

Enhanced recovery after surgery (ERAS) protocol in Oblique lumbar interbody fusion(OLIF): a case-controlled study

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Abstract

Background Enhanced recovery after surgery (ERAS) attempts to decrease the surgical stress response to minimize postoperative complications and improve functional rehabilitation after major surgery, but it has not been widely utilized in spinal surgery. This study is to evaluate the implementation of an ERAS pathway for patients undergoing oblique lumbar interbody fusion (OLIF) surgery.

Methods This was a retrospective cohort study of patients who underwent OLIF in 2018 prior to ERAS ("pre-ERAS", n=23) and in 2019 after ERAS was instituted ("ERAS", n=24). Major outcomes were collected including demographics, length of hospital stay, financial cost, postoperative complications, off-bed time and perioperative factors. Visual Analogue Scale (VAS) was used to evaluate the pain. The ERAS pathway and compliance with pathway elements were also recorded.

Results After ERAS implementation, we found no significant differences in the baseline characteristics between the two groups. In our study, the mean stay in the hospital was significantly lower ($p = 0.033$) in the ERAS group (15.3 ± 3.9 days) compared to the standard pathway group (13.0 ± 3.1 days). In comparison to the standard group, we also found a variation between the financial costs of surgery and hospitalization [(16446.5 ± 4353.3) vs (14237.7 ± 2784.9) USD, $P < 0.05$]. The ERAS group manifested a lower blood loss compared with the pre-ERAS group with statistical significance [(68.3 ± 57.1) vs (119.3 ± 104.8) ml, $P < 0.05$]. There was no significant difference in operative time, complications, and 30-d readmission rates ($P > 0.05$). Pain scores between the two groups showed a significant difference during the 3th hour and 6th hour ($P < 0.05$).

Conclusion Institution of an ERAS protocol appears to accelerate functional recovery and reduce length of stay, financial costs and decreased pain.

Background

Enhanced recovery after surgery (ERAS) is an evidence-based protocol in the care of surgical patients and reduce the impact of surgery, allowing patients to recover more quickly.(1) Peer-reviewed ERAS protocols are available for various surgical disciplines and procedures. Despite technical differences in these protocols, a common motif is present: minimization and improvement of the stress response. The proposed rationale suggests that by maintaining homeostasis, untoward effects such as postoperative catabolism, pain, and immune dysfunction can be attenuated.(2,3) Within orthopedic surgery, ERAS protocols were successfully applied to primary hip and knee replacement patients and has reduced LOS and accelerate return of function.(4) Recently, as attention is directed to ERAS for spine surgery with the development of guidelines from the ERAS Society and a more robust literature for its use in spine surgery.

Despite these positive results, the ERAS pathway is not currently widely adopted within spine surgery. Data on the safety, feasibility, and outcomes achieved with ERAS for spine surgery are still limited at present. Oblique lateral interbody fusion (OLIF) is a new technique in spine surgery, which can establish a work corridor direct access to the intervertebral space between the psoas muscles and the abdominal

vessels sheath. Through the retroperitoneal work corridor, OLIF can complete intervertebral fusion of anterior and middle column, restore the height of intervertebral space and foramen, and make the spinal canal or nerve root indirect decompression. OLIF is applicable to degenerative lumbar spine diseases, spinal tuberculosis, ankylosing spondylitis and postoperative revision. OLIF conforms to the current trend of minimally invasive spinal surgery, which has many advantages like less surgical trauma, less surgical bleeding loss, shorter hospital stay, faster recovery, less damage to the abdominal organs, no stimulation of the spinal nerve, and less damage to the psoas and lumbosacral plexus. (5-7)

In this study, the team adapted the ERAS model to patients undergoing OLIF surgery. We hypothesized that an ERAS spinal program would accelerate functional recovery after the surgery, reduce LOS, and improve patient and family satisfaction.

Methods

Study Design

This was a retrospective cohort study. The first cohort included all patients undergoing OLIF in 2018 before the implementation of ERAS. The second cohort included all patients on our ERAS pathway between January 2019 and December 2019 after the pathway was introduced. Major outcomes such as the demographic information and perioperative factors were logged into the electronic medical record. All patients meeting eligibility criteria were included in the ERAS spinal surgery program. The multidisciplinary ERAS team was composed of the key experts from the involved units, including surgeons, anesthetists, nurses, dieticians and clinical staffs. This study was approved by the institutional review board at the First Affiliated Hospital of Soochow University.

Data collection and Outcomes

The demographic data and common surgical outcomes of patients was captured from the First Affiliated Hospital of Soochow University congenital database. The primary outcome was length of stay, and the secondary outcomes were direct costs, program adherence, in-hospital postoperative complications, 30-day readmission, and reoperation rates.

ERAS pathway components

Our ERAS pathway consisted of three chronological components: preoperative, intraoperative and postoperative components (Table 1). Preoperatively, patients on our ERAS pathway received preoperative education, including goals of surgery and expectations for recovery and details of rehabilitation. In addition, a patient with the comorbidities was assessed and optimised. Patients are allowed to drink Short-chain polypeptides drinks within 8 hours and clear fluids within 2 hours before surgery to reduce preoperative fasting duration. The patients receive an ERAS preemptive analgesia regimen of NSAID (Celecoxib was given 200mg from 2 to 3 days) unless contraindicated or refused by the patient. Intraoperative care elements emphasized antimicrobial prophylaxis and the use of tranexamic acid and

maintenance of mean arterial pressure for decreasing blood loss. Postoperatively, patients are started immediately on a general diet and early ambulation is encouraged. For pain management, the opioid-sparing perioperative multimodal analgesia was carried out. Patients receive scheduled doses of celecoxib and pregabalin. Visual analogue scale (VAS) scores of pain were recorded at regular intervals after the surgery.

Surgical Techniques

After induction of general anesthesia, the patient was placed in lateral decubitus position on the right side. The operating segment was marked on the skin via a C-arm machine. A 5 cm skin incision was made on the marked disc level at the left abdomen. Then carry out blunt finger dissection of the abdominal oblique muscles, which includes the external oblique, internal oblique, and transversalis abdominis muscles. The surgeon uses the index finger to confirm the anterior border of the psoas muscle, sliding from the quadratus lumborum muscle to reach there. The retroperitoneal space was accessed by blunt dissection, and the peritoneal content was mobilized anteriorly. Place a Kirschner wire into the disc space from the antero-lateral corner to confirm the target disc space again. Sequential dilators were placed over the Kirschner wire. After the final tubular retractor was placed over the anterior one-third of the disk under illumination, the entire visualized area was made clearly. A lateral annulotomy was performed followed by a complete discectomy by using pituitary rongeurs and curettes, then removing the focus by using curette. After that, an appropriate-sized cage filled with autologous bone graft was inserted orthogonally in a press-fit fashion into the disc spaces. The above procedures were done step by step under C-arm fluoroscopic guidance. After completing the anterior procedure, the patient was turned to the prone position, and supplemental posterior instrumentation was then placed to sustain the stability of spine. Fig.2

Statistical Analysis

Continuous variables were presented using the mean (standard deviation) and median (range). Categorical variables were summarized using frequencies and percentages. Fisher's exact tests were carried out for categorical variables, and Wilcoxon Rank Sum tests were performed for continuous variables. A predetermined 2-sided alpha of 0.05 was considered statistically significant. Multiple regression analysis was performed with hospital stay as the dependent variable and taking Age, BMI, T-score, pain score, time to walk, operative time, and blood loss as an independent variable.

Results

The study enrolled 47 (PRE n =23, POST n = 24) patients who underwent OLIF in our department between February 2018 and March 2020. The patient baseline characteristics and comorbidities were shown in Table 1. There were no substantial differences between the two groups, including age, gender, body mass index, underlying comorbidities.

Table 1. Demographic and baseline characteristics of patients

	Pre-ERAS(n=23)	ERAS (n=24)	P value
Age (years)	64.1±10.7	58.2±11.5	0.08
Gender (male/female)	5/18	6/18	1.0
Body mass index (kg/m ²)	25.0±3.2	24.4±3.6	0.53
T-score (mean ± SD)	-1.13±1.54	-1.17±1.30	0.92
Spine operation history	3	2	0.666
Diabetes mellitus	4	2	0.416
Hypertension	8	9	1.0
COPD	1	0	0.489
CCD	2	2	1.0
Operated level (n)	38	36	-
L2-3	1	0	
L3-4	3	3	
L4-5	10	12	
L2-4	2	0	
L2-5	5	1	
L3-5	1	7	
L3-5 O + L5-S1 T	1	0	
L2-5 O + L5-S1 T	0	1	

ERAS=enhanced recovery after surgery, COPD=chronic obstructive pulmonary disease, CCD= Chronic cardiovascular disease, O=OLIF, T=TLIF

Program components and key metrics, and pathway compliance are shown in Table 2. Important preoperative interventions included patient education, nutrition optimization and preemptive analgesia which were used in 100% of the cases in the ERAS group. Limitation of preoperative fasting by allowing the ingestion of Short-chain polypeptides beverage within 8 hours and clear fluids within 2 hours before surgery was observed in 23 of 24 patients (96%). In addition, we found preemptive analgesia in 20 of 24 patients (83%). Intraoperatively, the following ERAS components were reviewed: antimicrobial prophylaxis, blood conservation and goal-directed fluid management were used in 100%, 77%, and 58% of patients, respectively. 22 of 24 patients (92%) received a multimodal pain regimen with acetaminophen.

Table 2. Enhanced recovery after surgery program components and adherence to guidelines

ERAS Components	Pathway Compliance (%)	Preoperative
		Patient education Patient education, expectations for recovery, Written patient 24/24 (100%)
		discharge criteria, details of recovery
Surgery to-do list	Treatment modalities, anesthesia evaluation, 24/24 (100%) smoking cessation	
Nutrition optimization	Nutrition consultation	24/24 (100%)

Preoperative fasting	Clear glucose-containing beverage 8 h before surgery, clear liquids until 2 h before surgery	23/24 (96%)
Preemptive analgesia	Celecoxib was given 200mg from 2 to 3 days before operation	20/24 (83%)
Intraoperative		
Antimicrobial prophylaxis	Cefathiamidine was given 2000mg at the beginning of anesthesia	24/24 (100%)
Blood conservation	Patients receiving TXA	12/24 (50%)
	Monitoring and maintenance of mean arterial pressure	25/24 (63%)
Goal-directed fluid management	A balanced volume replacement strategy	14/24 (58%)
Postoperative		
Analgesia	Multimodality analgesia regimen—acetaminophen, gabapentin, NSAIDs, and minimization of opioids	22/24 (92%)
Prophylaxis	VTE prophylaxis	22/24 (91%)
	PONV prophylaxis	21/24 (88%)
Early mobilization	Patients was encouraged to get out of bed on POD1	24/24 (100%)
Line management	Discontinuation urinary catheter on POD1	20/24 (84%)
Follow up	Regular follow-up and enrollment in patient-reported outcomes	23/24 (96%)

We compared pain scores between the two groups at different target levels (Table 3). Although the pain scores were lower in the ERAS group, it achieved significance only at POD2 ($P < 0.05$) and POD3 ($P < 0.05$), respectively, compared to the standard group. The mean pain scores for both the groups are shown in the figure 1. Perioperative factors were presented in Table 3. Median LOS was 13 days for the ERAS group, and 15 days for the pre-ERAS group. The ERAS group had a significantly shorter LOS than the pre-ERAS group ($P < 0.05$, Table 3). Also, the cost was significantly lower in the ERAS group than in the pre-ERAS group ($P < 0.05$, Table 3). The complication rate was 17.4% for the pre-ERAS group. Three patients showed abdominal distension on the first postoperative day which improved spontaneously the next several days. One patient experienced thigh and numbness postoperatively, which alleviated within 5 days after surgery. The complication rate in the ERAS group was 8.3%. One patient experienced abdominal distension postoperatively. One patient showed transient hip flexion weakness postoperatively which resolved from 4 days. As shown in Table 3, there were no significant differences in complication rate, 30-day readmission rates and operative time between the two groups ($P > 0.05$, Table 3). The intraoperative blood loss was lesser in the ERAS group than in the pre-ERAS group ($P < 0.05$, Table 3). The results of the multiple linear regression showed that early mobilization that likely contribute to shorter recovery (Table 4).

Table 3. Perioperative factors and postoperative outcomes

	Pre-ERAS (23)	ERAS (24)	P value
Blood loss (ml)	119.3±104.8	68.3±57.1	0.047
Operative time (min)	224.3±76.4	234.2±77.4	0.668
Hospital stay (days)	15.3±3.9	13.0±3.1	0.033
Complications(n)	4	2	0.416
Cost(USD)	16446.5±4353.3	14237.7±2784.9	0.047
Blood transfusion (n)	2	0	0.234
30-day readmission (n)	0	0	-
VAS			
1d	4.82±0.56	4.54±0.58	0.10
2d	4.52±0.50	3.67±0.47	4.28x10 ⁻⁷
3d	3.48±0.49	2.96±0.20	3.24x10 ⁻⁵
4d	2.78±0.41	2.54±0.49	0.084

ERAS=enhanced recovery after surgery,

Table 4. Results of multiple regression analysis for influence factors of hospital stay

	Classification for hospital stay	
	Standardized coefficients	P
Age	.019	.915
BMI (mean ± SD , g/cm ²)	.119	.440
T-score (mean ± SD)	.230	.188
Operative time (min)	.063	.748
Mean VAS score□Postop 4 day□	.260	.077
Time to walk (d)	.413	.018
Blood loss (ml)	.157	.381

*P <0.05

Discussion

OLIF has become more and more popular to treat degenerative diseases of the lumbar spine, which has many advantages like less surgical trauma, faster recovery, less damage to the abdominal organs, no stimulation of the spinal nerve and less damage to the psoas and lumbosacral plexus. However, OLIF are associated with high amounts of pain and other complications (8, 9). Wainwright et al.(10) reported that spinal procedures are associated with high amounts of pain, slow return of function, and prolonged hospital stays, among other complications. In addition, the evidence they reviewed indicated that ERAS principles would likely expedite return to function and minimize postoperative morbidity. Thus, more ERAS programs tailored for OLIF surgery will be required to speed the recovery of patients after OLIF surgery. We present our program and its results as a way to heighten exposure of ERAS in OLIF in an effort to improve care for our collective patients. Reduced operation time, blood loss, intraoperative fluid infusion, postoperative drainage, cost and LOS were observed after ERAS program implementation.

ERAS is a process that commences in the preoperative phase that ensures optimization before surgery, continues into the intraoperative/perioperative phase followed by discharge planning and post-discharge phase (11, 12). Once the decision to consider spinal surgery has been made, our ERAS team work to ensure the patients are in the best possible condition to undergo spinal surgery. Our team provided the education about ERAS to patients, which can help patients obtain better postoperative efficacy. A shorter preoperative fasting time and oral nutritional supplements were optimized to optimize the nutritional status of patients and improve patient satisfaction. Furthermore, we stress on control of intraoperative bleeding, we take a series of measures including control intraoperative blood pressure, application of hemostatic drugs (tranexamic acid) and precise operation, to minimize intraoperative hemorrhage. For MMA, We give a safe dose of pregabalin and acetaminophen. Preemptive analgesia can relieve postoperative pain by suppressing central autonomic hyperactivity and decrease opioid consumption after lumbar spine surgery (13, 14). We emphasized early transition to oral pain medications after surgery. A care pathway was designed involving all the professional disciplines to standardize aspects of postoperative care such as thromboprophylaxis, wound care, bowel regime, nutrition, voiding, and activity.

In this study, length of stay was reduced by 2 days for the ERAS intervention group compared to the pre-ERAS cohort. Importantly, in the setting of expedited hospitalizations, readmission and complication rates remained unchanged and nominal. Early mobilization that likely contribute to shorter recovery without increased readmission and complications (Table 4). Other institutions have shown LOS in ERAS spine surgery was decreased by 1.5 to 2 days with no change in complication or readmission rate (15, 16). Soffin(17) described an ERAS protocol for lumbar surgery. Median length of stay was noted to be 279 minutes, shorter than reports of average LOS after decompression being 2 days. However, not all centers have found improved length of stay for patients undergoing spine surgery within their ERAS programs

(18). The discordance in findings is likely due to differences in the patient population and the program goals. Grasu et al.(19) noted that patients with advanced metastatic disease or terminal illness may have prolonged hospitalizations for cancer care unrelated to surgical procedures for which they were admitted. From a financial perspective, in this study, the ERAS Program reduced direct costs per patient. Several studies have shown that ERAS protocols were cost-effective (20, 21, 22). These cost studies also confirmed a decrease LOS in their cohorts. Not unexpectedly, reduced length of stay and no increase in postoperative readmission were the main drivers of cost savings. Furthermore, cost savings often surpass the initial ERAS implementation costs. In addition, additional hospital revenue might accrue through rapid patient flow and turnover. Pain control is especially challenging, as spinal procedures are often associated with especially high levels of pain on the first post-operative day.(23) In addition, Postoperative pain is the primary factor affecting the length of hospital stay in patients.(24) It has been proposed that multimodal pain management strategies should be used whenever possible to reduce the consumption of narcotics.(25) The usage of opioids has to be cautious as it can interfere in both peripheral and central chemoreflex loops.(26) In our study, we compared the pain between two groups using the VAS score , mean daily pain scores were significantly reduced on postoperative days 2 and 3, respectively, in the ERAS cohort.

There are a number of limitations of this study. First, it is a retrospective cohort study with a relatively small sample size. It restricted the strength of evidence with respect to the effectiveness and safety of our ERAS pathway, so we are unable to prove the true effect of the ERAS pathway. Furthermore, critical elements such as education, patient reported outcomes, and preoperative nutrition evaluation have not been fully implemented. There are some challenges in the compliance of our team with the ERAS program. One such challenge to implementing this type of program is compliance owing to individual surgeon preference and a limited ability to monitor adherence to the program. The Hawthorne effect could have played a role as patients and providers were aware of the program and its goals. Finally, we are little known about functional recovery when the patients are discharged, and a program with patient reported outcomes monitoring will help to improve follow-up and assess patient and family satisfaction.

Conclusion

The current ERAS pathway for OLIF demonstrated to reduce blood loss, operation time, blood loss, cost and lengths of stay in the patients when compared to the conventional care pathway for OLIF. Meanwhile, there is no significant increase in rates of readmissions or complications after introduction of ERAS pathway. In summary, the ERAS program is effective to the surgical spine patient and improved patient satisfaction.

Abbreviations

OLIF=oblique lumbar interbody fusion; TLIF=transforaminal lumbar interbody fusion; DH=disc height; FH=foraminal height; FSL=fused segment lordosis; LL=lumbar lordosis; ODI=oswestry disability index; CSF=cerebrospinal fluid; LP=leg pain; BP=back pain

Declarations

Ethics approval and consent to participate

The study was approved by the Medical Ethics Committees of The First Affiliated Hospital of Soochow University.

Consent for publication

All authors have seen the manuscript and approved it to submit to your journal.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Li RJ assisted with care of the patient and wrote majority of the manuscript.

Shao XF helped literature review and writing assistance.

Jiang WM performed the surgery and approved the manuscript.

All authors have read and approved the manuscript.

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Figures

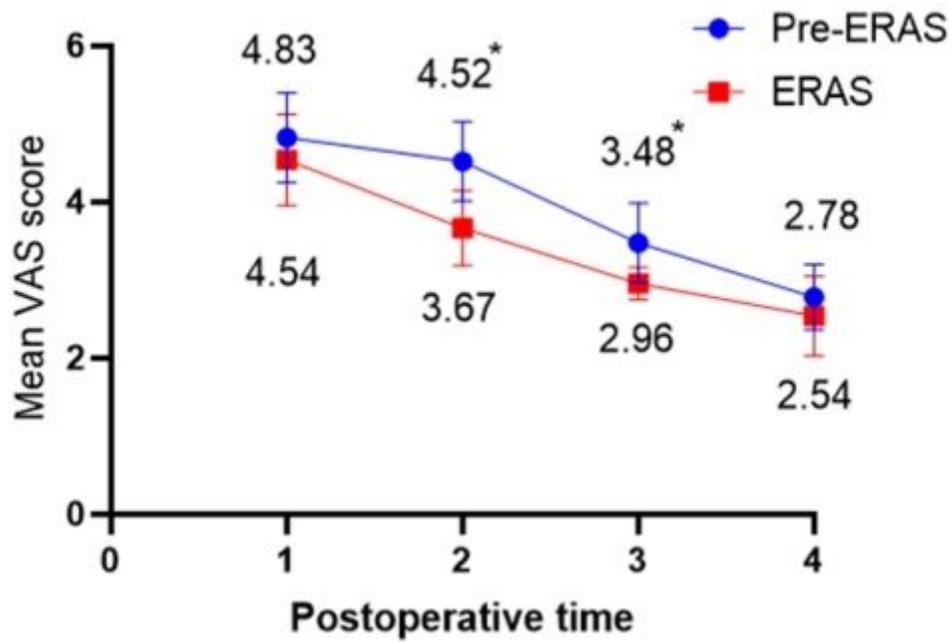


Figure 1

VAS score: ERAS group vs. Standard group *P-value < 0.05. T-test



Figure 2

Perioperative images of OLIF