of stay as evident by the smaller interquartile range (*P*<.001). There was an increase in total postoperative complications in the pre– compared with post–ERAS light groups (10.8% compared with 18.1%;

Table 3. Gynecologic Oncology Patient Subset Analysis Before and After Enhanced Recovery After Surgery Implementation

	Pre-ERAS (n=96)	Post-ERAS (n=46)	*P*
Demographics			
Age (y)	58.9±12.2	60.2±12.2	.56
Race			
White or Caucasian	79 (82.3)	39 (84.8)	.81
African American	15 (15.6)	7 (15.2)	1.00
Other	2 (2.1)	0 (0.0)	1.00
BMI (kg/m^2)	30.5±8.5	30.4±8.3	.92
ERAS protocol elements			
Neuraxial analgesia			
Epidural	25 (26.0)	5 (10.9)	.05
Spinal	17 (17.7)	41 (89.1)	<.001
Opioid consumption			
Morphine equivalents—intraoperative (mg)	13.3 (7.9, 25)	0.3 (0.25, 0.25)	<.001
Morphine equivalents—total (mg)	22.6 (15.8, 42.9)	21.9 (10, 42.7)	.52
Pain score			
Highest	9.0 (7, 10)	8.0 (7, 9)	.06
POD 0	4.8 (3.4, 6.5)	3.4 (1.3, 5.5)	<.001
POD 1	4.0 (2.6, 5.2)	3.3 (2.1, 5.1)	.23
POD 2	3.0 (1.1, 4.8)	3.3 (2, 4.7)	.27
Fluid administration			
Intraoperative net fluid balance (mL)	1,105.0 (825, 1,850)	280.0 (110, 533)	<.001
Total hospital net fluid balance (mL)	1,302.6 (−572, 3,196.8)	−739.2 (−2,471, 918.5)	<.001
Preoperative carbohydrate loading	NA	42 (91.3)	NA
Ambulation			
Day of surgery	6 (6.3)	18 (39.1)	<.001
More than 2 times on POD 1	56 (58.3)	45 (97.8)	<.001
LOS and financial outcomes			
LOS (d)	3.0 (2.5, 4.0)	3.0 (2, 3)	.03
NSQIP-predicted LOS*	2.0 (1.5, 3.3)	3.3 (2, 4.5)	<.001
30-d total hospital cost/patient†	$13,238 (11,100, 18,317)	$11,286 (9,227, 14,028)	.002
NSQIP outcomes*			
Surgical site infection	3 (3.1)	4 (8.7)	.21
Urinary tract infection	3 (3.1)	2 (4.3)	.66
Transfusion	27 (28.1)	3 (6.5)	.004
Unplanned return to OR	1 (1.4)	0 (0.0)	1.00
Pneumonia	4 (4.2)	0 (0.0)	.30
Pulmonary embolism	1 (1.0)	0 (0.0)	1.00
Deep venous thrombosis	0 (0.0)	1 (2.2)	.32
Unplanned intubation	2 (2.1)	0 (0.0)	1.00
Acute renal failure	1 (1.0)	0 (0.0)	1.00
Cardiac arrest	1 (1.0)	0 (0.0)	1.00
Sepsis or septic shock	2 (2.1)	1 (2.2)	1.00
Death within 30 d	0 (0.0)	0 (0.0)	
Readmission	4 (4.2)	3 (6.5)	.68
Total complications	49 (51.0)	14 (30.4)	.002
Total complications (excluding postoperative transfusions)	22 (22.9)	11 (23.9)	.26

ERAS, enhanced recovery after surgery; BMI, body mass index; POD, postoperative day; NA, not applicable; LOS, length of stay; NSQIP, National Surgical Quality Improvement Program; OR, operating room.
Data are mean±standard deviation, n (%), or median (interquartile range) unless otherwise specified.
* Reported through October 31, 2015.
† Costs include both direct and indirect hospital costs.

P=.01) that was the result of an increase in urinary tract infection rates (1.9% compared with 5.2%; *P*=.03).

During the two timeframes of the study, gynecologic patient satisfaction survey results were compared. There were 145 discharged gynecology patients who returned surveys (68 pre–ERAS and 77 post–ERAS implementation), which showed a marked improvement on the focus question regarding pain control ("how well your pain was controlled"), which increased from the 26th percentile to the 63rd percentile

Table 4. Characteristics and Comparison of Population Before and After Enhanced Recovery After Surgery Implementation on Light Pathway for Minimally Invasive Surgical Procedures

	Pre-ERAS (n=324)	Post-ERAS Gynecologic Light (n=249)	*P*
Demographics			
Age (y)	56±12.7	56±14.0	.64
Race			
White or Caucasian	271 (83.6)	211 (84.7)	.73
African American	27 (8.3)	25 (10.0)	.56
Other	26 (8.0)	13 (5.2)	.24
BMI (kg/m^2)	31.4±8.3	32.5±8.7	.42
Procedures			
LH (±BSO, nodes)	223 (68.8)	141 (56.6)	.003
TVH (±BSO)	66 (20.5)	55 (22.2)	.68
Laparoscopic colpopexy	1 (0.3)	17 (6.8)	<.001
ERAS protocol elements			
Opioid consumption			
Morphine equivalents—intraoperative (mg)	13.0 (6.7, 20.7)	0.0 (0, 0)	<.001
Morphine equivalents—total (mg)	23.6 (7.7, 32.1)	15.0 (5.0, 23.5)	<.001
Pain score			
Highest	7.5 (6, 9)	8 (6, 9)	.92
POD 0	4.4 (3, 5.9)	4.3 (2.4, 5.9)	.52
POD 1	3.4 (2, 5)	3.2 (1.7, 4.7)	.37
Fluid administration			
Intraoperative net fluid balance (mL)	932.5 (537.5, 1,300)	250.0 (50, 512.5)	<.001
Total hospital net fluid balance (mL)	1,381.5 (507.8, 2,315.7)	171.1 (−538.5, 633.8)	<.001
Preoperative carbohydrate loading	NA	227 (91.2%)	NA
Ambulation			
Day of surgery	66 (20.4)	81 (32.5)	<.001
More than 2 times on POD 1	125 (38.9)	177 (71.4)	<.001
LOS and financial outcomes			
LOS (d)	1.0 (1, 1)	1.0 (1, 1)	.80
NSQIP-predicted LOS	1.0 (1.0, 1.5)	1.0 (1, 1)	<.001
30-d total hospital cost/patient*	$8,277 (6,831, 10,096)	$7,606 (6,358, 9,663)	.014
NSQIP outcomes*			
Surgical site infection	3 (0.9)	6 (2.4)	.19
Urinary tract infection	6 (1.9)	13 (5.2)	.03
Transfusion	7 (2.2)	4 (1.6)	.76
Unplanned return to OR	2 (0.6)	2 (0.8)	1.00
Pneumonia	1 (0.3)	0 (0.0)	1.00
Pulmonary embolism	1 (0.3)	0 (0.0)	1.00
Unplanned intubation	1 (0.3)	0 (0.0)	1.00
Acute renal failure	0 (0.0)	0 (0.0)	
Cardiac arrest	1 (0.3)	0 (0.0)	1.00
Sepsis or septic shock	1 (0.3)	3 (1.2)	.32
Death within 30 d	1 (0.3)	0 (0.0)	1.00
Readmission	11 (3.4)	17 (6.8)	.08
Total complications	35 (10.8)	45 (18.1)	.01
Total complications (excluding postoperative transfusions)	28 (8.6)	41 (16.5)	.006

ERAS, enhanced recovery after surgery; BMI, body mass index; LH, laparoscopic hysterectomy; BSO, bilateral salpingo-oophorectomy; TVH, total vaginal hysterectomy; POD, postoperative day; NA, not applicable; LOS, length of stay; NSQIP, National Surgical Quality Improvement Program; OR, operating room.

Data are mean±standard deviation, n (%), or median (interquartile range) unless otherwise specified.

* Costs include both direct+indirect hospital costs.

(*P*<.001). On the teamwork question ("Staff worked together to care for you"), responses improved from the 32nd to the 90th percentile (*P*<.001) and on the nursing question response ("nurses kept you informed"), responses improved from the 17th to 26th percentile (*P*<.001) after implementing ERAS. For the few patients discharged from the short stay unit who would certainly been among the light pathway type of patients (an additional 12 patients pre–ERAS and 11 post–ERAS), patient satisfaction scores showed

a marked improvement on the pain control question (34th compared with 99th percentile; $P<.001$), was unchanged on the teamwork question (97th compared with 99th percentile), and increased on the nursing question (34th compared with 99th percentile; $P<.001$) after ERAS implementation.

Median total 30-day hospital costs per patient were decreased in all groups after implementing ERAS. The median costs decreased on the full pathway ($11,172 to $9,899; $P<.001$), the gynecologic oncology subset ($13,238 compared with $11,286; $P<.001$), and the light pathway patients ($8,277 compared with $7,606; $P<.001$).

DISCUSSION

After implementing an ERAS protocol, we demonstrated an association with significant improvements in length of stay, patient satisfaction, and decreased costs for women undergoing major gynecologic surgery. Like with any clinical paradigm shift, there are multiple considerations in how to optimize ERAS implementation; the most crucial at our institution was investing in a dedicated nurse to oversee the process but once the process becomes fully entrenched, this may not be needed. This transition is happening globally as evidenced by the Enhanced Recovery After Surgery Society's recently published guidelines for perioperative care in gynecologic oncology surgery.[8,9] Our results, like others including a 2015 meta-analysis, highlight the potential clinical benefits of ERAS shortened hospital stay, enhanced bowel recovery, similar pain control with reduced opioids with equivalent complication, mortality, and readmission rates, all with decreased costs.[2,10,12–14]

Patient satisfaction has become a particular area of focus in the current era of potential pay for performance. We confirmed that ERAS implementation was associated with marked patient satisfaction improvements although somewhat limited in that not all patients completed surveys. Our goals were to improve communication and patient satisfaction through setting expectations and standardization of care and part of the success was potentially attributable to both the teaching and the patient notebooks and checklists (available at www.uvaeras.com). Although actual patient pain scores only improved on postoperative day 0, there was still significant improvement on patient satisfaction with pain control. This potential paradox between pain scores and satisfaction with pain may be attributable to extensive preoperative counseling, managing expectations around the pain control process, and the patient's knowledge that the entire team was dedicated to pain management. This is consistent with another study that concluded "patient satisfaction was more strongly correlated with the perception that caregivers did everything they could to control the pain rather than with the pain actually being controlled."[14]

Overall, on the full ERAS pathway, postoperative blood transfusions decreased and two potential explanations exist. First, this may have been the result of a shift toward more stringent enforcement of institutional criteria for blood administration. Theoretically, a second explanation might be that it was the result of lower intraoperative fluid resuscitation in the ERAS patients leading to less hemodilution and a lower central venous pressure, which has been correlated with blood loss and transfusion in other types of major abdominal surgery.[15] With regard to the increased urinary tract infection rate on the light pathway, we could not detect any common themes or generate any hypotheses to explain it.

Our ERAS protocol has several unique anesthesia features compared with others. First, we used the Pleth Variability Index to manage intraoperative fluid administration, which measures fluid responsiveness based on respiratory variation in the photoplethysmographic waveform.[16–19] Respiratory variation is influenced by both tidal volumes and intraabdominal pressure,[20,21] and we found the device to be useful but acknowledge that the use of advanced, "goal-directed therapy" algorithms to manage intravenous fluids for ERAS are not necessarily considered standard of care.[22,23] Another novel feature was the use of N-methyl-D-aspartate antagonists as analgesic agents.[24–28] The intraoperative use of ketamine, coupled with continuous postoperative intravenous lidocaine infusions (and a morphine spinal), allowed us to transition away from epidural-based analgesia, which, at our institution, has been correlated with increased deep vein thrombosis risk as well as increased fluid administration to combat hypotension.[29] Some studies have suggested that intravenous lidocaine is not effective after hysterectomy[30,31]; however, because our institutional colorectal surgery experience was so positive, we incorporated it within the gynecologic ERAS protocol.[3,32]

This study suffers from multiple limitations inherent within the before-and-after study design, particularly the inability to differentiate association from causation. There is an inherent risk of selection bias as well as the fact that any associations revealed may reflect other changes in institutional culture or practices other than simply a new protocol implementation. Furthermore, our study had relatively small numbers of patients with limited power to detect small differences in rare complications. In an attempt to reduce the risk of these biases, risk stratification was performed with the American College of Surgeons' National Surgical Quality Improvement Program calculator and confirmed that our groups were

likely equivalent. Although a randomized trial would be vastly superior to evaluate the effect of ERAS given the extensive effort necessary to overcome institutional bias for traditional perioperative care, it would have been nearly impossible to accomplish.

The potential implications of these data are far reaching. Patient-centered quality outcomes are improved and the institution benefits from increased capacity with associated opportunistic revenue. As health care costs continue to rise, threatening our national economy, strong consideration should be given to widespread implementation of ERAS in gynecologic surgical patients.

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