

Impact of Compliance with an Enhanced Recovery After Surgery Program on the Outcomes Among Elderly Patients Undergoing Lumbar Fusion Surgery

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Background and Aim: The benefits of the enhanced recovery after surgery (ERAS) program to elderly patients have not been evaluated in lumbar fusion surgery. Compliance with the ERAS program is associated with prognosis. There is currently no adequate assessment about the importance of the individual components of ERAS program in lumbar fusion surgery. The aim of the study was to analyze the effect of compliance with our ERAS program and the relative importance of the individual ERAS program components among elderly patients undergoing lumbar fusion surgery.

Methods: A retrospective case-review study was conducted from March 2018 to March 2020. The ERAS program for lumbar fusion surgery at our department was implemented. Overall compliance was found to be 92.9%, and this was used as a cutoff for dividing patients into higher compliance and lower compliance groups. Patient characteristics and clinical outcomes were compared between groups.

Results: The overall compliance rate was 92.9%, distributing 91 patients into the higher compliance group and 169 patients into the lower compliance group. Patients with higher compliance were younger ($p=0.045$). The length of stay (LOS) of patients with higher compliance was significantly shorter than that of patients with lower compliance. Patients with higher compliance had significantly fewer complications ($p=0.031$). A multivariate analysis showed that surgical time ($p=0.029$), lower compliance ($p=0.034$), and early oral feeding ($p=0.026$) were predictors of any postoperative complications. On multivariate analysis, the following items remained correlated with prolonged LOS (LOS \geq 12 days): older age ($p=0.010$), lower compliance ($p<0.0001$), early ambulation ($p=0.018$), and stick to discharge criteria ($p=0.040$).

Conclusion: Low compliance with ERAS program among elderly patients undergoing lumbar fusion surgery was associated with a higher incidence of complications and prolonged LOS. The failure of early oral feeding was associated with increased complications, and the failure of early ambulation or sticking to discharge criteria was significantly more influential on prolonged LOS.

Keywords: compliance, elderly, enhanced recovery after surgery; ERAS, lumbar fusion surgery

Introduction

Enhanced recovery after surgery (ERAS) program is an evidence-based method that is focused on improving postoperative recovery.^{1,2} It was originally developed based on a study in elderly patients undergoing colon surgery, and has since been implemented in several other surgical areas. More recently the ERAS program was proven to be feasible and efficacious in reducing complications and length of stay (LOS) after lumbar fusion surgery.^{3,4}

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The number of elderly patients who need to undergo lumbar surgery has significantly increased. However, the postoperative complications are more prevalent in this patient group, and have long been the main causes of prolonged LOS and increased care costs.⁵ Enhancing the perioperative management and reducing peri-operative stress can be a cost-effective way to improve the safety in elderly patients.⁶

An ERAS program encompasses many elements from initial patient referral through discharge. The overall benefits can be attributed to the aggregation of marginal gains of each components.⁷ From the very beginning the ERAS program was designed with an emphasis on elderly patients as the target group.¹ The application of the ERAS program can minimize the stress responses to support recovery, which is particularly important for the vulnerable elderly patients with co-morbidities.⁸ Although benefits of the ERAS program to elderly patients have been reported in several types of surgeries, similar evaluation has not been extended to lumbar fusion surgery.

One of the confounding factors for accurate assessment of the ERAS program in elderly patients is compliance with the care protocols. It has been reported that compliance with the ERAS program is strongly associated with prognosis.^{6,9} While strict compliance with ERAS protocols is more difficult for all elderly patients in general, it might be particularly challenging for those undergoing lumbar fusion surgery. The requirement for active participation in the program may be considered as too aggressive by this patient group.¹⁰ Therefore further studies are required to assess the compliance with ERAS program in this particular population.¹⁰

The importance of the individual components of ERAS program in colorectal surgery had been reported that the minimally invasive surgical technique and avoidance of fluid overload was associated with the prognosis.^{11,12} Although, there is currently no adequate assessment about the different importance of singular elements of ERAS program in lumbar fusion surgery.

The aim of the present study was to analyze the effect of compliance with our ERAS program and the relative importance of the individual ERAS program components on postoperative complications and LOS among elderly patients undergoing lumbar fusion surgery.

Table 1 Components of Our ERAS Program

ERAS Program	
Pre-operative	
Education	Including the purpose, workflows and benefits of ERAS program, anticipated postoperative pain and expectations and risks of surgery, through verbal and handouts
Nutritional counselling	Nutrition screening during the perioperative period, including nutrition screening tools and laboratory indicators. Dietitians provide personalized diet guidance and nutritional supplement to patients in need
Fasting	Clear fluids including carbohydrate drink allowed up to 2 hours before surgery
Antithrombotic prophylaxis	Active/passive limb movement and antithrombotic stockings
Antimicrobial prophylaxis	Antibiotic prophylaxis within 1 hour of incision
Intra-operative	
Tranexamic acid	Used routinely
Standard anesthetic protocol	Multimodal analgesia; TIVA-based anesthetic technique with propofol, lidocaine, ketamine, ketorolac, antiemetics and with up to 0.5% MAC inhaled anesthetics, avoid N ₂ O; depth of anesthesia monitoring
Avoidance of salt and water overload	Goal-directed euolemia
Maintenance of normothermia	Keeping core temperature at 36–37°C
Local infiltration analgesia	Used routinely
Post-operative	
Early ambulation	In-bed mobilization within 4 hours after surgery. Encourage ambulation after 4 hours, Early treatment with physical therapists
Early removal of bladder catheter	Remove the bladder catheter when returning to the ward
Early oral feeding	Oral feeding at will after recovery from anesthesia
Postoperative multimodal analgesia	Adequately controlled pain; visual analog scales <4: no analgesia or oral minimal dose of nonopioid; visual analog scales: 4–6: oral or intravenous nonopioid visual analog scales ≥ 7: opioid

(Continued)

Table 1 (Continued).

	ERAS Program
Stick to Discharge Criteria	Discharge Criteria: No clinical complications; visual analog scales <3 with oral analgesics; Independent ambulation or ambulation with minimal assistance; adequate nutrition intake; absence of fever in the last 48 hours

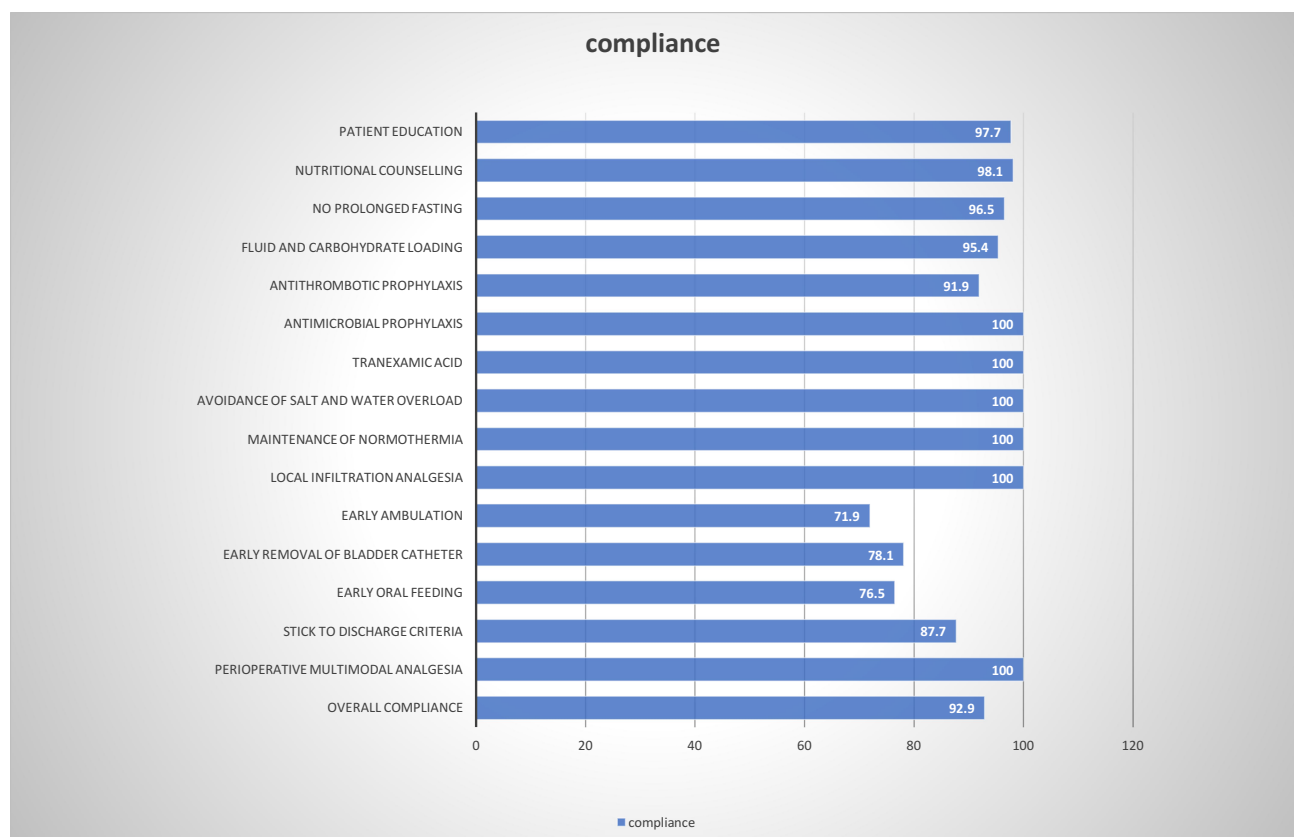
Abbreviations: TIVA, total intravenous anesthesia; MAC, minimum alveolar concentration.

Methods

Study Design

A retrospective case-review study was conducted in the department of orthopedics, Xuanwu Hospital Capital Medical University, also known as National Clinical Research Center for Geriatric Diseases, from March 2018 to March 2020. The ERAS program for posterior lumbar fusion surgery at our department was implemented in January 2018. For the reliability of the data, we started to record the data two months after the implementation of ERAS. Elderly was defined in our study as aged older than 65 years. The inclusion criteria

included patients older than 65 years who underwent open posterior lumbar fusion surgery with pedicle screw fixation. The main diagnosis was lumbar stenosis with instability, with some accompanied with scoliosis or spondylolisthesis. Exclusion criteria included the following: 1) loss of follow up; 2) circumferential fusion (a combination of anterior and posterior surgery); 3) a history of previous lumbar spine surgery; and 4) emergency operations. All patients underwent a standard mid-line posterior lumbar decompression and interbody fusion was preferred in the decompressed levels. All surgeries were performed by the same surgeon and the ERAS program was performed by the same group of trained anesthesiologists, surgeons and nurses. The ERAS program has been described in a previous publication by our group.¹³ The 15 components of our ERAS program are shown in Table 1. Compliance was recorded as the number of achieved items by dedicated staff who did not participate in the study and the compliance rate was defined as the number of program items observed divided by the total number of items. Overall compliance was found to be 92.9%, and this was used as

**Figure 1** Compliance rate to individual elements of the ERAS program.

a cutoff for dividing patients into higher compliance and lower compliance groups. During the study period, there were no major changes to the ERAS program at our department.

This study was approved by the institutional review board following the declaration of Helsinki principles in Xuanwu Hospital Capital Medical University (No. 2018008). All patients provided informed consent to the work.

Data Collection

Patient characteristics including age, gender, BMI, smoking status, comorbidities, American Society of Anesthesiologists (ASA) classification, preoperative Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) of back, VAS of leg, surgical level, surgical time and estimated blood loss were collected from all patients. We also recorded the clinical outcomes, including LOS, complications and 30-day readmission. LOS was defined as the time from admission to discharge recorded in the medical record. And we defined prolonged LOS as a LOS ≥ 12 days. Complications referred to all post-operative complications that occurred within 30 days after surgery and were determined by outpatient or follow-up doctors.

Statistical Analysis

Statistical analysis was performed using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean value \pm standard deviation (Mean \pm SD). Differences in mean values were tested with one-way analysis of variance and Student's *t*-test for normal data. Statistical analysis for categorical variable was performed by the Chi-square test. Univariate and multivariate logistic regression analyses for any complications and prolonged LOS were used to identify the influence of selected factors on clinical outcomes. *P* values < 0.05 were considered statistically significant.

Results

The compliance rates of ERAS items are shown in Figure 1. In general, the pre-operative and intra-operative ERAS items achieved significant compliance, whereas compliance of the postoperative ERAS items was relatively low: early ambulation (71.9%), early removal of bladder catheter (78.1%), early oral feeding (76.5%), stick to discharge criteria (87.7%). The overall compliance rate was 92.9%, distributing 91 patients into the higher compliance group ($>92.9\%$) and 169 patients into the lower compliance group ($\leq 92.9\%$).

Table 2 Patients' Characteristics

	Higher Compliance (>92.9)	Lower Compliance (≤ 92.9)	P value
Patients (n)	91	169	
Age, mean \pm SD	69.6 \pm 4.4	73.3 \pm 7.1	0.045
Gender			0.834
Male	40	72	
Females	51	97	
BMI	25.1 \pm 3.76	26.2 \pm 4.14	0.569
Smoker	9	14	0.664
Comorbidities			
Hypertension	48	79	0.356
Diabetes	36	55	0.258
Ischemic heart disease	12	15	0.277
Arrhythmias	5	5	0.310
Gastrointestinal	4	8	0.901
Chronic lung disease	5	6	0.458
Parkinson disease	2	4	0.931
Depression	6	7	0.387
ASA classification			0.936
I	2	5	
2	53	98	
3	36	66	
Preoperative ODI (%)	59.6 \pm 20.3	64.2 \pm 15.1	0.177
Preoperative VAS back	6.6 \pm 1.9	6.9 \pm 2.1	0.644
Preoperative VAS leg	7.78 \pm 2.0	7.60 \pm 2.3	0.738
Surgical level			0.062
I–2levels	65	101	
≥ 3 levels	26	68	
Surgical time, min	169.7 \pm 40.2	180.4 \pm 52.6	0.329
Estimated blood loss, mL	322.5 \pm 276.9	299.1 \pm 223.4	0.138

Abbreviations: ASA, American Society of Anesthesiologists; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

There were no statistical differences in gender ($p=0.834$), BMI ($p=0.569$), smoker ($p=0.664$), any comorbidities, ASA classification ($p=0.936$), preoperative ODI ($p=0.177$), preoperative VAS back ($p=0.644$), preoperative VAS leg ($p=0.738$), surgical level ($p=0.062$), surgical time ($p=0.329$) and estimated blood loss ($p=0.138$) between the two groups of patients. Notably, patients with higher compliance were younger (69.6 \pm 4.4 vs. 73.3 \pm 7.1 years, $p=0.045$). (Table 2).

The LOS of patients with higher compliance (11.8 \pm 4.5 days) was significantly shorter than that of patients with lower compliance (14.6 \pm 6.1 days). Patients with higher

Table 3 Logistic Regression for Any Complications

Characteristics	Univariable Analysis		Multivariable Analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
Age	1.10 (0.93–1.22)	0.248	1.89 (1.02–3.13)	0.029
Gender (Female)	0.83 (0.42–1.62)	0.576		
BMI	0.91 (0.88–1.25)	0.157		
Surgical level \geq 3	0.84 (0.42–1.68)	0.621		
ASA \geq 3	0.98 (0.49–1.95)	0.957		
Smoker	0.66 (0.23–1.89)	0.440		
Preoperative ODI (%)	0.82 (0.77–1.06)	0.127		
Preoperative VAS back	0.98 (0.88–1.14)	0.861		
Preoperative VAS leg	0.89 (0.74–1.30)	0.363		
Surgical time	1.96 (1.03–3.32)	0.023		
Estimated blood loss	1.03 (0.74–2.76)	0.694		
Lower compliance	2.47 (1.09–5.62)	0.031		
Patient education	0.91 (0.10–7.98)	0.930		
Nutritional counselling	0.72 (0.08–6.63)	0.774		
No prolonged fasting	0.62 (0.13–3.12)	0.566		
Fluid and carbohydrate loading	0.91 (0.19–4.29)	0.900		
Antithrombotic prophylaxis	1.10 (0.31–3.92)	0.884		
Antimicrobial prophylaxis	NA	NA		
Tranexamic acid	NA	NA		
Avoidance of salt and water overload	NA	NA		
Maintenance of normothermia	NA	NA		
Local infiltration analgesia	NA	NA		
Early ambulation	0.90 (0.43–1.87)	0.769	0.39 (0.17–0.91)	0.026
Early removal of bladder catheter	0.60 (0.28–1.27)	0.183		
Early oral feeding	0.42 (0.19–0.92)	0.030		
Stick to discharge criteria	0.98 (0.35–2.72)	0.968		
Perioperative multimodal analgesia	NA	NA		

Abbreviations: ASA, American Society of Anesthesiologists; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

compliance had significantly fewer complications ($p=0.031$). The details of complications are shown in [Table 3](#). 30-day readmission was not impacted by the level of compliance ($p=0.298$). Two patients of lower compliance group were readmitted within 30 days of discharge because of surgical site infection (SSI). During our follow-up, there was no occurrence of patient re-operation or death ([Table 4](#)).

A multivariate analysis showed that surgical time (OR 1.89, 95% CI 1.02–3.13, $p=0.029$), lower compliance (OR 2.54, 95% CI 1.17–5.78, $p=0.034$), early oral feeding (OR 0.39, 95% CI 0.17–0.91, $p=0.026$) were predictors of any postoperative complications ([Table 3](#)).

On multivariate analysis, the following items remained correlated with prolonged LOS (LOS \geq 12 days): older age (OR 1.45, 95% CI 1.02–1.66, $p=0.010$), lower compliance (OR 2.80, 95% CI 1.09–4.74, $p<0.0001$), early ambulation (OR 0.92, 95% CI 0.40–0.99, $p=0.018$), stick to discharge criteria (OR 0.89, 95% CI 0.71–0.97, $p=0.040$) ([Table 5](#)).

Table 4 Patients' Clinical Outcomes

	Higher Compliance (>92.9)	Lower Compliance (\leq 92.9)	P value
LOS, day	11.8 \pm 4.5	14.6 \pm 6.1	<0.0001
Any complications			0.031
Yes	8	32	
No	83	137	
SSI	3	10	0.355
Neurological deficit	1	2	0.951
Electrolyte abnormality	0	4	0.139
Pneumonia	1	3	0.673
DVT/thrombophlebitis	0	1	0.462
Pulmonary embolism	0	1	0.462
Myocardial infarction	1	2	0.951
Urinary tract infection	0	2	0.298
Stroke	0	1	0.462
Sepsis	0	1	0.462
Delirium	2	5	0.718
30-day readmission	0	2	0.298

Table 5 Logistic Regression for Prolonged LOS

Characteristics	Univariable Analysis		Multivariable Analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
Age	1.13 (1.01–1.34)	0.022	1.45 (1.02–1.66)	0.010
Gender (Female)	0.92 (0.66–2.03)	0.764		
BMI	0.96 (0.91–1.03)	0.893		
Surgical level \geq 3	1.35 (1.08–2.79)	0.021	1.23 (0.77–2.55)	0.087
ASA \geq 3	1.02 (0.74–1.87)	0.796		
Smoker	1.42 (0.77–3.06)	0.841		
Preoperative ODI (%)	1.50 (1.02–1.99)	0.045	1.62 (0.84–2.21)	0.139
Preoperative VAS back	0.95 (0.74–1.08)	0.259		
Preoperative VAS leg	1.21 (0.94–1.79)	0.632		
Surgical time	1.44 (1.08–3.76)	0.023	1.89 (0.95–3.13)	0.228
Estimated blood loss	1.30 (0.81–1.95)	0.516		
Lower compliance	2.98 (1.10–4.89)	<0.0001	2.80 (1.09–4.74)	<0.0001
Patient education	0.97 (0.66–3.45)	0.437		
Nutritional counselling	1.25 (0.83–2.23)	0.278		
No prolonged fasting	1.96 (0.55–4.46)	0.804		
Fluid and carbohydrate loading	0.88 (0.24–3.28)	0.633		
Antithrombotic prophylaxis	0.90 (0.48–2.22)	0.325		
Antimicrobial prophylaxis	NA	NA		
Tranexamic acid	NA	NA		
Avoidance of salt and water overload	NA	NA		
Maintenance of normothermia	NA	NA		
Local infiltration analgesia	NA	NA		
Early ambulation	0.83 (0.37–0.98)	0.014	0.92 (0.40–0.99)	0.018
Early removal of bladder catheter	0.50 (0.13–2.12)	0.498		
Early oral feeding	0.82 (0.59–1.49)	0.153		
Stick to discharge criteria	0.94 (0.75–0.98)	0.042	0.89 (0.71–0.97)	0.040
Perioperative multimodal analgesia	NA	NA		

Abbreviations: ASA, American Society of Anesthesiologists; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

Discussion

In this study, the overall compliance of our ERAS program was high, especially for the pre-operative and intra-operative items pre-operative and intra-operative items. Thorn et al considered that compliance of post-operative required more participation of the patients, which is less easily achieved.¹⁴ Pre-operative and intra-operative items are generally “passive” compliance, where an intervention is delivered to the patient without their direct contribution.¹⁴ With effective multidisciplinary systems and sufficient education, a high level of passive compliance is easier to achieve.

Our results showed that greater compliance is more easily achieved in patients who are younger. Likewise, Feroci et al also reached the similar conclusion despite variation in types of surgery.¹⁵ Patients with advanced age are more likely to suffered from cognitive decline, depression, more comorbidities and poor motor activity.^{16–18} These can lead to the delayed recovery in elderly patients, especially those who are frail, unable to ambulate and feed early. Moreover, elderly

patients commonly experienced issues of decreased ability to perform daily activities and difficulty with self-care, which leads to reluctance to discharge, even if the criteria are met.^{19,20} Although there was relatively sufficient preoperative education in our study, some elderly patients still had deviations in understanding of the ERAS items and difficulties in early recovery. Therefore, it is necessary to communicate effectively with care-givers and provide elderly patients with various forms of education including handouts preoperatively. Indeed, other studies found no significant variation in compliance with ERAS according to age.^{21,22} Considering that lumbar fusion surgery is performed for patients who present lower motor neuron signs such as radicular symptoms and frailty, which exacerbates the difficulty of complying with ERAS program among elderly patients.

In this study, we showed that high compliance correlated with lower complication rates and reduced rates of prolonged LOS. Similarly, in the setting of other surgeries, it was reported that adverse post-operative outcomes (complications and prolonged

LOS) were significantly increased with reducing compliance.^{11,23,24} Therefore, it is crucial to maintain compliance in order to improve the prognosis of patients. Iniesta et al suggested that the constant auditing and analysis of the results are helpful to ensure all or most elements of ERAS program are enforced.⁶ What's more, it is easier to maintain compliance when there are strict definitions and standardized elements of the ERAS program.

The lack of research on compliance with individual ERAS elements hindered our understanding of their actual contributions. Our study revealed that the failure of early oral feeding was associated with increased complications. And the failure of early ambulation or sticking to discharge criteria was significantly more influential on prolonged LOS than other elements of the ERAS program. Early feeding can promote the early recovery of gastrointestinal function and reduce risks of electrolyte abnormality.^{25,26} A recent study has proved that early ambulation after elective lumbar spine surgery is associated with significant improvements in LOS, urinary tract infection (UTI) and ileus.²⁷ On the other hand, due to factors beyond common discharge criteria, such as logistical and social issues, the delays of elderly patients in discharge directly increase LOS.²⁸ The other ERAS items were not independently linked to the prognosis indicators in our study. Nonetheless, the ERAS program is a multimodal pathway and all elements have an additive effect on prognosis.²⁹ It can be seen that compliance with the ERAS program is related to the outcomes, but the patients who do not achieve full compliance still benefit from the it.

Our research has some limitations. Our follow-up time was not long enough to evaluate the long-term prognosis and it was just a single-center study with a relatively small sample size. Moreover, we cannot determine whether compliance drives the outcomes or if patients who suffered from a complication were unable to comply with the elements of the ERAS program.

Conclusion

In summary, we found that low compliance with ERAS program among elderly patients undergoing lumbar fusion surgery was associated with a higher incidence of complications and prolonged LOS. Moreover, some individual elements of the pathway were more effective than others in reducing postoperative complications and LOS. The failure of early oral feeding was associated with increased complications and the failure of early ambulation or sticking to discharge criteria was significantly more influential on prolonged LOS.

Data Sharing Statement

Request for data sets generated and analyzed during the current study can be addressed to the corresponding author.

Ethics Approval and Consent to Participate

This study was reviewed and approved by the institutional review board following the declaration of Helsinki principles in Xuanwu Hospital Capital Medical University. The data collection process was entirely anonymous. The types of questions asked could not bring up any singular information that would make participants identifiable in the database and the results are presented in an aggregate manner. A written informed consent was obtained from all participants of this study.

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Author Contributions

ZEL was responsible for designing the search strategy, evaluating the articles, running statistical analysis and writing this article. CK was responsible for study execution, English editing and substantially revising this article. SBL was responsible for designing the protocol and substantially revising this article. WZS was responsible for drafting the article, interpreting and analyzing results. PW and STZ were responsible for acquisition of data, formatting the article and substantially revising this article. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests.

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