ORIGINAL ARTICLE

Perioperative Nursing Plan for Posterior Lumbar Interbody Fusion in Patients with Lumbar Spinal Stenosis Based on the Enhanced Recovery After Surgery Concept

Yingying Tan, Xuemei Zeng, Yuanyuan Zhou

Abstract

Objective: To evaluate the impact of perioperative nursing plans based on enhanced recovery after surgery on the recovery of patients undergoing posterior lumbar interbody fusion surgery for lumbar spinal stenosis.

Method: The study was conducted at Drum Tower Hospital, Nanjing, Jiangsu, China, between January 2020 and December 2022, and comprised patients with lumbar spinal stenosis who were randomly divided into experimental group A receiving enhanced recovery after surgery-based perioperative care, and control group B receiving routine care. Postoperative complications, wound healing time, hospital stay, and patient satisfaction were compared between the groups. Data was analysed using SPSS 25.

Results: Of the 100 patients, 50(50%) were in each of the two groups. Age and gender distribution was not significantly different between the groups ($p>0.05$). At baseline, the groups were clinically similar ($p=0.72$), but at one and three months post-surgery, group A showed significantly more improvement compared to group B ($p=0.001$). Pain level on days 1 and 3 post-surgery were significantly lower in group A than group B ($p=0.01$). Group A had a lower incidence of postoperative complications and shorter hospital stay than group B ($p<0.05$).

Conclusion: The enhanced recovery after surgery-based perioperative nursing plan significantly improved recovery outcomes for patients undergoing posterior lumbar interbody fusion surgery.

Keywords: Enhanced recovery after surgery, Clinical nursing, Lumbar spinal stenosis, Posterior lumbar interbody fusion surgery, Perioperative care. (JPMA 75: S-9 [Suppl. 02]; 2025) **DOI: https://doi.org/10.47391/JPMA.SRPH-03**

Introduction

Lumbar spinal stenosis (LSS) is generally caused by degenerative changes, developmental spinal stenosis, trauma, or iatrogenic factors. It can lead to shortening of the various diameter lines of the spinal canal, compressing the dural sac, spinal cord, or nerve roots, thereby causing corresponding neurological dysfunction.[1-3] LSS is more common in middle-aged and elderly people aged over 40 years, and its clinical manifestations include long-term lumbosacral pain, leg pain, progressive weakness, numbness, intermittent claudication, and difficulty walking in both the lower limbs.[4-6] The development of modern medicine has given birth to various surgical treatment plans for LSS. Posterior lumbar interbody fusion (PLIF) is a commonly used treatment for LSS. It has the advantages of sufficient decompression through posterior approach, providing load burden on the anterior column of the spine, preserving intervertebral space height while fusion, physiological lordosis and biomechanical characteristics of the lumbar spine, and providing good longitudinal support of the intervertebral space.[7-10] But it also has drawbacks, such as significant damage to the posterior structure of the spine and potential loss of tension in the posterior part of the vertebral body. Meanwhile, postoperative complications (PCs) are also negative effects that cannot be ignored.[11-13] The above issues have had a negative effect on the postoperative recovery (POR) of patients.[14-16] Therefore, implementing a reasonable perioperative nursing plan is necessary to promote patient recovery.[17-20] Enhanced recovery after surgery (ERAS) is a treatment model that involves multiple disciplines, such as surgery, anaesthesia, nursing, pharmacy, nutrition and rehabilitation.[21-24] It can reduce the patient's stress level, accelerate POR, shorten length of hospital stay (LOS), and reduce the risk of readmission by improving, optimising and combining various conventional treatment methods.[25-27] The success of ERAS model in the context of clinical nursing has been reported.[24,28,29] The application of ERAS protocols in clinical nursing has demonstrated significant achievements across various surgical contexts.[30-32] For instance, a study on laparoscopic cholecystectomy revealed that ERAS nursing interventions led to reduced postoperative pain, earlier mobilisation and shorter LOS compared to conventional care.[33,34] Similarly, in thoracolumbar fracture surgeries, ERAS nursing care improved rehabilitation outcomes, highlighting its effectiveness in managing complex orthopaedic cases.[35,36]

Department of Orthopaedics, Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School, Nanjing, Jiangsu, China.
Correspondence: Yuanyuan Zhou. e-mail: Yuaner790615@163.com
ORICID: 0009-0000-1074-2321

In the context of gynaecological malignancies, ERAS protocols not only alleviated pain, but also enhanced recovery metrics, indicating a robust application in oncology nursing.[37] Furthermore, research involving older gastric cancer patients showed that ERAS significantly expedited recovery of nutritional and inflammatory markers, further supporting its efficacy in geriatric care.[38,39] Lastly, a comparative study in elective caesarean section (CS) cases confirmed that ERAS protocols resulted in shorter LOS and improved POR.[40] Collectively, these findings underscore the transformative impact of ERAS in clinical nursing, enhancing patient outcomes across diverse surgical disciplines.[41,42] Nisivaco et al. applied ERAS to postoperative care of coronary artery bypass graft (CABG) and selected 93 patients for ERAS care. The results proved that the readmission rate of patients receiving ERAS care was 3.2%, lower than that of patients receiving routine care ($p<0.05$).[43] This indicates that applying ERAS to clinical nursing can effectively improve nursing outcomes.

The current study was planned to evaluate the impact of a perioperative nursing plan (PNP) based on ERAS on the recovery of patients undergoing PLIF surgery for LSS.

Patients and Methods

The study was conducted at Drum Tower Hospital, Nanjing, Jiangsu, China, between January 2020 and December 2022 with the ethics approval number 2019-088-02. Random sampling technique was used and the LSS patients were divided into two groups: experimental group A, receiving ERAS perioperative care, and control group B, receiving routine care. This random method ensured that each patient had an equal chance of being assigned to either group, which minimized selection bias and improved the validity of the study's findings. The sample size was calculated using statistical power analysis based on a significance level 0.05 and power 80%.[44]

Those included were patients of either gender aged 30-60 years diagnosed with LSS whose condition did not improve after at least six weeks of conservative treatment. The patients were scheduled for PLIF, had no previous history of mental illness and neurological disorders, and were able to act independently. Those excluded were patients outside the age range, having history of mental illness and neurological disorder, having liver or kidney dysfunction, metabolic diseases, cardiovascular or cerebrovascular diseases, or severe infections. Those with fractures, pathological fractures, or osteoporosis, or history of prior lumbar spine surgery were also excluded.

After taking informed consent from all the participants, basic data, such as age, gender, marital status, nature of work, and residential address, was recorded using a profrma who Cronbach alpha (α) coefficient was 0.9, indicating high reliability.

The patients' lumbar spine function (LSF) was scored using the Japanese Orthopaedic Association (JOA) scale, including clinical signs, subjective symptoms, bladder function, and activities of daily living (ADLs) for a total of 29 points.[45] To evaluate the perioperative nursing effect, LSF of patients was evaluated in the context of day of admission (DoA) using the Modified Ashworth Scale (MAS) 44 score at baseline, one month post-surgery (1MAS) and three months post-surgery (3MAS). The Visual Analogue Scale (VAS) 37 was used to evaluate the degree of pain, with 0 indicating no pain, 1-3 representing mild pain, 4-6 meaning moderate pain, 7-9 showing severe pain, and 10 indicating unbearable pain. PCs included urinary system infection, urinary retention, cerebrospinal fluid (CSF) leakage, incision infection, intraincision haematoma, lower limb deep vein thrombosis (DVT), pulmonary infection, and abdominal distension.[46] Patient Satisfaction Survey (PSS) 40 was used to evaluate nursing satisfaction from four aspects: nursing services, nursing communication, nursing environment, and nursing system. The survey had 29 items, with a gross score of 145 points. The Cronbach α coefficient was 0.95, indicating high reliability teams.

The anaesthesiologists were responsible for developing anaesthesia plans, operating room (OR) nurses were responsible for intraoperative care, and orthopaedic attending physicians were responsible for evaluating and analysing the nursing outcomes. the orthopaedic nurses were responsible for collecting data, selecting patients, implementing nursing care, and evaluating nursing outcomes.

To generate the PNP based on ERAS, a panel of experts was taken on-board. Those included were associated with tertiary Grade A hospitals, held a Bachelor's degree or above, were either medical experts with a professional title of deputy senior or above, or were nursing management experts with an intermediate professional title or above, or an intermediate clinical nursing expert who had been engaged in ERAS nursing for >5 years; and those who demonstrated high enthusiasm for research. A total of 340 ERAS and clinical nursing-related literature from the preceding five years was referred to, and two rounds of consultations were conducted with clinical experts in related fields.[47] The questionnaire was collected within a week. Both rounds of questionnaire responses had an effective rate of 100%, indicating that the experts had a high level of enthusiasm. The expert authority coefficient was determined on the basis of judgment and familiarity. The expert authority coefficients for the two rounds of inquiry were 0.89 and 0.90, both higher than 0.7, indicating

Table-1: Coefficient of variation for expert opinion.

Expert number	First-round coefficient of variation	First-round coefficient of variation	The first round of opinion
1	0.043	0.072	Add methods to guide patients to pain relief on the day of hospitalization
2	0.067	0.083	The content of "guiding the trauma patient for defecation" is added before surgery, and the drain tube can be removed when the drainage fluid is <500 ml
3	0.054	0.125	The drain tube can be removed when the drainage fluid is <500 ml
4	0.072	0.317	Add methods to guide patients to pain relief on the day of hospitalization
5	0.124	0.301	The content of "guiding the trauma patient for defecation" is added before surgery
6	0.118	0.289	Add methods to guide patients to pain relief on the day of hospitalization
7	0.258	0.274	The content of "guiding the trauma patient for defecation" is added before surgery
8	0.243	0.056	The content of "guiding the trauma patient for defecation" is added before surgery
9	0.157	0.094	Add methods to guide patients to pain relief on the day of hospitalization, the drain tube can be removed when the drainage fluid is <500 ml
10	0.173	0.159	The drain can be removed when the drain is <500 ml
11	0.084	0.178	The content of "guiding the trauma patient for defecation" is added before surgery
12	0.096	0.235	Add methods to guide patients to pain relief on the day of hospitalization
13	0.167	0.068	The drain tube can be removed when the drainage fluid is <500 ml
14	0.183	0.113	The content of "guiding the trauma patient for defecation" is added before surgery
15	0.217	0.163	The content of "guiding the trauma patient for defecation" is added before surgery

a high expert authority coefficient. After the second round of questioning, the opinions of the experts were generally consistent, with no additional opinions, and, as such, a PLIF PNP based on the ERAS concept was developed. The degree of coordination of opinions was evaluated using coefficient of variation (Table 1).

The PNP was divided into five stages: DoA, preoperative care, intraoperative care, postoperative care, and discharge guidance. On DoA, group A subjects received routine education and admission evaluation, and pain management was performed to achieve advanced analgesia. Preoperatively, the patients were given health education, psychological support, preoperative exercise and rehabilitation training along with pain management and anaesthesia plan development update. They were fasted for 6 hours and 2 hours before the surgery. During the surgery, the patients received urinary tract management, temperature management, infusion care, and drainage tube retention. When the surgical time exceeded 1.5 hours or the blood loss exceeded 300ml, catheterisation was considered. Routine postoperative care was performed, and the risk of falls, bed falls, pressure ulcers, and complications was assessed, with axial somersaults conducted every 2 hours. If the patients did not experience nausea or other symptoms 4 hours after surgery, a small amount of semi-liquid light diet was given, and a normal diet was restored 2-3 days after surgery. If a urinary catheter was not placed before surgery, it was placed according to the patient's condition during surgery and was removed as soon as possible after surgery. Multimodal pain management was performed after surgery, and psychological care was provided for those with VAS <3. Otherwise, medication was administered according to medical advice. On the day after surgery, the patients underwent functional exercise and completed the VAS scale on the 1st, 2nd and 3rd day after surgery. The wound healing, complications, and pain of the patient were assessed upon discharge, and follow-up visits were conducted at 1, 3 and 6 months post-surgery. The patients' emphasis on postoperative rehabilitation was strengthened through video explanations, and they were instructed to continue exercising after discharge. Subjects in control group B received routine perioperative care.

Data was analysed using SPSS 25. Data was expressed as either frequencies and percentages, or as mean ± standard deviation as appropriate. Further, t-tests, repeated measures of variance, chi-square test and Fisher's test were used as appropriate. The satisfaction level of patients was tested using a rank sum test. P<0.05 was considered statistically significant.

Results

Among the 100 patients, 50 (50%) were allocated to each group. There was no significant difference in age and gender distribution between the groups ($p>0.05$) (Table 2). The ERAS team comprised 24 members, including 8 (33.3%) management personnel and 16 (66.6%) implementation personnel.

At baseline, the groups were comparable regarding JOA scores ($p=0.72$). However, the 1MAS and 3MAS scores for group A were significantly better than those for group B ($p=0.001$). Pain levels on days 1 and 3 post-surgery were significantly lower in group A compared to group B ($p=0.05$) (Table 3).

In groups A and B, the postoperative lumbar flexion range of motion (ROM) was 30.6° and 27.3°, respectively. The ROM for extension was 22.1° and 18.4°, respectively. The mobility of the left-side and right-side bends was 20.6° and 16.5°, respectively. The rotational activity was 35.1° and 28.6°, respectively. Group A demonstrated significantly better outcomes than group B ($p<0.05$) (Figure 1).

Postoperative quality-of-life scores for group A were significantly better than those for group B (Figure 2). The VAS scores on DoA in groups A and B were 6.2±1.35 and 6.3±1.07, respectively (p=0.68). On days 1, 2, and 3 post-surgery, the VAS scores in group A were significantly better than those in group B (Table 4).

The scores of the five psychological dimensions after treatment in group B were 19.3±1.3, 21.4±0.9, 11±1.3,

Table-2: General characteristics of the patients in experimental and control groups.

Index	Experimental group		Control group		t/x^2	p-value
Gender	Male	Female	Male	Female		
Age (years)	47.82±7.43	46.95±7.21	47.51±7.14	47.12±6.89	0.061	0.951
Number of people	26	24	27	23	0.042	0.841
Primary school and below	9	9	7	8	0.219	0.898
Junior middle school	12	14	16	11		
High school and above	2	4	5	3		
Married	21	19	17	18	0.847	0.827
Unmarried	1	0	2	1		
Divorce	3	2	3	3		
Bereft of one's spouse	2	2	1	2		
Income<3000 USD	8	5	8	6	0.110	0.952
Income: 3000-6000 USD	18	10	16	12		
Income>6000 USD	6	3	4	4		
Employee medical insurance	10	7	9	7	0.309	0.961
Residents' medical insurance	11	9	13	8		
Commercial health insurance	5	4	5	5		
At one's own expense	2	2	1	2		
Brain work*	20	18	21	15	0.223	0.642
Manual labour	7	5	7	7		
City	17	14	18	12	0.174	0.679
Village	9	10	9	11		

*Intellectual or cognitive work as opposed to manual labour; USD: United States dollar.

Table-3: Intergroup comparison of Japanese Orthopaedic Association (JOA) scores.

Time	Experimental group	Control group	t-test	p-value
On the day of admission	11.4±0.929	11.3±1.013	0.514	0.608
One month after surgery (1MAS)	21.1±1.009	20.6±1.051	1.941	0.02
Three months after surgery (3MAS)	28.3±0.942	27.6±0.951	3.698	<0.001
F	F_{Time}=0.995		$F_{Interblock}$=0.086	
P	P_{Time}<0.001		$P_{Interblock}$=0.01	

MAS: Modified Ashworth Scale.

Table-4: Intergroup comparison of Visual Analogue Scale (VAS) scores.

Time	Experimental group	Control group	t-test	p-value
Day of Admission	6.2±1.35	6.3±1.07	0.41	0.68
On postoperative day 1	3.4±1.01	4.1±1.47	2.78	<0.001
On postoperative day 2	2.2±0.93	2.7±1.26	2.26	0.03
On postoperative day 3	1.5±0.68	1.9±0.87	2.56	0.01
On the day of discharge	0.4±0.54	0.5±0.65	0.84	0.40
F	F_{Time}=0.96		$F_{Interblock}$=0.10	
P	P_{Time}<0.001		$P_{Interblock}$=0.04	

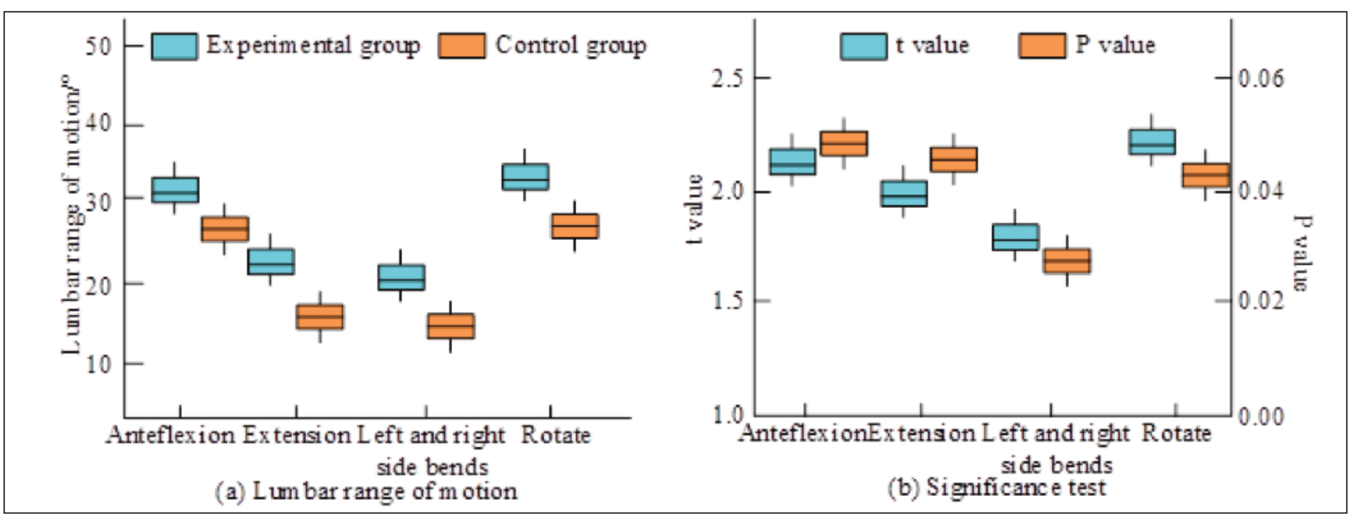

Figure-1: Lumbar mobility of the patients.

10.7±1.7, and 1.5±0.9. The total score of psychological resilience was 64.3±2.2. In group A, the scores of the five psychological dimensions were 1.2±20, 1.2±25.9, 1.2±11.4, 1.4±11.4, and 0.7±2.6, respectively, while the total psychological resilience score was 3.0±71.3 ($p<0.05$) (Figure 3).

The intergroup difference concerning PCs was significant (Table 5, Figure 4). Regarding LOS, the intergroup values on days 4, 6, and 7 were statistically significant (Table 6), and the wound healing time was significantly better on days 11 and 12 in group A compared to group B (Table 7).

The time to complete rehabilitation was lower in group A

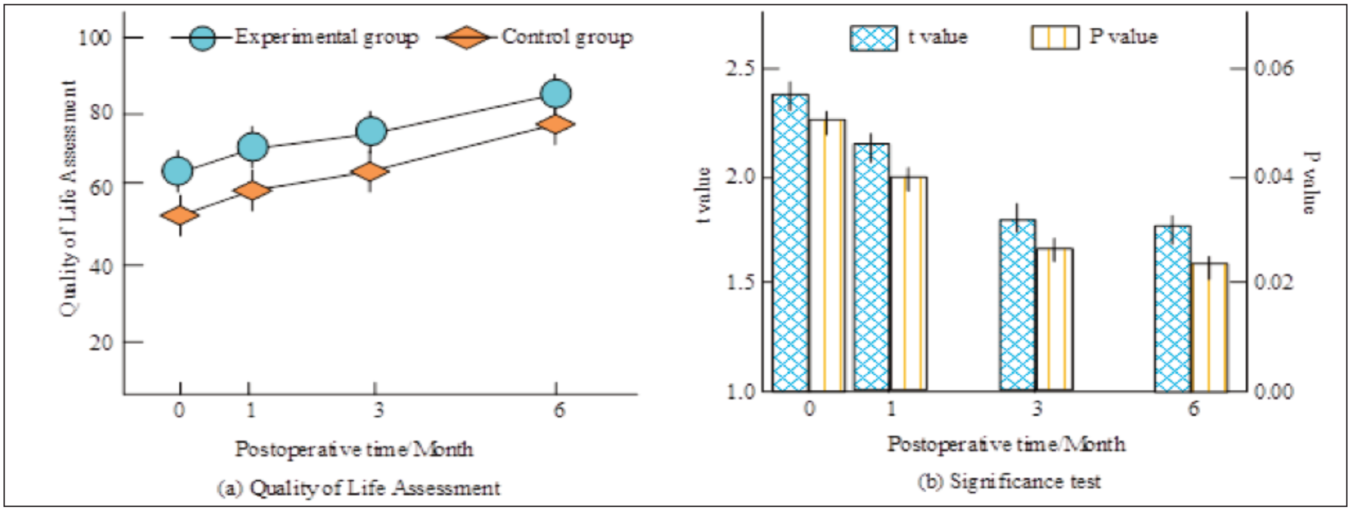

Figure-2: Postoperative quality of survival score.

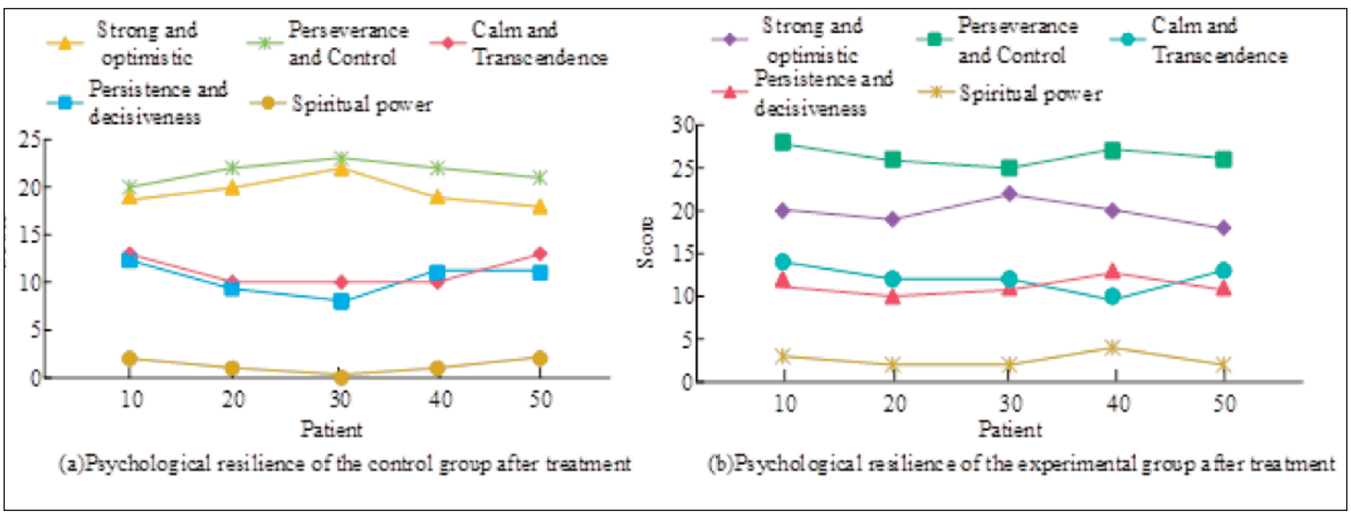

Figure-3: The psychological state scores of the patients.

Table-5: Postoperative complications.

Postoperative complications	Experimental group	Control group	x^2	*p*-value
Leakage of cerebrospinal	1	1	/	1.00
Uroschesis	0	5	5.26	0.02
Urinary infection	1	6	3.84	0.05
Abdominal distension	7	16	4.57	0.03
Deep venous thrombosis in the lower limbs	1	1	/	1.00
Wound infection	1	5	2.84	0.09
Pulmonary infection	2	6	2.17	0.14

Table-6: Length of hospital stay (LOS) data for the experimental and control groups.

Length of hospitalization	Experimental group	Control group	x^2	*p*-value
4 days	12	0	13.64	<0.001
5 days	23	3	20.79	5.1249
6 days	14	2	10.71	<0.001
7 days	1	9	7.11	<0.001
8 days	0	18	21.95	2.7967
9 days	0	17	21.42	3.6796
10 days	0	1	1.01	0.3149

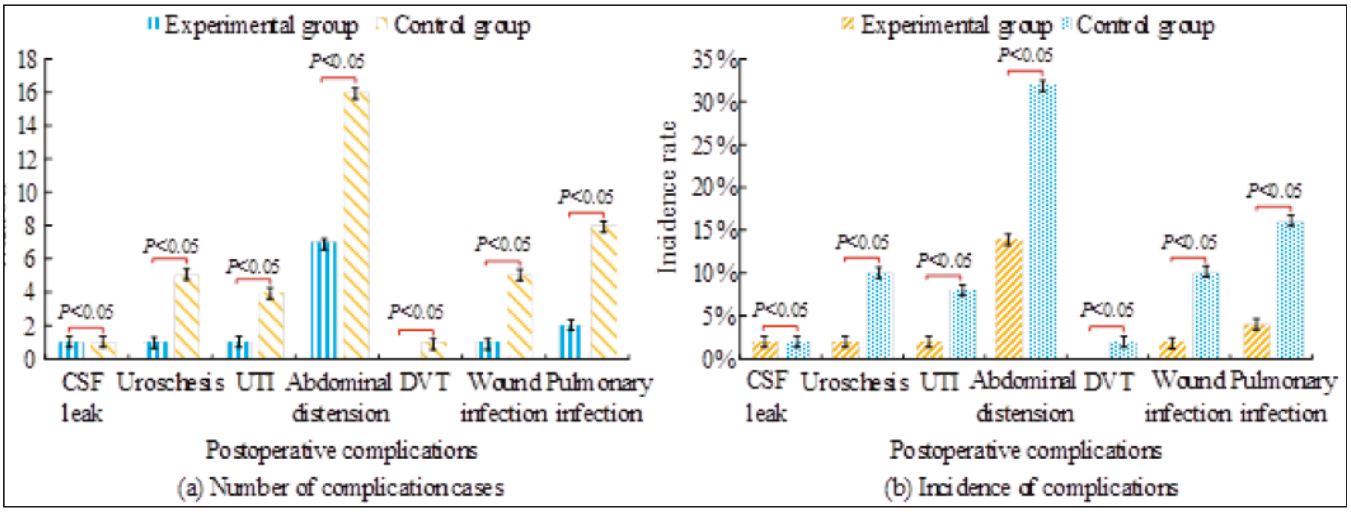

Figure-4: Number and incidence of postoperative complications.

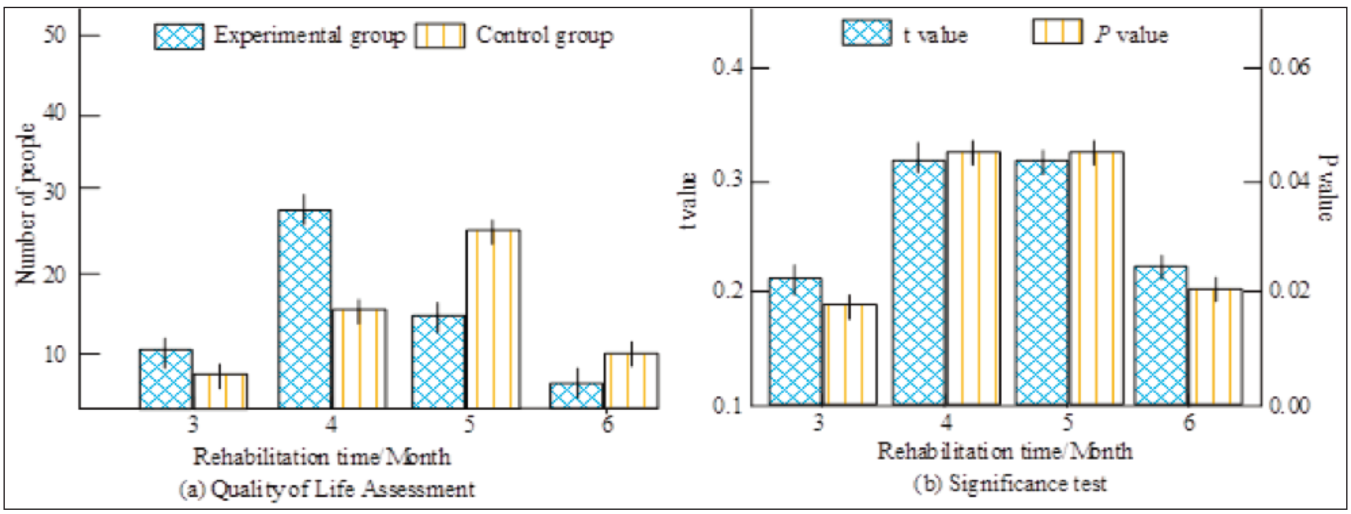

Figure-5: The time required for the patients to recover.

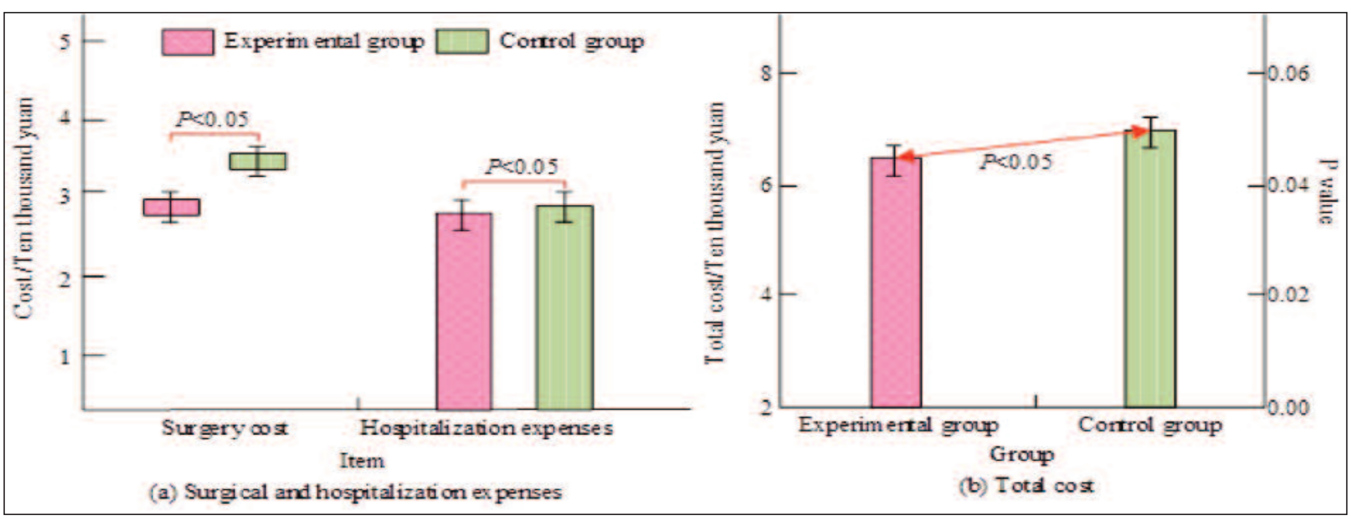

Figure-6: Lumbar mobility at 1 month after surgery.

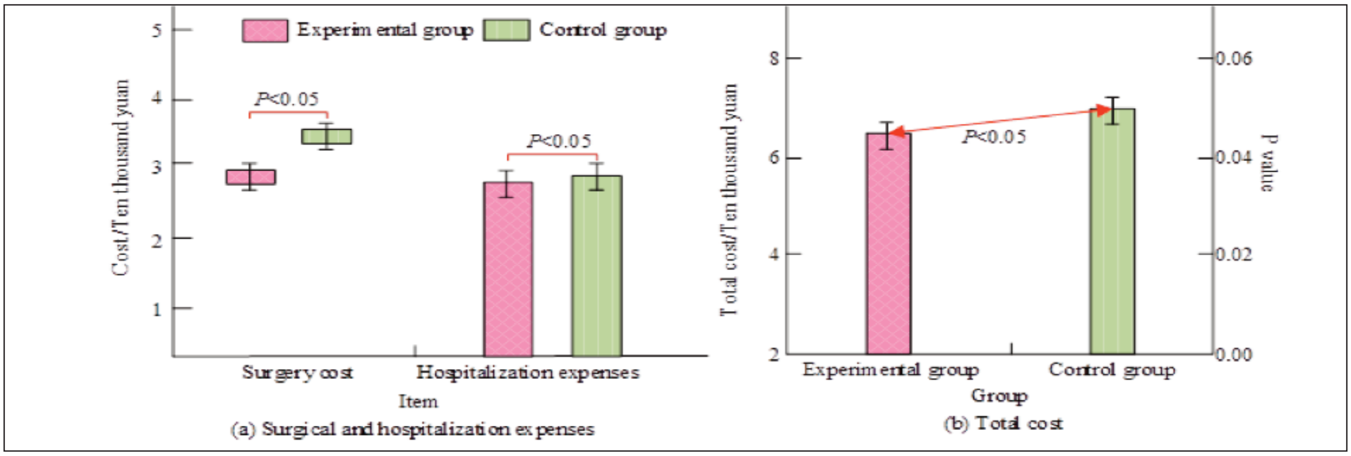

Figure-7: Surgical and hospitalisation costs.

Table-7: Intergroup comparison of wound healing time.

Wound healing time	Experimental group	Control group	x^2	*p*-value
10 days	1	0	1.0101	0.3149
11 days	8	2	4.0000	0.0455
12 days	19	5	10.7456	<0.001
13 days	12	9	0.5425	0.4614
14 days	8	13	1.5069	0.2196
15 days	2	19	17.4201	2.9964
16 days	0	2	2.0408	0.1531

Table-8: Intergroup comparison of wound healing time.

Item	Experimental group	Control group	*z*-score	*p*-value
Hospitality	37538.5±506.2	38096.3±566.7	/	/
Degree of satisfaction	**n (%)**	**n (%)**		
Very satisfied	8 (14)	3 (6)	-3.21	<0.001
Satisfied	31 (62)	14 (28)		
Commonly	10 (20)	28 (56)		
Unsatisfied	1 (2)	5 (10)		

than in group B (Figure 5). At the same time, lumbar ROM for extension, mobility of the left-side and right-side bends, and rotational activity values were better in group A compared to group B (Figure 6). Overall, surgical and hospitalization expenses were lower in group A compared to group B (Figure 7, Table 8). The level of satisfaction with nursing care was higher in group A compared to group B (Table 8).

Discussion

PLIF surgery can achieve the treatment of lumbar spinal stenosis by taking a small amount of bone tissue from the patient's iliac bone or from the donor, placing the bone tissue between the two vertebrae, and promoting the fusion of the two bone tissues.[48,49] However, due to the significant damage caused by PLIF surgery to the posterior structure of the spine, it can lead to issues, such as loss of tension in the posterior part of the vertebral body and iatrogenic spinal instability, causing serious physiological and psychological burden to the patients.[50,51] Therefore, in order to provide patients with holistic physical and mental care, and to increase their surgical tolerance, good PNP is necessary. ERAS, also known as rapid recovery surgical treatment, adopts an evidence-based perioperative management method that can reduce the physiological and psychological trauma stress caused by surgery, and can promote rapid POR through optimisation measures.[52,53]

The current study first compared the LSF and postoperative pain levels of patients. There was no statistically significant difference in LSF scores of patients at baseline. In the first month after surgery, significant differences began to appear between the groups, and at the third month after surgery, the intergroup difference widened.

ERAS, as a widely recognised nursing concept, is applied to perioperative care of various surgeries. A study team applied ERAS nursing to the perioperative care of rectal cancer surgery, selecting 13 patients for ERAS nursing. The patients receiving ERAS treatment had a compliance rate of ≥70%, and the LOS of this subgroup decreased from 6.5 days to 5 days (*p*=0.02).[54] Another study on ERAS care had 25 patients who were to undergo minimally invasive surgery total hip arthroplasty (MIS-THA) using receive ERAS care. The patients had shorter postoperative LOS and higher daily autonomous activity rate, and could walk independently within 24 hours after surgery.[55]

In the current study, postoperative pain level decreased significantly in group A compared to group B, indicating that nursing plans based on ERAS could reduce patients' pain levels. The difference was significant in every aspect the current study explored.

In the light of the current findings, future studies should incorporate extended follow-up periods to fully understand the long-term benefits and potential drawbacks of the PLIF PNP based on ERAS protocols.

Conclusion

The proposed PLIF PNP based on ERAS protocols demonstrated significant benefits for patients with lumbar stenosis. The innovative approach not only facilitated the recovery of lumbar function post-surgery, but also effectively reduced postoperative pain levels. Compared to traditional nursing plans, the PLIF PNP showed a marked improvement in patient outcomes.

Disclaimer: None.

Conflict of interest: None.

Source of Funding: None.

References

1. Hui Z, Lai-Fa W, Xue-Qin W, Ling D, Bin-Sheng H, Li JM. Mechanisms and therapeutic potential of chinonin in nervous system diseases. J Asian Nat Prod Res 2024;26:1405-20. doi: 10.1080/10286020.2024.2371040
2. Fang W, Sun W, Fang W, Zhao S, Wang C. Clinical features, treatment, and outcomes of patients with carfilzomib induced thrombotic microangiopathy. Int Immunopharmacol 2024;134:112178. doi: 10.1016/j.intimp.2024.112178
3. Bemidinezhad A, Radmehr S, Moosaei N, Efati Z, Kesharwani P, Sahebkar A. Enhancing radiotherapy for melanoma: the promise of high-Z metal nanoparticles in radiosensitization. Nanomedicine (Lond) 2024;19:2391-41. doi: 10.1080/17435889.2024.2403325
4. Elmqvist E, Lindhagen L, Försth P. No Benefit with Preservation of Midline Structures in Decompression for Lumbar Spinal Stenosis: Results From the National Swedish Spine Registry 2-Year Post-Op. Spine (Phila Pa 1976) 2022;47:531-8. doi: 10.1097/BRS.0000000000004313
5. Ammendolia C, Hofkirchner C, Plener J, Bussières A, Schneider MJ, Young JJ, et al. Non-operative treatment for lumbar spinal stenosis with neurogenic claudication: an updated systematic review. BMJ Open 2022;12:e057724. doi: 10.1136/bmjopen-2021-057724
6. Khazaei M, Dehghani E, Mehri S, Basatnia R. Assessment of the Brain Cortical Activity of Professional Cavers. Journal of Exercise and Health Science (JEHS) 2024. Doi: 10.22089/jehs.2023.13610.1052. [Ahead of print]
7. EskandariNasab M, Raeisi Z, Lashaki RA, Najafi H. A GRU-CNN model for auditory attention detection using microstate and recurrence quantification analysis. Sci Rep 2024;14:8861. doi: 10.1038/s41598-024-58886-y
8. Farrokhi M, Taheri F, Farrokhi M, Heydari Z, Darbani R, Salbi M, et al. Advancements and innovations in cancer management: a comprehensive perspective. Kindle 2024;4:1–161. doi: 10.5281/zenodo.11108886.
9. Wang Y, Zhai W, Yang L, Cheng S, Cui W, Li J. Establishments and evaluations of post-operative adhesion animal models. Adv Ther 2023;6:e2200297. Doi: 10.1002/adtp.202200297
10. Tian S, Chen X, Wu W, Lin H, Qing X, Liu S, et al. Nucleus pulposus cells regulate macrophages in degenerated intervertebral discs via the integrated stress response-mediated CCL2/7-CCR2 signaling pathway. Exp Mol Med 2024;56:408-21. doi: 10.1038/s12276-024-01168-4
11. Young J, Hartvigsen J, Roos E, Ammendolia C, Kongsted A, Skou S, et al. Prevalence of lumbar spinal stenosis symptoms in patients from primary care treated for knee or hip osteoarthritis or low back pain. Osteoarthritis Cartilage 2021;29(Suppl 1):s390-1.
12. Yang J, Guo C, Kong Q, Zhang B, Wang Y, Zhang L, et al. Learning curve and clinical outcomes of percutaneous endoscopic transforaminal decompression for lumbar spinal stenosis. Int Orthop 2020;44:309-17. doi: 10.1007/s00264-019-04448-1
13. Parsa H, Samiee Rad F, Borzui B, Rahmani A. Severe iron deficiency anemia in a patient with cavernous hemangioma of small intestine, a case report. Comp Clin Pathol 2015;24:207-10. Doi: 10.1007/s00580-014-1940-8
14. Efati Z, Shahangian SS, Darroudi M, Amiri H, Hashemy SI, Aghamaali MR. Green chemistry synthesized zinc oxide nanoparticles in Lepidium sativum L. seed extract and evaluation of their anticancer activity in human colorectal cancer cells. Ceramics International. 2023;49:32568-76. Doi: 10.1016/j.ceramint.2023.07.221
15. Akbarian M, Hosseini M, Mirzavi F, Amirahmadi S, Arab FL, Rajabian A. Punica granatum peel supplementation attenuates cognitive deficits and brain injury in rat by targeting the Nrf2-HO-1 pathway. Food Sci Nutr 2022;11:168-80. doi: 10.1002/fsn3.3049
16. Navari M, Zarei F, Sayedsalehi S, Mahmoudi T, Rostami M, Mahban A, et al. The Arg/Arg genotype of leptin receptor gene Gln223Arg polymorphism may be an independent risk factor for nonalcoholic fatty liver disease. Lab Med 2024;55:590-4. doi: 10.1093/labmed/lmae016
17. Hamedi F, Ranjbar-Naeini OR, Layeghi A, Heidariazar A, Zibaii MI, Latifi H. Self-referred microcavity-based fused-fiber fabry-perot refractometer. Opt Fiber Technol 2022;68:102753. Doi: 10.1016/j.yofte.2021.102753
18. Hamedi F, Huang C, Akbari F, Liu X, Mohtasebi M, Yeo C, et al. An affordable miniaturized speckle contrast diffuse correlation tomography (scDCT) device for 2D mapping of cerebral blood flow. In: Proceedings SPIE PC12827, Multiscale Imaging and Spectroscopy V, PC128270E. San Francisco, California: SPIE BiOS; 2024. Doi: 10.1117/12.3001780.
19. Letafati A, Bahari M, Salahi Ardekani O, Nayerain Jazi N, Nikzad A, Norouzi F, et al. HTLV-1 vaccination Landscape: Current developments and challenges. Vaccine X 2024;19:100525. doi: 10.1016/j.jvacx.2024.100525
20. Rostami N, Ghebleh A, Noei H, Rizi ZS, Moeinzadeh A, Nikzad A, et al. Peptide-Functionalized Polymeric Nanoparticles for Delivery of Curcumin to Cancer Cells. J Drug Deliv Sci Technol 2024;102:106337. Doi: 10.1016/j.jddst.2024.106337
21. Radmehr S, Dehghani F, Bai Y, Yang X, Li J. The impact of intermittent and continuous training on the levels of CIDE and Perilipin-1 proteins and their effect on the size of lipid droplets in the visceral adipose tissue of obese male rats. Eur J Hum Mov 2024;52:43-53. Doi: 10.21134/eurjhm.2024.52.4
22. Rotherham M, Moradi Y, Nahar T, Mosses D, Telling N, El Haj AJ. Magnetic activation of TREK1 triggers stress signalling and regulates neuronal branching in SH-SY5Y cells. Front Med Technol 2022;4:981421. doi: 10.3389/fmedt.2022.981421
23. Akbarzadeh I, Poor AS, Khodarahmi M, Abdihaji M, Moammeri A, Jafari S, et al. Gingerol/letrozole-loaded mesoporous silica nanoparticles for breast cancer therapy: In-silico and in-vitro studies. Microporous Mesoporous Mater 2022;337:111919. doi: 10.1016/j.micromeso.2022.111919
24. Moradi Y, Atyabi SA, Ghiassadin A, Bakhshi H, Irani S, Atyabi SM, et al. Cold atmosphere plasma modification on Beta-carotene-loaded nanofibers to enhance osteogenic differentiation. Fibers Polym 2022;23:18-27. doi: 10.1007/s12221-021-0033-y
25. Ahmadabady S, Hosseini M, Shafei MN, Marefati N, Salmani H, Amirahmadi S, et al. The effects of curcumin in learning and memory impairment associated with hypothyroidism in juvenile rats: the role of nitric oxide, oxidative stress, and brain-derived neurotrophic

factor. Behav Pharmacol 2022;33:466-81. doi: 10.1097/FBP.0000000000000694

26. Dabouri Farimani F, Hosseini M, Amirahmadi S, Akbarian M, Shirazinia M, Barabady M, et al. Cedrol supplementation ameliorates memory deficits by regulating neuro-inflammation and cholinergic function in lipopolysaccharide-induced cognitive impairment in rats. Heliyon 2024;10:e30356. doi: 10.1016/j.heliyon.2024.e30356
27. Yari A, Fasih P, Goodarzi A, Nouralishahi A, Nikeghbal D. The effect of augmented reality book on the proficiency of local anesthesia administration of the inferior alveolar nerve. J Dent Educ 2024;88:1000-8. doi: 10.1002/jdd.13522
28. Doyle NM, Keeler K, Glenski TA, Goodrich E, Madhira M. Enhanced recovery after surgery in pediatric cerebral palsy patients undergoing bilateral lower extremity orthopedic surgery: A pilot study. Paediatr Anaesth 2022;32:582-3. doi: 10.1111/pan.14348
29. Fariman SK, Danesh K, Pourtalebiyan M, Fakhri Z, Motallebi A, Fozooni A. A robust optimization model for multi-objective blood supply chain network considering scenario analysis under uncertainty: a multi-objective approach. Sci Rep 2024;14:9452. doi: 10.1038/s41598-024-57521-0
30. Saberi R, Mirazi N, Amirahmadi S, Darbandi ZK, Vafaee F, Rajabian A, et al. Ameliorative effects of thiamin on learning behavior and memory dysfunction in a rat model of hypothyroidism: implication of oxidative stress and acetylcholinesterase. Metab Brain Dis 2023;38:2603-1. doi: 10.1007/s11011-023-01317-0
31. Sarbaz P, Beigoli S, Payami B, Eshaghi Ghalibaf MH, Amirahmadi S, Hosseini M, et al. Curcuma longa impact on behavioral, brain oxidative stress, and systemic inflammation in rats exposed to inhaled paraquat. Toxicol Environ Health Sci 2024;16:1-12. doi: 10.1007/s13530-024-00124-2.
32. Mehrnia M, Kholmovski E, Katsaggelos A, Kim D, Passman R, Elbaz MSM. Novel Self-Calibrated Threshold-Free Probabilistic Fibrosis Signature Technique for 3D Late Gadolinium Enhancement MRI. IEEE Trans Biomed Eng 2025;72:856-69. doi: 10.1109/TBME.2024.3476930.
33. Widjaya NK, Astrid M, Priyo S. Effectiveness of ERAS nursing programme to pain level, early mobilization and length of stay for patients post cholecystectomy laparoscopy in Pluit Hospital, Jakarta. Asian J Soc Humanit 2024;2:2079-86.
34. Ebrahimi A, Pourkargar DB. Distributed model predictive control of integrated process networks based on an adaptive community detection approach. In: 2024 American Control Conference (ACC). Toronto, ON: IEEE; 2024. doi: 10.23919/ACC60939.2024.10644230
35. Zhu R, Cui L, Zhou R. Progress in the application of nursing care based on ERAS concept after thoracolumbar fracture surgery. J Clin Nurs Res 2024;8:141-6. doi: 10.26689/jcnr.v8i3.4729.
36. Nouri S, Navari M, Zarei F, Rostami M, Mahmoudi T, Rezamand G, et al. NAMPT gene rs2058539 variant is a risk factor for nonalcoholic fatty liver disease. Rev Assoc Med Bras (1992) 2024;70:e20230188. doi: 10.1590/1806-9282.20230188
37. Liao H, Lei Y. Application of ERAS concept in clinical nursing of patients with advanced cancer pain of gynecological malignant tumors. Front Oncol 2023;13:1173333. doi: 10.3389/fonc.2023.1173333
38. You K, Han H. Application of ERAS in older patients with gastric cancer. Medicine (Baltimore) 2024;103:e38409. doi: 10.1097/MD.0000000000038409
39. Luo P, Guo Y, He Y, Wang C. Clinical characteristics, treatment and outcome of pembrolizumab-induced acute pancreatitis. Invest New Drugs 2024;42:369-75. doi: 10.1007/s10637-024-01452-0
40. Saxena RK, Indrani C, Roshini P, Maji A. Early versus delayed initiation of oral feeds among mothers after caesarean delivery: A comparative study. J Clin Diagn Res 2022;16:QC01-5. doi: 10.7860/JCDR/2022/53266.16342.
41. Asadiof F, Safarpour B, Barabadi S, Karkargh FK, Janbozorgi A, Khayayi R, et al. Exploring the comparative efficacy of reality and paradox therapy in treating post-traumatic stress disorder in traumatized adolescents: An analytical review. Contemp Read Law Soc Justice 2024;16:645-56.
42. Shalamzari S, Bagritsevich M, Melles A, Obeid I, Picone J, Connolly D, et al. Big data resources for digital pathology. In: 2023 IEEE Signal Processing in Medicine and Biology Symposium (SPMB); 2023. New York, NY: IEEE, 2023; pp 1-6. doi: 10.1109/SPMB57696. 2023. 10372264.
43. Nisivaco S, Patel B, Coleman C, Kitahara H, Torregrossa G, Balkhy HH. Postoperative Day 1 Discharge After Robotic Totally Endoscopic Coronary Bypass: The Ultimate in Enhanced Recovery After Surgery. Innovations (Phila) 2023;18:159-66. doi: 10.1177/15569845231164374
44. Cohen J. Statistical power analysis for the behavioral sciences, 2nd ed. New York, NY: Routledge; 2013. Doi: 10.4324/9780203771587
45. Grieco M, Galiffa G, Lorenzon L, Marincola G, Persiani R, Santoro R, et al. Enhanced recovery after surgery (ERAS) program in octogenarian patients: a propensity score matching analysis on the "Lazio Network" database. Langenbecks Arch Surg 2022;407:3079-88. doi: 10.1007/s00423-022-02580-y
46. Dimitrov VM. Application of enhanced recovery after surgery protocols in colorectal cancer, complicated by malignant bowel obstruction: A review of the literature. J Biomed Clin Res 2021;14:10-5. doi: 10.2478/jbcr-2021-0002.
47. Wang H, Chen L, Chen P, Huang W, Wang J. Effect of enhanced recovery after surgery management combined with nano-antibacterial dressing during perioperative nursing practice on rehabilitation of patients with gynecological tumor. Mater Express 2021;11:1064-70. doi: 10.1166/mex.2021.2052.
48. Matthews K, White RS, Ewing J, Abramovitz SE, Kalish RB. Reducing healthcare disparities using enhanced recovery after surgery for cesarean delivery. Am J Obstet Gynecol 2021;224(Suppl 1):s522-3. doi: 10.1016/j.ajog.2020.12.857.
49. Thillainadesan J, Yumol MF, Suen M, Hilmer S, Naganathan V. Enhanced Recovery After Surgery in Older Adults Undergoing Colorectal Surgery: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Dis Colon Rectum 2021;64:1020-8. doi: 10.1097/DCR.0000000000002128
50. Julien-Marsollier F, Michelet D, Assaker R, Doval A, Louisy S, Madre C, et al. Enhanced recovery after surgery: Many ways for the same destination. Paediatr Anaesth 2021;31:375-6. doi: 10.1111/pan.14115
51. Huepenbecker SP, Iniesta MD, Zorrilla-Vaca A, Ramirez PT, Cain KE, Vaughn M, et al. Incidence of acute kidney injury after open gynecologic surgery in an enhanced recovery after surgery pathway. Gynecol Oncol 2021;163:191-8. doi: 10.1016/j.ygyno.2021.08.006
52. Bongers BC, Dejong CHC, den Dulk M. Enhanced recovery after surgery programmes in older patients undergoing hepatopancreatobiliary surgery: what benefits might prehabilitation have? Eur J Surg Oncol 2021;47:551-9. doi: 10.1016/j.ejso.2020.03.211
53. Marsden J. Enhanced recovery after surgery (ERAS): A literature review of implications for ostomates and stoma care nurses. Gastrointest Nurs 2020;18:32-7. doi: 10.12968/gasn.2020.18.5.32.
54. Besson AJ, Kei C, Djordjevic A, Carter V, Deftereos I, Yeung J. Does implementation of and adherence to enhanced recovery after surgery improve perioperative nutritional management in colorectal cancer surgery? ANZ J Surg 2022;92:1382-7. doi: 10.1111/ans.17599
55. Liao IT, Lin YT, Chen CY, Lai KH, Wang CT. Enhanced recovery after surgery pathway shortens length of stay and ensures same-day independent mobilization in minimally invasive surgery of total hip arthroplasty. Formos J Musculoskelet Disord 2020;11:47-54. Doi: 10.6492/FJMD.202004/PP.0003