Enhanced Recovery After Surgery (Eras) Program for Elderly Patients With Short-level Lumbar Fusion

Peng Wang  
Xuanwu Hospital

Qiang Wang  
Xuanwu Hospital

Chao Kong  
Xuanwu Hospital

Ze Teng  
Chinese Academy of Medical Sciences Cancer Institute and Hospital

Zhongen Li  
Xuanwu Hospital

Sitao Zhang  
Xuanwu Hospital

Wenzhi Sun  
Xuanwu Hospital

Mingli Feng  
Xuanwu Hospital

Shibao Lu (✉️ shibaoluspine@sina.com)  
Xuanwu Hospital of Capital Medical University

Research article

Keywords: Enhanced recovery after surgery, Elderly, Lumbar fusion surgery

DOI: https://doi.org/10.21203/rs.3.rs-31308/v1

License: ☺️ This work is licensed under a Creative Commons Attribution 4.0 International License.  
Read Full License
Abstract

Background: Degenerative disorders of the lumbar spine decrease the mobility and quality of life of elderly patients. Lumbar fusion surgery is the primary method of treating degenerative lumbar spine disorders; however, the surgical stress response associated with major surgery has been linked to pathophysiological changes in the elderly, resulting in undesirable postoperative morbidity, complications, pain, fatigue, and extended convalescence. In the present study, we aimed to determine whether enhanced recovery after surgery (ERAS) significantly improved satisfaction and outcomes in elderly patients (>65 years old) with short-level lumbar fusion.

Methods: A total of 192 patients were included, 96 in the ERAS group and 96 case-matched patients in the non-ERAS group. Data including demographic, comorbidity and surgical information were collected from electronic medical records. ERAS interventions were categorized as preoperative, intraoperative and postoperative. We also evaluated primary outcome, surgical complications, length of stay (LOS), postoperative pain scores and 30-day readmission rates.

Results: There were no statistically significant intergroup differences in regards to demographics, comorbidities — American Society of Anaesthesiologists (ASA) grade or the number of fusion levels. There were also no differences between mean surgery time of intraoperative blood loss between the ERAS and non-ERAS groups. In addition, the mean preoperative Japanese Orthopaedic Association (JOA) score — Visual Analogue Score (VAS) for the back and legs and Oswestry Disability Index (ODI) score were not significantly different between the two groups. Overall, ERAS pathway compliance was 92.1%. There were no significant differences in the number of complications or the mortality rates between the ERAS and non-ERAS groups. Furthermore, the mean postoperative JOA score — VAS for the back and legs, ODI and readmission rates score revealed no significant differences between the groups at 30-day follow-up point. However, we observed a statistically significant decrease in LOS in the ERAS group (12.30±3.03 of ERAS group versus 15.50±1.88 in non-ERAS group, p=0). Multivariable linear regression showed that comorbidities (p=0.023) and implementation of ERAS program (p=0.002) were correlated with prolonged LOS. Multivariable logistic regression showed that no characteristics were associated with complications.

Conclusions: This report describes the first ERAS protocol used in elderly patients after short-level lumbar fusion surgery. Our ERAS program is safe and could help decreases LOS in elderly patients with short-level lumbar fusion.

Background

With the improvement of people’s living standards and medical standards, the life expectancy and the number of elderly persons in China continues to increase. The aging population has its own special characteristics, which are gaining increased research attention (1). Generally speaking, elderly people over 75 years of age will experience reduced vital capacity, dysfunction of ventilation / blood flow ratio,
osteoporosis, muscle atrophy, decreased muscle strength, decreased central regulatory function, reduced motor coordination, reduced strain control, and other pathophysiological changes, and the prevalence of degenerative diseases of the lumbar spine also increases (2).

Degenerative disorders of the lumbar spine may cause significant neural compression, increased pain, and a decrease in the mobility and quality of life of elderly patients. Furthermore, to help maintain their independence, more elderly patients who have failed conservative treatment of their lumbar spinal disorder, are looking toward a surgical solution. It is increasingly important to identify interventions that are effective at improving the quality of life of elderly patients with spinal disorders (3).

Lumbar fusion surgery is the main way for treating degenerative lumbar spine disorders, the surgical stress response associated with major surgery describes fundamental metabolic changes that lead to increased catabolism, immunosuppression, free radical production, and hypercoagulable states (4). These physiologic alterations have been linked to changes in organ function resulting in undesirable postoperative morbidity, complications, pain, fatigue, and extended convalescence (5).

The benefits of enhanced recovery after surgery (ERAS) including reduction in the surgical stress response to minimize postoperative complications and improve surgical outcomes and functional rehabilitation after major surgery without increase in readmission rates, and increased patient satisfaction (4). These decrease the surgical stress responses are of particular importance for the vulnerable patient with comorbidities, who is often also frail and elderly (6). Although ERAS has been shown to be effective for patients in general, few studies have addressed the effectiveness of ERAS in elderly patients with spinal disorders (7).

There is no single surgical method applicable to all lumbar degenerative diseases. The elderly suffer from recurrence after aperture surgery due to the decreased elasticity of the intervertebral disc, lumbar fusion surgery has its own advantages in the treatment of degenerative spinal diseases in the elderly. The aim of this study was to determine whether ERAS could significantly improve care in the perioperative period and decreases perioperative complications, in-hospital length of stay (LOS) and 30-day readmission rates in elderly patients (>65 years old) with short-level lumbar fusion.

**Materials And Methods**

*Inclusion criteria and patient selection.* This is a retrospective cohort study of prospectively collected data. The study enrolled lumbar disc herniation or lumbar spinal stenosis patients if they were over the age of 65 years old underwent lumbar fusion at one or two levels from January 2018 to December 2019 (non-ERAS group), and between January to December 2019 (ERAS group). Both groups were cared for by the same surgical team. A retrospective non-ERAS group in which patients were treated under traditional perioperative protocols was case-matched to ERAS group. Diagnosis of degenerative disorders of the lumbar spine was performed by two spinal orthopaedic specialists based on clinical symptoms and MR images of the lumbar spine, which were used to identify the responsibility segments. Surgery was indicated when patients with typical symptoms of spinal stenosis and did not respond to conservative
treatments. Individuals who had infection disease, trauma, cauda equina injury, neoplasm were excluded in this study, as well as those planned for a revision of a previous fusion.

Demographic data including age, gender and body mass index (BMI). Comorbidities included hypertension, heart disease, diabetes, osteoporosis, stomach problem, bowel or intestinal problem, psychological symptoms. Other interest included American Society of Anesthesiologists (ASA) physical status score, preoperative Japanese Orthopaedic Association Score (JOA), Oswestry Disability Index (ODI), Visual Analogue Score (VAS) for back and legs score. Operative records were reviewed to the number of fusion levels, operative time, intraoperative blood loss. The primary outcome data were analyzed included complication, length of stay, postoperative pain scores and 30-day readmission rates. All data were collected from the electronic medical record.

ERAS interventions. ERAS program was proposed and planned in 2017. The core group consisted of anesthesiologists, spine surgeons, nutritionists, physical therapists, physicians, geriatricians and nurses. After literature review and experience discussion, a reasonable ERAS program was obtained. With the approval of the ethical committee for human subjects of the Xuanwu Hospital of Capital Medical University (Beijing, China), we began to implement the ERAS program in September 2018. Our ERAS interventions were divided into preoperative, intraoperative and postoperative, included administration of the following: (1) patient education and counseling; (2) preoperative fasting; (3) antibiosis before surgery; (4) standard anesthetic protocol; (5) multimodal analgesia; (6) early feeding after surgery; (7) gastrointestinal management; (8) early mobilization; (9) early removal of bladder catheter; (10) antithrombotic prophylaxis. The details of ERAS for pathway is presented in Table 1.
Table 1
Patient demographics

| Patient Demographics   | ERAS       | non-ERAS   | P  |
|------------------------|------------|------------|----|
| Sample size            | 95         | 95         |    |
| Age (years)            | 72.39±6.12 | 70.81±6.27 | 0.12|
| Male/Female            | 45/50      | 40/55      | 0.47|
| Body mass index        | 25.67±3.32 | 25.73±4.00 | 0.93|
| Smoker                 | 3          | 5          | 0.25|

**Comorbidities**

| Comorbidity             | ERAS | non-ERAS | P  |
|-------------------------|------|----------|----|
| Hypertension            | 68   | 74       | 0.32|
| Heart disease           | 26   | 24       | 0.74|
| Chronic lung disease    | 0    | 2        | 0.16|
| Diabetes                | 24   | 31       | 0.26|
| Osteoporosis            | 16   | 15       | 0.84|
| Gastrointestinal        | 8    | 5        | 0.39|
| Psychological symptoms  | 3    | 2        | 0.65|
| Preoperative JOA        | 8.30±2.11 | 8,12±1.90 | 0.59|
| Preoperative ODI, %     | 60.89±11.88 | 58.88±8.26 | 0.55|
| Preoperative VAS (Back) | 7.15±0.72 | 7.01±0.70 | 0.25|
| Preoperative VAS (Leg)  | 7.06±0.63 | 7.09±0.59 | 0.56|

**ASA grade**

| ASA grade | ERAS | non-ERAS |
|-----------|------|----------|
| I         | 13   | 10       |
| II        | 68   | 73       |
| III       | 14   | 12       |
| IV        | 0    | 0        |

**No. of levels fusion**

| No. | ERAS | non-ERAS | P  |
|-----|------|----------|----|
| 1   | 44   | 40       | 0.56|
| 2   | 51   | 55       | 0.56|
Operative time        | 186.78±57.38 | 198.72±69.48 | 0.58 |
---                   |             |             |      |
Intraoperative blood  | 283.38±195.44| 311.51±219.44| 0.42 |
loss                 |             |             |      |

Statistical analysis. All statistical analyses were performed using the SPSS software version 17.0 (SPSS, Inc., Chicago, IL, USA). Patient demographics, comorbidities data, markers of baseline health, and clinical outcomes were compared between ERAS group and non-ERAS group using Student's test and $\chi^2$ test. Multivariable linear regression analysis was used to assess the association of risk factors (ERAS elements) with LOS.

A value of $P<0.05$ was considered for significant differences.

Results

Demographics. A total of 192 patients were included, there were 96 patients in the ERAS group (45 men and 50 women, mean age 72.39±6.12 years, mean BMI 25.67±3.32) and 96 patients in the non-ERAS group (40 men and 55 women, mean age 70.81±6.27 years, mean BMI 25.73±4.00). All surgeries were performed by a senior surgeon. Preoperative characteristics were similar between the two groups (Table 1). Demographic data were compared, and no statistically significant intergroup differences were observed. And there were not significantly different with comorbidities, ASA grade or the number of fusion levels. The mean ERAS group and non-ERAS group operative time and intraoperative blood loss showed no significant difference. In addition, the mean preoperative JOA, VAS for the back and legs and ODI score showed no significant difference.

Compliance to ERAS pathway. Our ERAS protocol included 15 elements interventions (Table 3), overall pathway compliance was 92.1% (Table 2). Patient education and counselling, no prolonged fasting, antimicrobial prophylaxis and all Intra-operative ERAS items were used in 100% of cases. Items with the lowest compliance were early removal of bladder catheter (52.6%).
Table 2
ERAS pathway compliance

| Compliance with the ERAS program | n (%) |
|---------------------------------|-------|
| Variable                        | n (%) |
| Pre-operative ERAS items        |       |
| Patient education and counselling | 95(100) |
| No prolonged fasting            | 95 (100) |
| Fluid and carbohydrate loading  | 90 (94.7) |
| Antithrombotic stockings        | 95 (100) |
| Antimicrobial prophylaxis        | 95 (100) |
| Intra-operative ERAS items      |       |
| Tranexamic acid                 | 95 (100) |
| Maintenance of normothermia     | 95 (100) |
| Local infiltration analgesia    | 95 (100) |
| Postoperative ERAS items        |       |
| Early ambulation                | 63 (66.3) |
| Early removal of bladder catheter | 50 (52.6) |
| Early oral feeding              | 70 (73.7) |
| Perioperative multimodal analgesia | 93 (97.9) |
| Overall compliance (rate)       | 92.1  |
Table 3
Postoperative outcomes

| Outcome measure          | ERAS   | non-ERAS | P   |
|--------------------------|--------|----------|-----|
| **Complications**        |        |          |     |
| Cerebrovascular accident | 0      | 1        | 0.32|
| Cardiac arrest           | 0      | 0        |     |
| Deep vein thrombosis     | 0      | 1        | 0.32|
| Surgical site infection  | 1      | 4        | 0.17|
| Spinal fluid leakage     | 1      | 2        | 0.56|
| Neurological             | 1      | 1        | 1   |
| LOS                      | 12.30±3.03 | 15.50±1.88 | 0   |
| 30-day readmissions      | 1      | 1        |     |
| 30-day mortality         | 0      | 0        |     |

Outcomes. The main clinical outcomes are shown in Table 4, after the implementation of ERAS, there was no significant difference in complication and mortality between ERAS group and non-ERAS group. Furthermore, the mean postoperative JOA, VAS for the back and legs, ODI and readmission rates score showed no significant difference at 30-day follow-up, as complete data were available for 83% of patients at this early time point. However, we observed a statistically significant decrease in LOS in the ERAS group (12.30±3.03 of ERAS group versus 15.50±1.88 in non-ERAS group, p=0). Multivariable linear regression showed that comorbidities (p=0.023) and implementation of ERAS program (p=0.002) were correlated with prolonged LOS. On the other hand, age (p=0.379), sex (p=0.085), BMI (p=0.535), smoker (p=0.137), ASA ≥3 (p=0.062), fusion number (p=0.236), operative time (p=0.151), blood loss (p=0.079), preoperative JOA (p=0.235), preoperative VAS Back (p=0.949), preoperative VAS Leg (p=0.656) and preoperative ODI (p=0.179) were not related to LOS. Multivariable logistic regression showed that no characteristics were associated with complications.
Table 4
Multivariable analyses for LOS and complications

| characteristic       | Multivariable linear regression for LOS | Multivariable logistic regression for any complications |
|----------------------|----------------------------------------|--------------------------------------------------------|
|                      | Coefficient (95% CI) | p value | OR (95% CI) | p value |
| Age                  | 0.24(-0.13 to 0.26)  | 0.379   | 1.15 (0.89-1.26) | 0.563   |
| Female               | 1.28(-0.51 to 1.10)  | 0.085   | 1.07 (0.91-1.14) | 0.210   |
| BMI                  | -0.033(-0.13 to 0.07) | 0.535   | 0.97 (0.92-1.06) | 0.085   |
| Smoker               | 0.76(-0.21 to 1.11)  | 0.137   | 2.10 (0.85-3.24) | 0.121   |
| Comorbidities        | 1.26(0.29 to 2.23)   | 0.023   | 1.56 (0.77-2.91) | 0.074   |
| ASA≥3                | 0.98(-0.03 to 1.92)  | 0.062   | 2.31 (0.98-4.53) | 0.060   |
| Fusion number        | 2.15(-1.29 to 3.37)  | 0.236   | 1.98 (0.91-2.58) | 0.140   |
| Operative time       | 0.36(-0.19 to 1.08)  | 0.151   | 1.33 (0.86-3.46) | 0.088   |
| Blood loss           | 1.12(-2.56 to 4.95)  | 0.079   | 1.44 (0.65-1.90) | 0.872   |
| ERAS                 | -2.98(-3.76 to -1.64) | 0.002   | 0.72 (0.31-1.09) | 0.077   |
| Preoperative JOA     | 0.34(-0.46 to 0.88)  | 0.235   | 0.81 (0.70-1.34) | 0.179   |
| Preoperative VAS (Back) | 0.65(-0.70 to 2.01)  | 0.949   | 1.12 (0.81-2.03) | 0.235   |
| Preoperative VAS (Leg) | 0.98(0.01 to 1.37)   | 0.656   | 2.09 (0.95-2.71) | 0.068   |
| Preoperative ODI (%)  | -0.02(-0.07 to 0.01) | 0.179   | 1.36 (0.74-2.28) | 0.307   |

Discussion
A loss of disc height occurs with aging and may place non-physiological loads on adjacent segments as well as the facet joints, a common source of low back pain. Low back pain and sciatica can significantly impair psychosocial functioning and lead to sleep disorders, depressive symptoms, and may be linked to coronary heart disease, particularly in elderly persons (8). However, due to poor physical function and comorbidities of the elderly persons, the lumbar spinal surgery in elderly patients has been associated with high rates of perioperative complications (9). Worley et al. found that patients aged 65 had an increased risk of inpatient morbidity (10). Initially proposed by Danish surgeon, Henrik Kehle, ERAS is a multi-professional and multidisciplinary approach to the care of the surgical patient in order to obtain a rapid recovery after surgical intervention (11). While the initial efforts focused on colorectal surgery, the basic principles have been adopted to multiple surgical specialties (6, 12-14). ERAS protocols have been shown to be particularly beneficial for the elderly people who often have co-morbidities and run a higher risk of surgical complications. Furthermore, these principles have been applied in patients with total hip arthroplasty, total knee arthroplasty, and those with intertrochanteric fracture, who not only experienced reduced hospital LOS, but also in improvement in patient care and reduced health care costs (15, 16).

At its core, the ERAS program aims at faster recovery, and LOS was used as the primary efficacy parameter. This study showed that application of ERAS in elderly patients with short-level lumbar fusion could decrease the LOS.

Shorting fasting and feeding time is one of the important preoperative elements in our ERAS program. Because of perioperative starvation induces stress hormones release of the inflammatory cytokine and the accumulation of lipid products in skeletal muscles, traditional preoperative fasting for at least 8 h and oral feeding on postoperative 1 day may cause insulin resistance and metabolic stress (17, 18). Insulin resistance and metabolic stress could increase the rate of postoperative complications (19). Shortening preoperative fasting and postoperative eating time may shifts cellular metabolism to a more anabolic state (20). Therefore, it can minimise protein loss, improve patient comfort and decrease insulin resistance (21). Good nutritional status could reduce the occurrence of complications such as wound infections and may help wound healing (22). Research examining shortening preoperative fasting and postoperative eating time of elderly patients with lumbar surgery is markedly lacking, despite studies indicating that it is safe and effective (1, 18, 23). Our studies showed that elderly patients received carbohydrate drink 2 hours before the induction anesthesia and after surgery drinking water starting 2-4 hours early feeding started 6 hours is safe and without increasing complications.

Compared to other reports of ERAS in spine surgery, our ERAS program early mobilization compliance was high. Early mobilization is considered a key element of postoperative care in our ERAS program. Traditional long stay in bed was associated with infections and muscle weakness. Although a wealth of data confirms that early mobility could reduce the incidence of many of these complications and that early mobility within 24 hours after spinal surgery is safe (24-26), there are few studies that investigate how early elderly patients can safely get out of bed and ambulate, and the way of the elderly patients get out of bed and ambulate. In this study, our early mobility protocol were from sitting out of bed...
or walking with assistance to walking without assistance within 24 hours. Early mobilization following surgery has multiple benefits including improved ventilation, muscle strength and functional capacity (24), our results showed that early mobilization in elderly patients after short-level lumbar fusion is safe and without increasing complications and 30-day readmission rates.

However, this study has several limitations. This study is the retrospective design, small sample size. Given the lack of long-term follow-up data, definitive conclusions cannot be drawn beyond a 30-day period. Furthermore, the ERAS and non-ERAS group were assessed at different times, which may have introduced analytical bias. Further multicenter studies with a larger participant population are required to confirm the safety and efficacy of our ERAS protocol in elderly patients after short-level lumbar fusion surgery.

Conclusions

In conclusion, this report describes the first ERAS protocol used in elderly patients after short-level lumbar fusion surgery. Our ERAS program is safe and could help decrease LOS in elderly patients with short-level lumbar fusion.

Abbreviations

ERAS, enhanced recovery after surgery; LOS, length of stay; BMI, body mass index; ASA, American Society of Anesthesiologists; JOA, Japanese Orthopedic Association; ODI, Oswestry Disability Index; VAS, Visual Analogue Score

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

Consent for publication

Not applicable

Availability of data and materials

All data generated or analyzed during this study are included in this published article

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

**Funding**

This work was supported by the National Natural Science Foundation of China (81871794).

**Authors' contributions**

P.W., Q.W., M.F. and S.L. conceived of and designed the experiments. P.W., C.K., and TZ. performed the experiments. Q.W., Z.L., S.Z. and W.S. analysed the data. P.W. wrote the paper. S.L. and M.F. revised the manuscript. All authors reviewed the manuscript.

**Acknowledgements**

Not applicable.

**References**

1. Xu B, Xu WX, Lao YJ, Ding WG, Lu D, Sheng HF: Multimodal Nutritional Management in Primary Lumbar Spine Surgery: A Randomized Controlled Trial. Spine (Phila Pa 1976): 44(14):967-74, 2019.

2. Adogwa O, Elsamadicy AA, Vuong VD, Moreno J, Cheng J, Karikari IO, et al: Geriatric comanagement reduces perioperative complications and shortens duration of hospital stay after lumbar spine surgery: a prospective single-institution experience. J Neurosurg Spine: 27(6):670-5, 2017.

3. Rihn JA, Hilibrand AS, Zhao W, Lurie JD, Vaccaro AR, Albert TJ, et al: Effectiveness of Surgery for Lumbar Stenosis and Degenerative Spondylolisthesis in the Octogenarian Population. The Journal of Bone and Joint Surgery-American Volume: 97(3):177-85,2015.

4. Dietz N, Sharma M, Adams S, Alhourani A, Ugiliweneza B, Wang D, et al: Enhanced Recovery After Surgery (ERAS) for Spine Surgery: A Systematic Review. World Neurosurg. 2019;130:415-26.

5. Gerhardt J, Bette S, Janssen I, Gempt J, Meyer B, Ryang YM. Is Eighty the New Sixty? Outcomes and Complications after Lumbar Decompression Surgery in Elderly Patients over 80 Years of Age. World Neurosurg:112:e555-e60,2018.

6. Ljungqvist O, Hubner M: Enhanced recovery after surgery-ERAS-principles, practice and feasibility in the elderly. Aging Clin Exp Res: 30(3):249-52,2018.

7. Soffin EM, Vaishnav AS, Wetmore DS, Barber L, Hill P, Gang CH, et al: Design and Implementation of an Enhanced Recovery After Surgery (ERAS) Program for Minimally Invasive Lumbar Decompression Spine Surgery: Initial Experience. Spine (Phila Pa 1976), 44(9):E561-E70, 2019.

8. Cloyd JM, Acosta FL, Jr., Ames CP: Complications and outcomes of lumbar spine surgery in elderly people: a review of the literature. J Am Geriatr Soc:56(7):1318-27,2008.
9. Drazin D, Al-Khouja L, Lagman C, Ugiliweneza B, Shweikeh F, Johnson JP, et al: Scoliosis surgery in the elderly: Complications, readmissions, reoperations and mortality. J Clin Neurosci 34:158-61 2016.

10. Worley N, Marascalchi B, Jalai CM, Yang S, Diebo B, Vira S, et al: Predictors of inpatient morbidity and mortality in adult spinal deformity surgery. Eur Spine J 25(3):819-27 2016.

11. Bardram L, Funch-Jensen P, Jensen P, Crawford ME, Kehlet H: Recovery after laparoscopic colonic surgery with epidural analgesia, and early oral nutrition and mobilisation. Lancet 345(8952):763-4 1995.

12. Keil DS, Schiff LD, Carey ET, Moulder JK, Goetzinger AM, Patidar SM, et al: Predictors of Admission After the Implementation of an Enhanced Recovery After Surgery Pathway for Minimally Invasive Gynecologic Surgery. Anesth Analg 129(3):776-83 2019.

13. Stein MJ, Frank SG, Lui A, Zhang T, Zhang J: Ambulatory latissimus dorsi flap breast reconstruction: A prospective cohort study of an enhanced recovery after surgery (ERAS) protocol. J Plast Reconstr Aesthet Surg 72(12):1950-5 2019.

14. Parise P, Cinelli L, Ferrari C, Cossu A, Puccetti F, Garutti L, et al: Early Red Flags Associated with Delayed Discharge in Patients Undergoing Gastrectomy: Analysis of Perioperative Variables and ERAS Protocol Items. World J Surg 44(1):223-31 2020.

15. Kang Y, Liu J, Chen H, Ding W, Chen J, Zhao B, et al: Enhanced recovery after surgery (ERAS) in elective intertrochanteric fracture patients result in reduced length of hospital stay (LOS) without compromising functional outcome. J Orthop Surg Res 14(1):209 2019.

16. Vendittoli PA, Pellei K, Desmeules F, Masse V, Loubert C, Lavigne M, et al: Enhanced recovery short-stay hip and knee joint replacement program improves patients outcomes while reducing hospital costs. Orthop Traumatol Surg Res 105(7):1237-43 2019.

17. Ljunggren S, Hahn RG, Nystrom T: Insulin sensitivity and beta-cell function after carbohydrate oral loading in hip replacement surgery: a double-blind, randomised controlled clinical trial. Clin Nutr 33(3):392-8 2014.

18. Fujikuni N, Tanabe K, Tokumoto N, Suzuki T, Hattori M, Misumi T, et al: Enhanced recovery program is safe and improves postoperative insulin resistance in gastrectomy. World J Gastrointest Surg 8(5):382-8 2016.

19. Pillinger NL, Robson JL, Kam P: Nutritional prehabilitation: physiological basis and clinical evidence. Anaesth Intensive Care 46(5):453-62 2018.

20. Scott MJ, Baldini G, Fearon KC, Feldheiser A, Feldman LS, Gan TJ, et al: Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: pathophysiological considerations. Acta Anaesthesiol Scand 59(10):1212-31 2015.

21. Alito MA, de Aguilar-Nascimento JE: Multimodal perioperative care plus immunonutrition versus traditional care in total hip arthroplasty: a randomized pilot study. Nutr J 15:34 2016.

22. Bohl DD, Shen MR, Mayo BC, Massel DH, Long WW, Modi KD, et al: Malnutrition Predicts Infectious and Wound Complications Following Posterior Lumbar Spinal Fusion. Spine (Phila Pa 1976)
23. Cao G, Huang Q, Xu B, Huang Z, Xie J, Pei F. Multimodal Nutritional Management in Primary Total Knee Arthroplasty: A Randomized Controlled Trial. J Arthroplasty 32(11):3390-5 2017.

24. Ramos Dos Santos PM, Aquaroni Ricci N, Aparecida Bordignon Suster E, de Moraes Paisani D, Dias Chiavegato L. Effects of early mobilisation in patients after cardiac surgery: a systematic review. Physiotherapy 103(1):1-12 2017.

25. Castelino T, Fiore JF, Jr., Niculiseanu P, Landry T, Augustin B, Feldman LS. The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. Surgery 159(4):991-1003 2016

26. Rupich K, Missimer E, O’Brien D, Shafer G, Wilensky EM, Pierce JT, et al. The Benefits of Implementing an Early Mobility Protocol in Postoperative Neurosurgical Spine Patients. Am J Nurs 118(6):46-53 2018