The Potential Risk Factors for Prolonged Length of Stay Despite an Enhanced Recovery After Surgery Protocol for Elderly Patients Undergoing Short-Level Lumbar Fusion Surgery

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Abstract

Objective: To identify the risk factors associated with prolonged length of stay (LOS) despite an enhanced recovery after surgery (ERAS) protocol in short-level lumbar fusion surgery. Methods: We gathered data for all patients undergoing short-level lumbar fusion surgery from January to November 2021. Given the discharge criteria, a threshold was set according to mean LOS, and two groups were spontaneously formed: LOS shorter than the threshold for discharge (control group, n = 114) and LOS longer or equal to the threshold for discharge (delayed group, n = 72). Preoperative metrics were compared to identify risk factors associated with prolonged LOS. Results: A total consecutive 186 patients with complete medical records were enrolled (77 males and 109 females; mean age 71.08 ± 5.70 years). After dichotomization according to the threshold for discharge, there were 114 patients in control group and 72 in delayed group. Statistical analysis demonstrated that age ≥75 years (P = .002), female sex (P < .001), American Society of Anesthesiologists grade ≥3 (P = .035), operation time (P < .001), anesthesia time (P < .001), ambulation time >1 day (P = .027), removal of urinary catheter time >1 day (P = .019), fusion levels (P < .001), Clavien-Dindo grade > 1 (P < .001) and allogeneic transfusion (P = .009) were significantly related to prolonged LOS. Binary logistic regression revealed that age ≥75 years old, female sex and Clavien-Dindo grade >1 were independent risk factors of prolonged LOS. Conclusions: In this retrospective study, we analyzed the potential risk factors associated with delayed LOS despite implementing ERAS, further, binary logistic regression exhibited that age ≥75 years old, female sex and Clavien-Dindo grade >1 were independently correlated with prolonged LOS.

Keywords: Independently, compliance, lumbar fusion surgery, enhanced recovery after surgery, length of stay

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Introduction

Kehlet proposed enhanced recovery after surgery (ERAS) in 1997, which provides a multimodal, multidisciplinary management strategy. The primary purpose of ERAS is to reduce postoperative adverse events and accelerate recovery by decreasing stress responses, shortening the length of stay (LOS) and hospitalization costs. Compared with conventional perioperative care, ERAS has demonstrated its superiority in reducing postoperative complications and LOS. While ERAS has been widely applied in many surgical fields, its use in spine surgery is in an early stage.

Although there is a reduction in LOS and lower complication rates, specific patients cannot be discharged as quickly as expected despite ERAS, demonstrating that there were potential risk factors related to prolonged LOS. Hence, it is critical to elucidate the risk factors and implement customized perioperative management strategy. Previous studies reported satisfactory results after implementing ERAS in spine surgery; however, few studies report the risk factors correlated with prolonged LOS despite ERAS for short-level lumbar fusion surgery. Therefore, this study aimed to identify the perioperative prognostic risk factors associated with prolonged LOS and to identify customized prophylaxis protocols to facilitate function recovery and earlier discharge.

Patients and Methods

Study Design

This was a retrospective study. ERAS was implemented in January 2019. Since then, the protocol has been a part of routine perioperative care protocol in our center. The detailed information of our ERAS items is displayed in Table 1. Most of the elements follow recently published ERAS society recommendations in lumbar fusion surgery. A period from January to December 2021 was selected, and inclusion criteria were as follows: 1) lumbar disk herniation, lumbar spinal stenosis, and lumbar spondylolisthesis according to radiographic examination and magnetic resonance imaging by two experienced surgeons; 2) no history of spine surgery; 3) age greater than 65 years; and 4) short-level lumbar fusion surgery, defined as the number of fusion levels no more than two. The exclusion criteria were 1) emergency operation; 2) lack of clinical data; 3) combined surgery. Ultimately, 186 consecutive patients were recruited. And all of these patients were strictly followed the same discharge criteria published by our department previously: no clinical complications; visual analog scales < 3 with oral analgesics; independent ambulation or ambulation with minimal assistance; absence of fever in the last 48 hours. The collected preoperative clinical data included age, sex, body mass index (BMI), smoking status, concomitant diseases, American Society of Anesthesiologists (ASA) grade, preoperative albumin, and hemoglobin levels, operation time, anesthesia time, estimated blood loss (EBL), and need for allogeneic transfusion. Postoperative complications (nausea and vomiting, electrolyte imbalance, urinary retention, deep venous thrombosis, postoperative hypoproteinemia, surgical site infection, and myocardial ischemia), LOS, urinary catheter extraction time, and mobilization time were also extracted. Patient baseline characteristics are displayed in Table 2. Given one person could have more than one postoperative complications, and to simplify the impact of complications on LOS, the Clavien-Dindo Classification of Surgical Complications was utilized. According to the discharge criteria, in order to identify the potential risk factors for prolonged LOS, a threshold was set according to mean LOS, and two groups were spontaneously formed: LOS shorter than the threshold for discharge (control group, n = 114) and LOS longer or equal to the threshold for discharge (delayed group, n = 72). Then preoperative factors (age, sex, BMI, smoker, ASA, preoperative albumin level and hemoglobin level), intraoperative data (EBL and perioperative transfusion), and postoperative indexes (urinary catheter extraction time, mobilization time and Clavien-Dindo grade) were dichotomized as follows: age 75 years, BMI (18.5-24 kg/m², and < 18.5 kg/m² or ≥ 24 kg/m²), ASA ≥ 3 or < 3, preoperative albumin (≥ 35 or < 35 g/L), hemoglobin level (normal: > 120 g/L in males and > 110 g/L in females or abnormal), ambulation time (≤ 1 or > 1 day), removal of urinary catheter time (≤ 1 or > 1 day), Clavien-Dindo grade (≤ 1 or > 1), smoking (Yes or No) and allogeneic transfusion (Yes or No). EBL, operation time, and anesthesia time were treated as continuous variables. Univariate analysis was performed to identify the risk factors resulting in prolonged LOS. Multivariate analysis was performed to determine the independent risk factors associated with prolonged LOS for the significant factors.

Statistical Analysis

Continuous variables were expressed as mean value ± standard deviation for normally distributed data. For non-normally-distributed data, the median and interquartile range was used. Categorical variables were expressed using proportions. Continuous variables were analyzed using the two-sample T-test, while statistical analysis for categorical variables was performed using the Chi-square test or the Fisher exact test. Binary logistic regression for multivariate analysis was used to identify the independent risk factors of prolonged LOS. All statistical analyses were performed using SPSS software version 25.0 (SPSS, Inc,
Table 1. Enhanced Recovery After Surgery Items for Short Level Lumbar Fusion Surgery.

| Preoperative | Intraoperative | Postoperative |
|--------------|---------------|--------------|
| Education and counseling | Antibiotic prophylaxis within 1 hour of incision | Antithrombotic prophylaxis |
| Preoperative nutritional | Used routinely | Early oral feeding |
| Cessation of smoking and alcohol | Multimodal analgesia: TIVA-based anesthetic technique with propofol, lidocaine, ketamine, ketorolac, antiemetics and with up to .5% MAC inhaled anesthetics, avoid N2O; depth of anesthesia monitoring | Multimodal analgesia |
| Anemia management | Standard anesthetic protocol | Nausea and vomiting prophylaxis |
| Fasting | Maintenance of normothermia | Encourage patients to ambulate as early as possible |
| Preanesthetic medication | Local infiltration analgesia | | |
| | Fluid management | Removal of bladder catheter on POD 1 | Consider to remove bladder catheter within 24 hours in short level lumbar fusion surgery |

Armonk, NY, USA), and P-values <.05 were considered statistically significant.

Results

Demographic Data

A total consecutive 186 patients were enrolled (77 males and 109 females; mean age 71.08 ± 5.70 years; mean BMI 25.65 ± 3.63 kg/m²; operation time and anesthesia time were 187.61 ± 55.94 mins and 246.88 ± 58.35 mins, respectively). There were 84 patients with one fusion level and 102 patients with two fusion segments. The mean EBL was 247.43 ± 199.20 mL. Twenty-eight received an allogeneic transfusion. There were 22 patients with preoperative albumin levels lower than 35 g/L and 13 patients with preoperative hemoglobin levels lower than the standard value, respectively. The preoperative Oswestry disability index was 52.68 ± 3.12, and the preoperative visual analog scale for back and leg were 5.04 ± 1.48 and 5.63 ± 1.53, respectively. The detailed demographic data are displayed in Table 2.

After dichotomization according to the threshold for discharge, there were 25 (21.9%) patients aged 75 years or older in control group with 46.5% being female and 31 (43.1%) patients in delayed group with 77.8% being female, respectively. In control group, the mean operation and anesthesia times were 175.47 ± 48.99 mins and 233.91 ± 51.37 mins, respectively, and in delayed group they were 206.84 ± 61.00 mins and 267.41 ± 63.05 mins, respectively. There were 80 (70.2%) patients ambulating and 88 (77.2%) patients who had the urinary catheter removed on postoperative day (POD) 1 in control group while 39 (54.2%) and 44 (61.1%) patients in delayed group, respectively. There were no significant difference in preoperative functional status between groups. The characteristics of these groups are detailed in Table 3.

Compliance With the ERAS Protocol

Compliance was recorded as the number of achieved items by trained nurses and the compliance rate was defined as the number of program items observed divided by the total number of items. According to previous studies, higher
compliance with ERAS protocols yields better outcomes.\textsuperscript{14,16} In the present study, the overall compliance with the ERAS pathway was 92.1\% (Table 4). The items with lower compliance were ambulation on POD 1 (63.9\%) and removal of bladder catheter on POD 1 (70.9\%). After dichotomization according to the threshold for discharge, the compliance of ambulation and removal of bladder catheter on POD 1 in control group was 70.2\% (n = 80) and 77.2\% (n = 88), respectively while in delayed group, they were 54.1\% (n = 39) and 61.1\% (n = 44), respectively (Table 3).

### Table 2. Baseline Characteristics of all Patients (n = 186).

| Variable                                  | n    | %    |
|-------------------------------------------|------|------|
| Age, years                                | 71.08 ± 5.70 |
| Sex                                       |      |      |
| Female                                    | 109  | 58.6 |
| Male                                      | 77   | 41.3 |
| BMI, kg/m\^2                              | 25.65 ± 3.63 |
| Smoker                                    | 29   |      |
| Operation time, min                       | 187.61 ± 55.94 |
| Anesthetic time, min                      | 246.88 ± 58.35 |
| EBL, ml                                   | 247.43 ± 199.20 |
| Allogenic transfusion                     |      |      |
| Yes                                       | 28   | 15.1 |
| No                                        | 158  | 84.9 |
| ASA                                       |      |      |
| <3                                        | 93   | 50.0 |
| ≥3                                        | 93   | 50.0 |
| LOS, day                                  | 7.16 ± 2.83 |
| Preoperative albumin level, g/L            | 38.14 ± 3.02 |
| Preoperative hemoglobin level, g/L         | 132.26 ± 15.30 |
| Concomitant diseases                      |      |      |
| Hypertension                              | 121  | 65.1 |
| Diabetes                                  | 58   | 31.2 |
| Cardiovascular system disease             | 36   | 19.4 |
| Gastrointestinal                          | 9    | 4.8  |
| Osteoporosis                              | 30   | 16.1 |
| Fusion levels                             |      |      |
| 1                                         | 84   | 45.2 |
| 2                                         | 102  | 54.8 |
| Postoperative complications               |      |      |
| Nausea and vomiting                       | 14   | 7.5  |
| Electrolyte imbalance                     | 19   | 10.2 |
| Postoperative hypoproteinemia             | 123  | 66.1 |
| Urinary retention                         | 1    | 0.5  |
| Urinary tract infection                   | 3    | 1.6  |
| Deep venous thrombosis                    | 8    | 4.3  |
| Surgical site infection                   | 13   | 7.0  |
| Myocardial ischemia                       | 13   | 7.0  |
| Preoperative ODI,%                        | 52.68 ± 13.12 |
| Preoperative VAS (back)                   | 5.04 ± 1.48 |
| Preoperative VAS (leg)                    | 5.63 ± 1.53 |

### Risk Factors for Prolonged LOS

There were 72 patients whose LOS was longer or equal to the threshold for discharge. Age ≥ 75 years (P = .002), female sex (P < .001), ASA ≥ 3 (P = .035), operation time (P < .001), anesthesia time (P < .001), ambulation time > 1 day (P = .027), removal of the urinary catheter time > 1 day (P = .019), Clavien-Dindo grade > 1 (P < .001), and allogenic transfusion (P = .009) were significantly related to prolonged LOS. Multivariate logistic regression revealed that age older than 75 years (odds ratio (OR) 5.149; 95\% confidence interval (CI) 2.045-12.966, P = .001), female (OR 5.185, 95\% CI 2.183-12.317, P < .001) and Clavien-Dindo grade > 1 (OR 15.936, 95\% CI 5.220-48.652, P < .001) were independent risk factors for prolonged LOS (Table 5).

### Discussion

Substantial attention has been paid to the effects of compliance with ERAS and the reduction of LOS.\textsuperscript{17-19} To our knowledge, few studies are focusing on the risk factors associated with prolonged LOS in short-level lumbar fusion surgery despite the implementation of ERAS protocol. In our study, we found that age ≥ 75 years, female sex, ASA ≥ 3, operation time, anesthesia time, delayed postoperative ambulation, prolonged removal of urinary catheter, Clavien-Dindo grade > 1 and allogenic transfusion were associated with prolonged LOS. Multivariate logistic regression revealed that age, female sex and more severe postoperative complications were independently related to prolonged LOS in short-level lumbar fusion surgery, following a previous study to some extent.\textsuperscript{20,21} Regarding other risk factors, a rational interpretation for such an outcome was the distribution differences in the number of fusion levels. There were 51 (27.4\%) patients with two fusion segments in control group and 51 (70.8\%) patients in delayed group, leading to different operation and anesthesia times and the number of patients undergoing allogenic transfusion.

In a retrospective cohort study, Li et al showed elderly patients with comorbidities are at a higher risk for complications after lumbar spine surgery.\textsuperscript{20} Analogously, in a retrospective analysis of 585 patients who underwent lumbar spine surgery, Kanaan et al found male patients walked significantly longer distance than female patients, although clinically insignificant.\textsuperscript{22} In our study, we found that age older than 75 years and females were independently related to prolonged LOS despite ERAS, which reminds us of the importance of age and gender on postoperative complications, and more attention should be
paid to these patients in perioperative management to prevent postoperative complications.

The increasing proportion of the aging population is generally associated with comorbidities and the postoperative complication rate following lumbar fusion surgery. ERAS results in shorter LOS and fewer postoperative complications than conventional perioperative care. Although ERAS has been widely applied in other surgical fields, its implementation in spine surgery, though promising, is still in the early stages. In a retrospective propensity score matching, D’Astorg et al revealed that the ERAS protocol decreased the hospital LOS (2.6 vs 4.4 days, \( P < .0001 \)), while postoperative complications were similar in two groups. In current study, according to Clavien-Dindo

### Table 3. Risk Factors for Prolonged Length of Stay.

| Variable                        | Control group (n = 114) | Delayed group (n = 72) | \( p \) |
|---------------------------------|------------------------|------------------------|------|
| Age, years                      |                        |                        |      |
| <75                             | 89                     | 41                     | .002 |
| \( \geq 75 \)                   | 25                     | 31                     |      |
| Sex                             |                        |                        | .000 |
| Female                          | 53                     | 56                     |      |
| Male                            | 61                     | 16                     |      |
| ASA                             |                        |                        | .035 |
| <3                              | 64                     | 29                     |      |
| \( \geq 3 \)                    | 50                     | 43                     |      |
| BMI, kg/m\(^2\)                 |                        |                        | .264 |
| 18.5-24                         | 44                     | 22                     |      |
| \( <18.5 \) or \( >24 \)       | 70                     | 50                     |      |
| Operation time, min             | 175.47 ± 48.99         | 206.84 ± 61.00         | .000 |
| Anesthesia time, min            | 233.91 ± 51.37         | 267.41 ± 63.05         | .000 |
| Preoperative albumin level, g/L |                        |                        | .104 |
| \( \geq 35 \)                   | 104                    | 60                     |      |
| \( <35 \)                       | 10                     | 12                     |      |
| Preoperative hemoglobin level, g/L |                    |                        | .245 |
| Normal                          | 108                    | 65                     |      |
| Abnormal                        | 6                      | 7                      |      |
| Ambulation time, days           |                        |                        | .027 |
| \( \leq 1 \)                    | 80                     | 39                     |      |
| \( >1 \)                        | 34                     | 33                     |      |
| Removal urinary catheter time, days |                   |                        | .019 |
| \( \leq 1 \)                    | 88                     | 44                     |      |
| \( >1 \)                        | 26                     | 28                     |      |
| Smoker                          |                        |                        | .356 |
| Yes                             | 20                     | 9                      |      |
| No                              | 94                     | 63                     |      |
| Allogenic transfusion           |                        |                        | .009 |
| Yes                             | 11                     | 17                     |      |
| No                              | 103                    | 55                     |      |
| Fusion levels                   |                        |                        | .000 |
| 1                               | 63                     | 21                     |      |
| 2                               | 51                     | 51                     |      |
| Clavien-Dindo grade             |                        |                        | .000 |
| \( \leq 1 \)                    | 105                    | 43                     |      |
| \( >1 \)                        | 9                      | 29                     |      |
| Preoperative ODI,%              | 51.04 ± 11.58          | 53.51 ± 13.15          | .412 |
| Preoperative VAS (back)         | 4.89 ± 1.78            | 5.48 ± 1.57            | .114 |
| Preoperative VAS (leg)          | 5.56 ± 1.68            | 5.89 ± 1.87            | .786 |

LOS: length of stay; ASA: American Society of Anesthesiologists grade; BMI: body mass index; ODI: Oswestry Disability Index; VAS: visual analog scale.
complication grade, we found patients with delayed LOS had more severe postoperative complications \((P < .001, \text{Table 3})\), and Clavien-Dindo grade > 1 was independently correlated with prolonged LOS (Table 5). What’s more, it is worth noting that despite meticulous preoperative nutritional care and early oral feeding, there were 123 patients with postoperative hypoproteinemia (Table 2). According to previous studies, preoperative nutritional status is critical for recovery after major surgery and correlated with postoperative complications and prolonged LOS,\textsuperscript{27,28} therefore, it is essential to take additional measures to prevent severe postoperative hypoproteinemia.

Table 4. Compliance to Enhanced Recovery After Surgery Pathway.

| Variable | n(%) |
|----------|------|
| Preoperative | |
| Education and counseling | 180(96.8%) |
| Preoperative nutritional | 164(88.2%) |
| Cessation of smoking and alcohol | 186(100%) |
| Anemia management | 173(93.1%) |
| Fasting | 186(100%) |
| Preanesthetic medication | 186(100%) |
| Intraoperative | |
| Tranexamic acid | 186(100%) |
| Standard anesthetic protocol | 186(100%) |
| Maintenance of normothermia | 186(100%) |
| Fluid management | 186(100%) |
| Local infiltration analgesia | 186(100%) |
| Antimicrobial prophylaxis | 180(96.8%) |
| Postoperative | |
| Ambulation on POD 1 | 119(63.9%) |
| Nausea and vomiting prophylaxis | 176(94.6%) |
| Early oral feeding | 162(87.1%) |
| Multimodal analgesia | 138(74.2%) |
| Antithrombotic prophylaxis | 171(91.9%) |
| Removal of bladder catheter on POD 1 | 132(70.9%) |
| Overall compliance | 92.1% |

Patients must actively participate in ERAS programs even though there may be reduced compliance with specific ERAS items.\textsuperscript{7} In our study, the items with lower compliance were ambulation on POD 1 (63.9%) and removal of bladder catheter on POD 1 (70.9%). Previously, because of the reduction of bladder function and the longer functional recovery of spine surgery, few studies explicitly illustrated the time of ambulation and removal of a bladder catheter and only stressed the concept of early ambulation and early removal of the bladder catheter.\textsuperscript{29,30} Given the adverse events associated with prolonged bed rest and the importance of early ambulation in reducing LOS,\textsuperscript{29,31} attention should also be paid to adverse events related to prolonged urinary drainage (urinary tract infections and surgical site infections).\textsuperscript{32,33} In a before and after cohort study on elderly patients who underwent elective spine and peripheral nerve surgery, Ifrach et al\textsuperscript{34} showed improved mobilization and ambulation on POD 0 in ERAS group, and proved the safety and feasibility of early mobilization and ambulation in this population. In the present study, patients were explicitly requested to ambulate and remove the bladder catheter on POD 1 unless there were contraindications. Only one patient developed urinary retention (Table 2) in 132 patients (Table 3) who had the bladder catheter removed on POD 1, and there were no adverse events associated with early mobilization.

The present study has several limitations. First, this was a monocentric, retrospective study, and there were some offsetting and confounding factors. Second, the small sample size limits the robustness of our findings. Thirdly, due to the characteristic of spine surgery, the severe stress response and longer functional recovery, and the feature of the elderly population, patients with more than two fusion levels were excluded. This decision may have introduced selection bias. Finally, the imbalance of distribution of fusion levels between two groups may be the results of current study, hence, studies with comparable fusion levels are needed to further explore the risk factors associated with prolonged LOS.

Table 5. Multivariate Logistic Regression Analysis of Factors Associated with Prolonged Length of Stay.

| Variable | B   | OR(95%CI)   | p   |
|----------|-----|-------------|-----|
| Operation time | .011 | 1.009(953-1.027) | .576 |
| Anesthesia time | .018 | 1.018(982-1.056) | .339 |
| Female | 1.646 | 5.185(2.183-12.317) | .000 |
| Age | 1.639 | 5.149(2.045-12.966) | .001 |
| ASA | .199 | 1.119(345-1.945) | .651 |
| Allogeneic transfusion | .635 | 1.888(696-5.118) | .212 |
| Fusion level | .517 | 1.678(665-4.232) | .273 |
| Delayed ambulation | .184 | 1.202(502-2.881) | .680 |
| Clavien-Dindo grade | 2.769 | 15.936(5.220-48.652) | .000 |
| Delayed removal of urinary catheter | .486 | 1.625(654-4.038) | .295 |
Conclusion

In this retrospective study, we analysed the potential risk factors associated with delayed LOS despite implementing ERAS, further, binary logistic regression exhibited that age ≥75 years old, female sex and Clavien-Dindo grade >1 were independently correlated with prolonged LOS.

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Declaration of Conflicting Interests

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Ethical Approval

The institutional review board in Xuanwu Hospital Capital Medical University approved the study (No. 2018086), which followed the Declaration of Helsinki principles.

Informed Consent

A written informed consent was obtained from all participants of this study.

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