Enhanced Recovery After Surgery Pathway: Association with Lower Incidence of Wound Complications and Severe Hypoalbuminemia in Patients Undergoing Posterior Lumbar Fusion Surgery

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Research Article

Keywords: Enhance recovery, ERAS, Wound complications, Nutrition

Posted Date: December 30th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1202700/v1

Version of Record: A version of this preprint was published at Journal of Orthopaedic Surgery and Research on March 24th, 2022. See the published version at https://doi.org/10.1186/s13018-022-03070-z.

Abstract

Background. Wound complications were associated with worse satisfaction and additional costs in patients underwent posterior lumbar fusion(PLF) surgery ,the relationship between enhanced recovery after surgery(ERAS)pathway and wound complications remains poorly characterized.

Methods. In this retrospective single-center study, we compared 530 patients receiving ERAS pathway care with previous 530 patients in non-ERAS group. The primary aim of our study was to identify the relationship between ERAS program and the incidence of postoperative wound related complications and other complications following PLF surgery, other outcomes included the length of stay(LOS), 90-day hospital and rehabilitation center readmission.

Results. Average patient age was 65yr. There were more patients with old cerebral infarction in ERAS group ($p<0.01$), other demographics and comorbidities were similar between both groups. Patients in ERAS group had a lower incidence of postoperative wound-related complications compared with non-ERAS group(12.4 vs 17.8%, $p=0.02$).The non-ERAS group had a significantly higher rate of wound dehiscence or poor wound healing(6% vs 3%, $p=0.02$). ERAS group had a lower incidence of server postoperative hypoalbuminemia(serum albumin less than 30g/L)(15.8% vs 9.0% $p<0.01$).Additionally, ERAS patients had a shorter postoperative LOS (8.0±1.5 vs 9.5±1.7 $p<0.01$), lower rate of readmission within 90 days (1.9% vs 6.4%, $p<0.01$) and discharge to rehabilitation center (4.2% vs 1.0%, $p<0.01$).

Conclusion. ERAS pathway may help to decrease the rates of postoperative wound complications and server hypoalbuminemia following PLF surgery, additionally, we demonstrated that ERAS pathway was also associated with shorter LOS and lower rate of readmissions within 90-day.

Background

With rapid population aging in many countries, the incidence of lumbar diseases is gradually increasing. Posterior lumbar fusion(PLF) surgery is a common procedure for treatment of degenerative lumbar spinal disease[1]. Postoperative wound complications are associated with delayed recovery and reoperation after surgery[2, 3].Wound complications included superficial or deep surgical site infection(SSI), wound dehiscence, poor wound healing and persist wound drainage[4–6]. Previous literature reported that the rate of SSI following spinal surgery was 0.7%-12.0%, Numerous factors had been reported as risk factors for postoperative wound infection[7–9]. However, few studies have been conducted to investigate the influential factor of other wound healing complications after PLF surgery. Given the higher rate of wound complications, efforts are needed to reduce the incidence of wound complications and enhance recovery.

Enhanced recovery after surgery (ERAS) program is a multidisciplinary perioperative management approach designed to reduce the surgical stress response and accelerate recovery after surgery[10]. ERAS protocol has been implemented in other surgical settings for many years. Some studies also identified that the application of the ERAS program was associated with a reduction of the length of stay (LOS) and postoperative complications in patients undergoing spinal fusion surgery[11, 12]. However, the

relationship between ERAS and wound healing remains poorly characterized, some studies reported that ERAS did not result in reduction of SSI, which is not consistent with others, additionally, underlying mechanisms for such relationship are still unknown[13, 14].

The primary aim of our study was to identify the relationship between ERAS program and the incidence of postoperative wound related complications and other complications following PLF surgery. The secondary aim was to evaluate the impact of ERAS pathway on other outcomes, including LOS and 90-day hospital or rehabilitation center readmission.

Materials And Methods

Study Design

This was a single-center retrospective analysis study, and data of all patients were obtained from the electronic medical record system. We included consecutive patients who underwent PLF surgery with or without spinal decompression between January 2017 and July 2021. Patient data included preoperative, intraoperative, and postoperative variables. Approval was obtained from the ethics committee of our hospital (permit data 2018.4.3; no. 2018086).

ERAS Protocol

We designed an evidence-based ERAS protocol and implemented the protocol for our perioperative management in our institution from January 2019. The ERAS team consisted of anesthesiologists, spine surgeons, nutritionists and nurses, with geriatricians and physicians providing valuable suggestions. Our protocol consisted of preoperative, intraoperative, and postoperative interventions based on current reliable evidences (Table 1). Compliance was also evaluated according to the number of achieved individual elements items of ERAS program by two dedicated stuffs who did not know every patient and not participate in data analysis. The discharge criteria for both groups were as follows: (1) the patient’s preoperative symptoms had been relieved completely or mostly, or treatment met the patient's expectations; (2) patients were able to walk without any support, (3) patients had no surgery-related complications or the postoperative complications had been controlled, and (4) no further treatment was required.

Table 1
Perioperative management pathway of non-ERAS group and ERAS group

	Non-ERAS	ERAS	Compliance
Preadmission	No intervention	1. Education on smoking and excessive drinking cessation; available counseling services at any time; appropriate optimization of chronic disease in outpatient and inpatient settings; nutritional assessment and support	98.3%
Preoperative	Not standardized	2. Informing patients and relatives about risk and discomfort related to procedure in greater detail; ensuring that patients learn and understand ERAS pathway	99.0%
	Route preparation	3. Avoiding mechanical bowel preparation and use of gastric tube	99.4%
	No intervention	4. Drinking oral carbohydrate beverage 2h before surgery; no prolonged fasting	97.7%
	No intervention	5. Oral administration of 150mg of Pregabalin	97.1%
Intraoperative	No intervention	6. Infiltration of local anaesthesia with a mixture of 10ml 2% lidocaine and 10ml 1% ropivacaine into the musculature prior to incision and after skin closure	99.4%
	Antibiotic prophylaxis within 1 h of incision	7. Antibiotic prophylaxis within 1 h of incision	100%
	Not standardized	8. Intravenous infusion of tranexamic acid	98.1%
	Not standardized	9. Maintenance of normothermia; maintaining fluid balance	100%
Postoperative	Intake of fluid on POD1	10. Early intake of fluid on the day of surgery(after recovery from anesthesia)	81.1%
	Not standardized	11. Ealy function rehabilitation on the day of surgery and ambulate on POD1	70.7%
	Not standardized	12. Postperative prophylaxis against thrombosis and postoperative nausea and vomiting	94.5%
	Not standardized	13. Removal of urinary catheters on the day of surgery and removal of drain tube on POD 2	72.6%
	No intervention	14. Multimodal analgesia and opioid-sparing analgesia	100%

POD1:postoperative day 1;POD2:postoperative day 2

	Non-ERAS	ERAS	Compliance
	No intervention	15. Intake of oral nutrition powder for every meal	98.1%
	Route postoperative antimicrobial prophylaxis	16. Route postoperative antimicrobial prophylaxis	100%
POD1:postoperative day 1;POD2:postoperative day 2			

Data Collection

All patients who underwent PLF surgery with or without decompression for lumbar disc herniation, lumbar spinal canal stenosis and spondylolisthesis between January 2017 and July 2021 were reviewed and included in our study. The exclusion criteria were patients with(1) revision surgery;(2) combined cervical and lumbar fusion surgery; (3) non-contiguous segmental surgery; (4)drug treatment for cancer; (5) lack of postoperative information; and (6)congenital spinal deformity. The first consecutive patients (ERAS group) underwent elective lumbar fusion surgery from January 2019 to July 2021. Those patients were then compared with the previous case-matched consecutive patients (non-ERAS group) who had undergone surgery from January 2017 to December 2018 prior to the implementation of ERAS program. All patients' demographic data including age, sex, body mass index (BMI), comorbidities, and preoperative laboratory values were obtained before surgery. Intraoperative variables included the number of fused segments, estimated blood loss and surgical time. Postoperative variables included postoperative complications within 90 days after surgery, LOS, rate of 90-day readmission, rate of albumin transfusion, total amount of albumin infusion. In present study, patients with postoperative serum albumin below 35g/L was defined as hypoalbuminemia and postoperative serum albumin below 30g/L was defined as severe hypoalbuminemia. SSI was assessed according to the Centers for Disease Control (CDC) and Prevention criteria which was based on symptoms, histopathologic exam, imaging test and bacterial cultures of the drainage[15]. Figures 1a–h provided one example of postoperative SSI following PLF surgery. Wound dehiscence which was also known as poor wound healing was diagnosed when superficial, partial or complete separation of surgical wound were recorded in wound nursing records, and persist wound drainage refers to wound drainage for more than 3 days which created a moist dressing with negative bacterial culture [4, 6].

Statistical Analysis

All statistical analyses were performed using the SPSS software (version 22.0; SPSS, USA). Continuous variables are presented as mean ± standard deviation, categorical variables are presented as frequencies with percentages. Continuous variables were analyzed using a 2-tailed student's t test, and categorical variables were analyzed using the Fisher's exact or chi-square tests. A p-value of 0.05 was considered significant.

Results

We reviewed 1190 individuals who underwent PLF surgery between January 2017 and July 2021 from our electronic medical records. Among them, a total of 1060 patients met our inclusion criteria, and 130 patients were excluded because of lack of postoperative data, history of combined cervical and lumbar fusion surgery.The study flowchart was provided in Figure 2. A total of 530 ERAS patients were compared with previous 530 patients without receiving ERAS care. No significant differences in age, sex and BMI were identified between both groups, so further matching was not attempted. In present study, Mean age was 64.2 years in the non-ERAS cohort compared with 65.0 years in the ERAS cohort, $p=0.27$.There were more patients with old cerebral infarction in ERAS group ($p<0.01$), other demographics and comorbidities were similar between both groups. No significant differences were observed in the number of fused segments and surgical time. The serum preoperative albumin level of the ERAS group was similar with that of the non-ERAS group (39.6g/L vs 39.9g/L, $p=0.31$). Patients in the ERAS group had less intraoperative blood loss than those in the non-ERAS group, but it was statistically insignificant. (344.1ml vs 314.3ml $p=0.10$) (Table 2).

Table 2
Baseline Characteristics of Patients in the Two Groups

Variable	Non-ERAS(n=530)	ERAS(n=530)	P Value
Gender			P=0.21
Female	323(61%)	303(57%)	
Male	207(39%)	227(43%)	
Age(yr)	64.2±0.9	65.0±1.0	P=0.27
Weight(kg)	68.3±0.9	69.5±1.0	P=0.09
BMI(kg/m^2)	25.7±0.3	26.0±0.3	P=0.21
Co-Morbidities			
Cardiovascular disease	288(54%)	280(53%)	P=0.62
Diabetes disease	109(21%)	134(25)	P=0.07
Mental disease	7(1%)	10(2%)	P=0.46
Digestive disease	18(4%)	21(4%)	P=0.63
Old cerebral infarction	7(1%)	24(5%)	P<0.01*
Pulmonary disease	15(2%)	10(2%)	P=0.31
Preoperative albumin	39.9±0.3	39.6±0.3	P=0.31
Procedure-related			
Fusion level			P=0.91
1~3	482(90%)	483(90%)	
4~5	48(10%)	47(10%)	
Operative time(min)	209.1±30.2	203.0±28.0	P=0.16
EBL(ml)	344.1±28.3	314.3±21.1	P=0.10
The rate of albumin infusion, n (%)	152(29%)	39(7%)	P<0.01*
BMI:body mass index; EBL:estimated blood loss.			

Postoperative Complications

In present study, patients in ERAS group had a lower incidence of postoperative wound-related complications compared with non-ERAS group(12.4 vs 17.8%, p=0.02).The non-ERAS group had a significantly higher rate of wound dehiscence or poor wound healing(6% vs 3%, p=0.02), however, no

difference was observed in postoperative SSI and persist wound drainage between both groups. Despite similar incidence of postoperative hypoalbuminemia (serum albumin less than 35g/L) (50.4% vs 45.7%, p=0.12), ERAS group had a lower incidence of server postoperative hypoalbuminemia(serum albumin less than 30g/L)(15.8% vs 9.0% p<0.01). With regards to albumin infusion rate, the albumin infusion rate (7.4% vs 28.6%, p<0.01) in the ERAS group were lower compared with non-ERAS group. (Table 3). Although less patients had postoperative cardiovascular complications, pneumonia and deep venous thrombosis, no significant difference was observed in rates of these complications(Table 3).

Table 3
The outcomes of patients in the two groups

	Non-ERAS (n=540)	ERAS (n=540)	P Value
Wound complications, n(%)	94(17.8%)	66(12.4%)	P=0.02*
SSI,n(%)	21(4.0%)	16(3.0%)	P=0.40
Wound dehiscence,p n(%)	33(6.0%)	17(3.0%)	P=0.02*
Persist wound drainage,n(%)	40(7.5%)	33(6.2%)	P=0.39
Other complications			
Cardiovascular disease	5(1%)	5(1%)	P=1.00
Acute cerebral infarction	3(0.6%)	3(0.6%)	P=1.00
Pneumonia	9(1.7%)	6(1.0%)	P=0.44
Haematoma	6(1.0%)	4(0.8%)	P=0.53
DVT	7(1.2%)	5(1.0%)	P=0.56
Urinary tract infection	11(2.0%)	4(0.8%)	P=0.07
Hypoalbuminemia	267(50.4%)	242(45.7%)	P=0.12
Server hypoalbuminemia	84(15.8%)	48(9.0%)	P<0.01*
Albumin infusion	152(28.6%)	39(7.4%)	P<0.01*
Preoperative LOS(d)	5.7±0.8	5.5±0.7	P=0.32
Postoperative LOS(d)	9.5±1.7	8.0±1.5	P<0.01*
Rate of readmission	34(6.4%)	10(1.9%)	P<0.01*
Discharge to rehabilitation centre,n(%)	22(4.2%)	5(1.0%)	P<0.01*

SSI: surgical site infection; DVT:deep venous thrombosis; LOS: the length of stay

The Los And 90-day Readmission

The preoperative LOS was similar between two groups, the average postoperative LOS in ERAS group was 8.0 d, compared with 9.5d in non-ERAS group, $p<0.01$. Compared with the control group, the ERAS group had a lower rate of readmission within 90 days (1.9% vs 6.4%, $p<0.01$). Additionally, ERAS group had a lower rate of discharge to rehabilitation center (4.2% vs 1.0%, $p<0.01$).

Disscusion

Wound complications had been reported as the risk factors for prolonged LOS and more hospitalization cost[2, 9, 16]. In addition to avoiding implant device-associated infections, perioperative management and nutritional support were also important to minimize wound complications. In present study, we identified that our ERAS pathway was associated with a lower incidence of wound complications including SSI, wound dehiscence and persist wound drainage. Additionally, we found that patients receiving the ERAS care had a lower rate of sever postoperative hypoalbuminemia without increasing the albumin transfusion. Patients in ERAS group had shorter LOS and a lower rate of readmission, this result was consistent with previous studies.

Despite great advances in antibiotics and surgical instruments over the past few decades, wound healing following PLF surgery still remains a challenging clinical problem. Many studies were conducted to discuss the risk factors and treatment for postoperative SSI[7, 13], however, few literature reporting other wound problem including wound drainage and wound dehiscence which might also contribute to a reduction of satisfaction were found. In present study, the rates of wound dehiscence and persist wound drainage were 4.5% and 6.7%, which was higher than the rate of postoperative SSI. Persist wound drainage and wound dehiscence might be early symptom of infection and they could create a humid environment for the growth of bacteria. Equal attention should be pay to patients with non-infection wound complications.

As a multidisciplinary and multifaceted perioperative care pathway, ERAS protocol consists of preoperative, intraoperative and postoperative interventions which may help to reduce the effect of those risk factors on adverse events[12, 17]. To the best of our knowledge, this is the first study to evaluate the impact of ERAS pathway on wound complications in Asian patients. Although no significant difference was observed in SSI and wound drainage, we found that the implement of ERAS was beneficial in reducing the incidence of wound complications in patients underwent PLF surgery, especially wound dehiscence.

Several possible reasons may explain our finding. First, previous studies had proved that perioperative malnutrition and hypoalbuminemia were independent risk factors for postoperative SSI and nutrition is a key player at each of the wound healing steps (haemostasis, inflammatory, proliferative and remodelling phase)[5, 18], in present study, the patients in ERAS group had a lower incidence of server postoperative hypoalbuminemia which may result from the nutrition support and early rehabilitation of digestive

function[19]. Xu et al.[10] conducted a prospective randomized controlled trial and also found that perioperative multimodal nutritional management effectively reduced albumin infusion and incidence of wound drainage.Second, preoperative education on smoking and optimization of chronic disease may contribute to the reduction of wound complications. Pirkle et al[16]. retrospectively reviewed an PearlDiver national insurance claims database of 12519 patients undergoing lumbar fusion surgery and found that diabetes was an independent factor for wound infection after single and multi-level fusion surgery. In a systematic review and meta-analysis of 107 studies, preoperative smoking was found to be associated with an increased risk of the wound complications[20]. More efforts were needed to identify the effect of preoperative interventions on postoperative complications by conducting prospective randomized controlled studies. At last, prolonged drain duration also was proved to be associated with higher incidence of wound infection in patients with lumbar spinal fusion surgery[7]. In present study, patients in EARS group were recommended to remove drain on postoperative day 1and postoperative day 2.

With regard to other complications, a high rate of postoperative hypoalbuminemia was observed in our study population, with nearly one in every two patients had postoperative hypoalbuminemia or server hypoalbuminemia, a lower rate of server hypoalbuminemia was observed in ERAS group compared with non-ERAS group. Avoiding mechanical bowel preparation and early postoperative enteral nutrition relieve irritation of the gastrointestinal tract and facilitate the recovery of gastrointestinal motility[21, 22], These measures may help to improve nutrition and less patients developed server hypoalbuminemia(serum albumin <30g/L) in ERAS group. However, the incidence of hypoalbuminemia(serum albumin <35g/L)was similar between groups, more effective perioperative nutritional support protocol was needed to improve nutritional status. Additionally, a trend toward the lower rate of urinary tract infection in ERAS group was observed(p=0.07), although there was no statistical significance, the potential association may be detected in a long-term studies with larger sample sizes. Moreover, the implement of ERAS pathway did not increase the risk of cardiovascular complications, acute cerebral infarction and local haematoma, which were consistent with previous studies on ERAS pathway[23, 24].

In present study, although the preoperative LOS was similar between two groups, the postoperative LOS decreased from 9.5 days in the non-ERAS group to 8.0 days in the ERAS group. We did not evaluate the effect of ERAS on postoperative LOS for short-segment and long-segment fusion surgery separately, but previous studies had reported that patients in the ERAS group had significantly shorter LOS compared with non-ERAS group after short lumbar fusion and long segment deformity surgery[17, 25]. A lower rate of 90-day readmission was also observed in ERAS group, this result was consistent with previous retrospective study of 124 patients conducted by Adeyemo et al[12].Postoperative multidisciplinary care and multimodal pain control may contribute the lower incidence of readmission for postoperative complications and transferring to rehabilitation center.

However, this study had several limitations. First, it was a single-center study so that patients included in our study were only from our institution, and the variables data were only acquired from our electronic medical records, we couldn’t avoid the loss of part information, for example, the total costs and patient satisfaction. Also, the primary outcome of our study was the incidence of wound complications within

90-day, despite our efforts to identify wound problems, some minor wound complications may still be overlooked. Moreover, the compliance with ERAS protocol was associated with postoperative outcomes, but due to the lack of standardized perioperative management pathway, it was difficult to evaluate the compliance with ERAS program of patients in non-ERAS group, and efforts are needed to maximize compliance with specific enhanced recovery pathway standards.

Conclusion

In this prospective cohort study, we found that ERAS pathway may help to decrease the rates of postoperative wound complications and server hypoalbuminemia following PLF surgery, but our ERAS pathway did not seem to reduce rate of other complications, more effective interventions were needed to improve postoperative nutrition. Additionally, we demonstrated that ERAS pathway was also associated with shorter LOS and lower rate of readmissions within 90-day.

Abbreviations

PLF,posterior lumbar fusion; ERAS, enhanced recovery after surgery; SSI, surgical site infection;LOS, the length of stay; BMI,body mass index;POD1,postoperative day 1;POD2,postoperative day 2;POD3,postoperative day 3; DVT: deep venous thrombosis; EBL:estimated blood loss.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethical committee for human subjects of the Xuanwu Hospital of Capital Medical University(permit data 2018.4.3; no. 2018086)

Consent for publication

We obtained permission from the participants to publish their data.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no financial and non-financial competing interests.

Funding

No funding was received.

Authors' contributions

Shuaikang Wang, Peng Wang and Shibao Lu designed the experiments. Shuaikang Wang and Peng Wang performed the experiments. Xiangyu Li and Wenzhi Sun reviewed and analyzed the data. Shuaikang Wang wrote the paper. Shibao Lu revised the manuscript. All authors reviewed the manuscript.

Acknowledgements

Not applicable.

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Figures

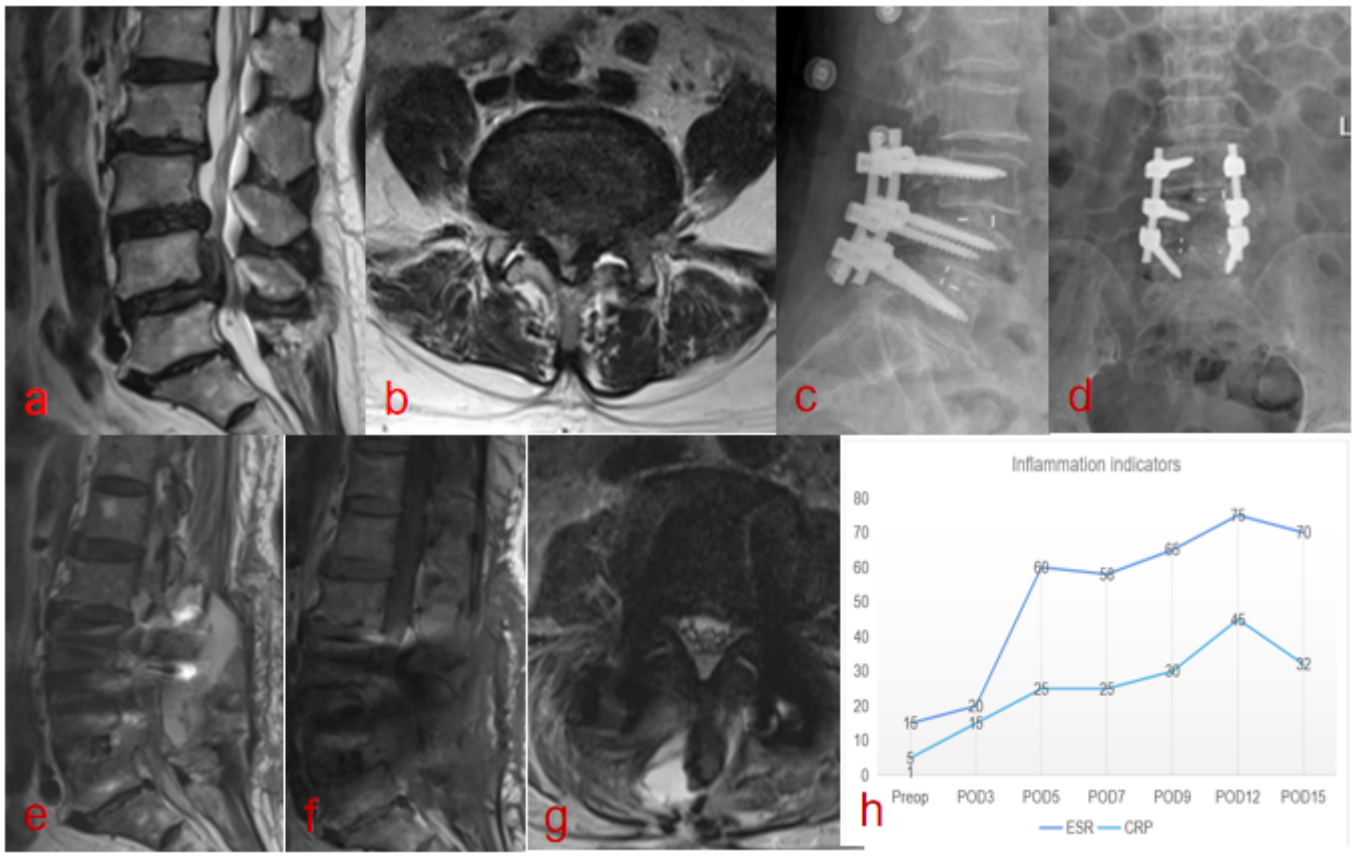

Figure 1

A 57-year-old male patient with postoperative surgical site infection. **a,b** lumbar MRI showed preoperative disk herniation and spinal canal stenosis. **c,d** lumbar postoperative X ray showed satisfactory position of screw and cage. **e,f** on the 4th day after surgery, T2WI sagittal plane and cross-sectional plane showed mixed high and equal signals and **g** T1WI showed a low signal in the deep incision. **h** serum C-reactive protein (CRP) level and erythrocyte sedimentation rate increase sharply from postoperative day 3. The SSI was confirmed by her complaint of localized pain,symptoms of fever, imaging test and laboratory.

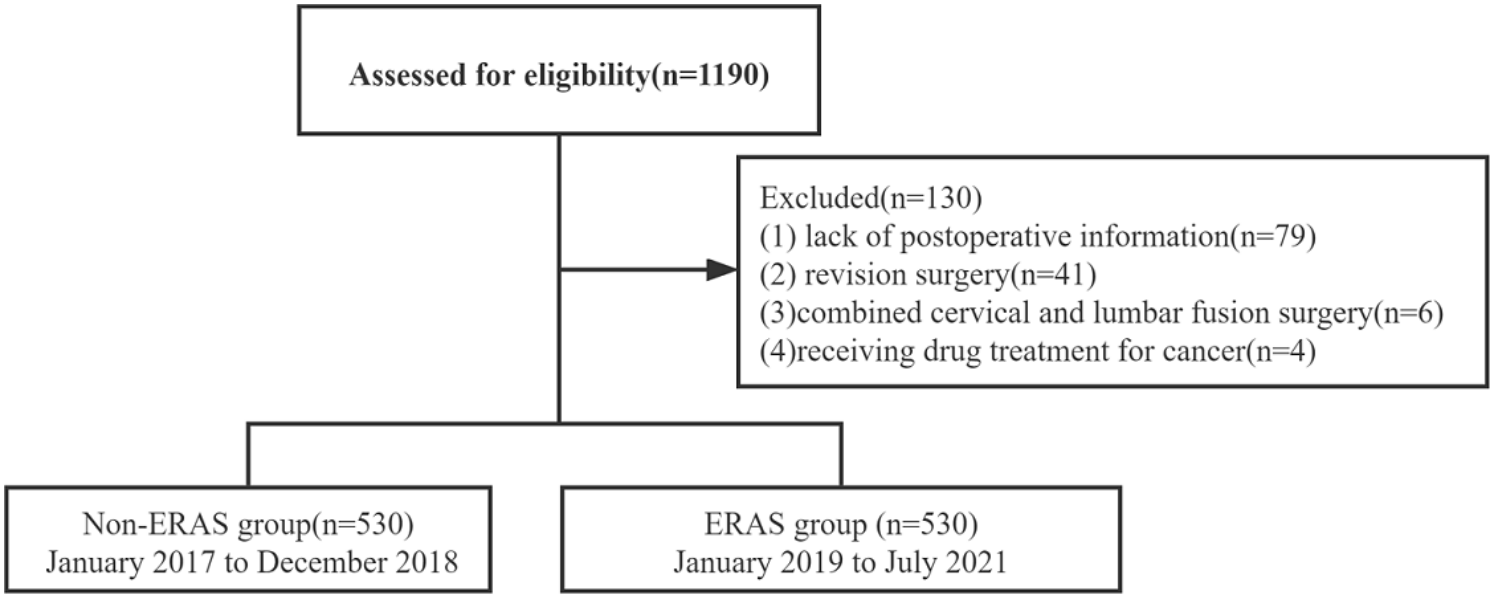

Figure 2

The study flowchart