Trials

STUDY PROTOCOL

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Clinical evaluation of enhanced recovery versus conventional care in the perioperative period for intradural extramedullary spinal tumors: a study protocol for a multicenter, randomized controlled trial

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Abstract

Background This randomized clinical trial protocol aimed to investigate the comparative efficacy of an enhanced recovery after surgery (ERAS) protocol versus traditional perioperative care programs in patients with intradural extramedullary spinal tumors.

Methods The study included 180 patients aged 18–80 years, who were randomly assigned to two groups: Group A receiving traditional perioperative care and Group B receiving accelerated rehabilitation perioperative care. The nurse responsible for patient care was informed of the group assignment, but the patients themselves remained blinded to the intervention. The primary outcome measure was the Karnofsky Performance Scale score, which assessed functional status. The secondary outcomes included the Japanese Orthopedic Association Scale, Numeric Pain Rating Scale, length of postoperative hospital stay, duration of urethral catheterization, patient satisfaction questionnaire, and complication rates. Follow-up assessments were conducted telephonically 1 month, 3 months, and 6 months after the surgery.

Discussion This study protocol provided a structured approach to assess the potential benefits of ERAS during the perioperative period for patients with intradural extramedullary tumors, aiming to improve patient outcomes and overall care efficiency.

Trial registration This study has been registered with the China Clinical Trials Registry (Project No: ChiCTR2200063347). Registered on September 5 2022.

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Keywords Intradural extramedullary spinal tumors, Fast-track rehabilitation, Postoperative care, Randomized controlled trial, Study protocol

Administrative information

Note: the numbers in curly brackets in this protocol refer to SPIRIT checklist item numbers. The order of the items has been modified to group similar items (see http://www.equator-network.org/reporting-guidelines/spirit-2013-statement-defining-standard-protocol-items-for-clinical-trials/).

Title {1}	**Clinical Evaluation of Enhanced Recovery Versus Conventional Care in the Perioperative Period for Intradural Extramedullary Spinal Tumors: A Study Protocol for a Multicenter, Randomized Controlled Trial**
Trial registration {2a and 2b}.	This study has been registered with the China Clinical Trials Registry (Project No: ChiCTR2200063347
Protocol version {3}	version V1.1 dated 2022–09-05
Funding {4}	This work was funded by Technology and Innovation Foundation of Fujian, China (grant No.2021Y0021 to RW).
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Name and contact information for the trial sponsor {5b}	Fujian Provincial Department of Science and Technology. Fuzhou china xl_zsjd@163.com
Role of sponsor {5c}	The trial sponsor is a government organization engaged in conducting and coordinating research activities at the Provincial level in China. Sources of funding had no role in determining study protocol and will not be involved in data collection, analysis, or interpretation.

Introduction

Background and rationale {6a}

Intradural extramedullary spinal tumors, situated outside the spinal cord but within the dural sheath, constitute a significant proportion, approximately 65–70%, of spinal canal tumors [1–5]. The limited volume of the spinal canal accentuates the impact of these tumors because their presence can result in the compression of the spinal cord, nerve roots, and adjacent tissues. This compression gives rise to a spectrum of symptoms characterized by sensory, motor, and autonomic dysfunction, encompassing manifestations such as pain, sensory deficits or loss in nerve roots, sensory abnormalities, motor impairments, and bowel or bladder dysfunction [2, 4, 6].

The cornerstone of current treatment for intradural extramedullary spinal tumors remains the surgical excision of the responsible lesion. This intervention aims to enhance nerve function and alleviate the compression experienced by nerve roots and the spinal cord itself [7]. With the continuous evolution of surgical approaches, introducing microscopic access plays a pivotal role in managing these tumors. The microscope-assisted access technique offers advantages such as smaller incisions and reduced surgical trauma. However, it comes with the inherent complexities of operating close to critical neurovascular structures and intricate tissue networks. Consequently, surgical risks and complications remain a concern, necessitating careful consideration during perioperative rehabilitation care [6].

Enhanced recovery after surgery (ERAS), which was first conceptualized by Henrik Kehlet in 1997, represents a series of perioperative optimization measures rooted in evidence-based medicine. The primary goal of ERAS is to mitigate physiological and psychological traumatic stress during the perioperative period, consequently reducing complications and expediting recovery [8, 9]. ERAS has enjoyed widespread success across various medical domains, including general surgery, cardiothoracic surgery, obstetrics and gynecology, and orthopedic joint replacement procedures [10]. ERAS principles have been increasingly embraced within the realm of spine surgery, garnering acceptance among a growing cohort of spine surgeons in recent years [11].

Our team has pioneered the development of Perioperative Care of Enhanced Recovery (PCER) to further enhance the management of intradural extramedullary spinal tumors and mitigate postoperative complications. PCER integrates the fundamental concepts of ERAS into the perioperative care regimen for intradural extramedullary spinal tumors.

Objectives {7}

This randomized clinical trial protocol aimed to investigate the comparative efficacy of an ERAS protocol

versus traditional perioperative care programs in patients with intradural extramedullary spinal tumors.

Trial design {8}

This prospective, multicenter, randomized clinical trial was designed to rigorously investigate the comparative efficacy of PCER versus conventional perioperative care protocols (CPC) for patients undergoing treatment for intradural extramedullary spinal tumors. This study randomly allocated patients with intradural extramedullary spinal tumors to one of two groups: PCER or CPC. The objective was to discern and analyze the differences in clinical outcomes resulting from these distinct perioperative care strategies. This research sought to provide valuable insights that can contribute to optimizing the management of intradural extramedullary spinal tumors and reducing postoperative complications.

Methods: participants, interventions, and outcomes

Study setting {9}

This study adopted a prospective, multicenter, noninferiority randomized controlled trial (RCT) to compare the effectiveness of accelerated perioperative rehabilitation care against usual care in patients receiving treatment for intradural extramedullary spinal tumors. The study encompassed a follow-up period of 6 months. Informed consent was obtained from all participants. The actual intervention was concealed from both the subjects and the follow-up personnel until the end of the follow-up period, as indicated in Table 1. This study received ethical approval from the ethics committee of Union Hospital, Fujian Medical University, China (Grant No. 2020YF034-01), and is registered with the China Clinical Trials Registry (Project No: ChiCTR2000040508). Neurosurgery Department of Hainan Province People's Hospital has 7 chief physicians and professors, 7 associate chief physicians and associate professors. There are 113 beds, two wards and a 16-bed specialist intensive care unit, with a strong professional team of nearly 100 people. The neurosurgery department of the First People's Hospital of Changde City has 37 doctors, 108 nurses, and 1 pharmacist. The annual discharge number of the department exceeds 3000 person-times, and the annual operation volume exceeds 2500 cases. Fujian Medical University Union Hospital has a total of 179 beds. There are 33 doctors and technicians in the whole department, with an annual operation volume of nearly 2000 cases and an annual outpatient emergency volume of about 10,000 person-times.

Eligibility criteria {10}

Study participants

Patients were required to provide informed consent voluntarily before being considered for random grouping.

Inclusion criteria

The inclusion criteria were as follows:

(1) Age between 18 and 80 years.
(2) Magnetic resonance imaging (MRI) and computed tomography (CT) scans confirming the intradural extramedullary nature of the neoplasm.
(3) Lesion length less than three vertebral segments on sagittal T2-weighted sequences.
(4) Willingness to provide informed consent.

Exclusion criteria

The exclusion criteria were as follows:

(1) Pregnancy.
(2) Confirmation of intramedullary or extravertebral involvement during intraoperative assessment.
(3) CT findings indicating spinal instability in the lesioned segment and adjacent segments.
(4) Presence of severe scoliosis or spinal deformity.
(5) History of prior surgeries at the surgical site.
(6) Ongoing infection.
(7) Inability to adhere to the required follow-up protocol or deemed to be at increased risk by the investigator.
(8) Inability to provide written informed consent or adhere to the trial protocol.
(9) Expected survival time of less than 1 year.
(10) Planned emigration within 1 year or communication disorders.
(11) Presence of other serious physical or psychological diseases unsuitable for surgery.
(12) Participation in other concurrent clinical trials.
(13) Rheumatic immune diseases with symptoms resembling those of the study condition.
(14) Unsuitability for specialized examinations such as MRI or CT with contrast enhancement.

Who will take informed consent? {26a}

Patients scheduled for surgery for intradural extramedullary tumors will undergo eligibility screening to determine their suitability for participation in the trial. Once the surgeon assesses the patient as eligible, their family will be invited to meet with the study doctor. During this meeting, their families will have the opportunity to raise any questions they may have and sign informed consent forms.

Table 1 Details of the two care processes

Time	CPC group	PCER group
At admission	Hospital admissions	Hospital admissions
	/	☐ Pelvic floor muscle training(anal lift training)
	Diet	Diet
	☐ Conventional diet	☐ Healthy diet: High protein, coarse fiber, low fat, avoid spicy stimulation
	Psychological evaluation	Psychological evaluation
	/	☐ Hospital Anxiety and Depression Assessment Scale (HADS)
	/	☐ Interventions
Day before surgery	Oral care	Oral care
	☐ Brushing teeth (using a toothbrush)	☐ Brushing teeth (using a toothbrush) + mouthwash
	Lung care interventions	Lung care interventions
	☐ Guided deep breathing for effective coughing	☐ Active respiratory circulation technology
	/	☐ Nebulization bid or tid
	Preoperative rehabilitation instruction	Preoperative rehabilitation instruction
	☐ Postural training: axial rollover	☐ Postural training: axial roll, lateral rise, and prone position training ☐ Neck rehabilitation exercises ☐ Lumbar core muscle group rehabilitation training: arch bridge exercise, flying swallow pointing water
	/	☐ Functional exercise: bedtime bowel training
	Diet	Diet
	☐ Conventional diet	☐ Choosing a diet according to the recipe provided 1 day before surgery
	☐ Fasted from 10:00	☐ Fasting 4–6 h before surgery
	/	☐ Oral preoperative nutrition pack ≤ 400 mL 2 h before surgery
	/	☐ Providing appropriate nutritional support based on the patient's nutritional status
Intraoperative	Intraoperative body temperature:	Intraoperative body temperature:
	☐ Room temperature 24–26℃	☐ Room temperature 24–26℃ + Temperature control blanket
Day of surgery	Diet	Diet
	☐ Fasting on the day of surgery	☐ Liquid diet 4–6 h after surgery
	Pain management	Pain management
	☐ Use painkillers as directed for pain	☐ Analgesic pump for continuous analgesia for 48 h (PCA) ☐ Use of nonsteroidal analgesics (flurbiprofen)
	Oral care	Oral care
	☐ Warm boiled water gargle	☐ Mouthwash
	Position guidance	Position guidance
	☐ Horizontal position	☐ Flat position (turning on the axis at least every 2 h) (stress injury chain management model) ☐ Lumbar towel pad to relieve lumbar muscle soreness

Table 1 (continued)

Time	CPC group	PCER group
First day after surgery—the day before discharge	Diet	Diet
	☐ Transition from a liquid diet to a general diet	☐ Eat the day after surgery according to the recipe prescribed by the doctor
	Oral care	Oral care
	☐ Toothbrushing	☐ Toothbrushing + rinsing with mouthwash
	Breathing training	Breathing training
	☐ Guided deep breath	☐ Active respiratory circulation technique
	Time to get out of bed and move around	Time to get out of bed and move around
	☐ Based on the actual situation	☐ After 48 h (second day after surgery) After the removal of the drainage tube
		☐ Psychological support and encouragement for getting out of bed
	Defecation management	Defecation management
	☐ Removal time of the urinary catheter: according to the actual situation ☐ Constipation care: guidance to eat a more easily digestible diet	☐ Time of urinary catheter removal: 24 h later ☐ Constipation management: coarse fiber diet, auricular acupuncture, massage of the abdomen, foot trigeminal, early bed mobility, and medication such as opiates
	Rehabilitation exercise	Rehabilitation exercise
	☐ VTE prevention: family-assisted active + passive exercise instruction ☐ Observation of muscle strength and movement of the extremities ☐ Observation of diarrhea	☐ VTE prevention: family-assisted active + passive exercise instruction + bedtime bicycle exercise ☐ Supine chest lift: lifting the chest and shoulders ☐ Arch bridge: lying on your back with your legs straight and together to lift your hips and raise your back ☐ Raising the upper body in the supine position ☐ Straightening and alternately elevating the legs in the prone position ☐ Five-point support method ☐ Flying swallow method ☐ Holding wall push-ups
	☐ Bedside activities	☐ Balance training in standing position (prevention of nerve root adhesions) ☐ Nerve root sliding exercise
	Wounds	Wounds
	☐ Infrared irradiation in case of poor healing	☐ Infrared irradiation (starting on the first postoperative day)

Additional consent provisions for collection and use of participant data and biological specimens {26b}

Consent for subject data and biological samples is also included in the informed consent form. No biological samples will be collected for this trial.

Interventions

Explanation for the choice of comparators {6b}

A total of 180 patients aged from 18 to 80 years were included. The including patients were strictly assigned to two groups according to a random assignment table. The group A undergoing traditional perioperative care and group B undergoing accelerated rehabilitation perioperative care. The responsible nurse was informed, but the patients were blind. The primary outcome was Karnofsky's functional status score (Karfsky, KPS, percentile). Secondary outcomes were the Japanese orthopedic association scale, numeric pain rating scale, length of postoperative hospital stay and urethral catheterization, patient satisfaction questionnaire, and complication rates. The follow-up was conducted by the telephone at 1 month, 3 months, and 6 months after surgery.

Intervention description {11a}

Regarding the development of the intervention, it was indeed developed by the team of nurses and the doctor involved. While the initial development may have involved these individuals, they have since created a

training manual to ensure consistency and quality in the delivery of the intervention.

Criteria for discontinuing or modifying allocated interventions {11b}

The termination criteria were as follows: (1) Emergence of other life-threatening diseases. (2) Patient demise. (3) Patient or family request to withdraw from the study. (4) Inability to contact patients for the follow-up. Medical personnel will assess whether immediate withdrawal from the study is necessary in their best interests.

Strategies to improve adherence to interventions {11c}

In the current study, inpatients will be monitored weekly by study nurses and physicians until the follow-up period. Therefore, patients will benefit from additional attention and care from the study team to ensure adherence to the study protocol.

Relevant concomitant care permitted or prohibited during the trial {11d}

Throughout the study, participants maintained their standard treatment and drug treatment procedures. It is recommended that clinicians manage participants in a usual way, but they must observe the above warnings.

Provisions for post-trial care {30}

There is no anticipated harm and compensation for trial participation.

Outcomes {12}

The primary objective of this study was to track Karnofsky (KPS) functional status score over 6 months. Follow-up was performed at 1 month, 3 months, and 6 months after operation. The secondary objective of this study was to Japanese Orthopaedic Association (JOA) score scale, numerical rating scale (NRS) [12] pain assessment, postoperative catheter indwelling time, patient satisfaction questionnaire, and complication rate over 6 months. The Perioperative assessment of this study was to Nutritional status assessment (NRS2002 Scale) [13], Bed fall/fall risk assessment [14], Pressure sore risk assessment (Braden Scale) [15], Thrombosis risk assessment (Caprini Scale) [16], Functional status assessment of activities of daily living (Barthel Scale) [17], Sleep assessment (PSQI Pittsburgh Scale) [18], Hospital Anxiety and Depression Scale (HADS) [19], and these assessments were conducted during hospitalization before and after surgery. Follow-up was performed at 1 month, 3 months, and 6 months after operation.

Participant timeline {13}

The study encompassed a follow-up period of 6 months. Informed consent was obtained from all participants. The actual intervention was concealed from both the subjects and the follow-up personnel until the end of the follow-up period, as indicated in Table 2.

Table 2 Implementation of the program evaluation schedule

Evaluation timing	Screening period	Treatment period	Visit 1	Visit 2	Visit 3	Visit 4
Evaluation	Screening	Randomization	Discharge	1 month ± 7 days	3 months ± 14 days	6 months ± 28 days
Entry criteria	√					
Signing the informed consent form	√					
Demographic Information	√					
Admission education	√					
Physical examination	√	√	√	√	√	√
Ancillary examination guidance	√	√	√	√	√	√
Guidance on preoperative precautions		√				
Intraoperative care		√				
Postoperative care		√	√			
Improvement in nursing documentation	√	√	√			
Complication occurrence		√	√	√	√	√
Discharge instructions			√			
Adverse nursing events	√	√	√			
Various evaluation forms	√		√	√	√	√
Patient satisfaction questionnaire			√			

Sample size {14}

The sample size calculation for the mean of two samples used the following parameters: $\alpha = 0.05$ (two-sided test), $\beta = 0.2$, sample ratio 1:1. Literature review and reference to KPS score results yielded the following values: $\mu A = 90$ (rehabilitation group), $\mu B = 80$ (control group), $\sigma = 9.165$ [13]. The calculated sample size for each group was 70. Accounting for a 20% dropout rate, the final planned sample size was 172. Considering site-specific conditions, the enrollment in the study aimed to reach 180 subjects.

Recruitment {15}

Recruitment from 2022–09-01 to 2024–01-01 or after the required number of patients has been reached, whichever comes first. If there are not enough registrations by the deadline, we will submit an extension application. Participants were recruited as patients attending the study conducting hospital to recruit investigators. Job announcements were also disseminated through the hospital's official website and various other online platforms, facilitating the participation of interested patients. Ultimately, eligible participants who provided written informed consent were randomized and received treatment.

Assignment of interventions: allocation

Sequence generation {16a}

A total of 180 patients will be enrolled. Participants will be randomly assigned to a 1:1 allocation, blocking randomization, with 90 participants in the ERAS group and 90 participants in the traditional rehabilitation group. Randomization will be completed prior to intervention using a computerized randomization procedure. This will be overseen by a biostatistician who is not involved in patient recruitment and data analysis. Therefore, participants and investigators were blinded until treatment was completed.

Concealment mechanism {16b}

The allocation sequence will be implemented using a central allocation system within the Electronic Data Capture (EDC) software. Instead of physical envelopes, the allocation assignments will be generated and stored digitally within the EDC system. Each allocation will be uniquely identified and securely managed within the software. The allocation status will be securely saved within the EDC system, ensuring confidentiality and integrity. Access to the allocation information will be restricted to authorized personnel only, with allocation assignments saved in password-protected files. Any changes or updates to the allocation will be logged and monitored to prevent unauthorized modifications. Additionally, the allocation results will be transmitted to a designated email address for further confirmation and record-keeping purposes. This digital approach enhances security and efficiency while maintaining the confidentiality of the allocation process.

Implementation {16c}

The designated email address will serve as a secure communication channel for managing participant enrollment and intervention assignment. This email address will be monitored by the research team responsible for generating the allocation sequence and managing participant enrollment. Allocation Sequence Generation: The allocation sequence will be generated by designated researchers or statisticians who are independent of participant enrollment and intervention assignment. Participant Enrollment: Trained research staff at each recruitment site will be responsible for enrolling participants into the trial. Intervention Assignment: Once enrolled, participants will be assigned to interventions by the same research staff based on the allocation sequence provided by the central allocation system. This process will be overseen by the principal investigator or designated lead researcher to ensure adherence to protocol.

Assignment of interventions: blinding

Who will be blinded {17a}

The study was designed in a single-blind manner, i.e., the follow-up specialist, statistician, and research assistant were blinded, but the responsible nurse had the right to know the patient's nursing and rehabilitation methods.

Procedure for unblinding if needed {17b}

The termination criteria were as follows: (1) Emergence of other life-threatening diseases. (2) Patient demise. (3) Patient or family request to withdraw from the study. (4) Inability to contact patients for the follow-up. The termination criteria will be unblinded and reported to the Clinical Research Ethics Committee of Fujian Medical University Union Hospital.

Data collection and management

Plans for assessment and collection of outcomes {18a}

General principles

(1) Admission education:

- Introduction of the supervising physician and responsible nurse.
- Guidance on ward environment, facilities, and safety management.
- Guidance on smoking and alcohol cessation.

(2) Preoperative auxiliary examination precautions:
Ensuring proper preparation for preoperative tests.

(3) Perioperative assessment:

- Nutritional status assessment (NRS2002 Scale).
- Bed fall/fall risk assessment.
- Pressure sore risk assessment (Braden Scale).
- Thrombosis risk assessment (Caprini Scale).
- Functional status assessment of activities of daily living (Barthel Scale).
- Sleep assessment (PSQI Pittsburgh Scale).
- Pain assessment (NRS Numerical Scale).
- Functional status assessment [KPS, Japanese Orthopedic Association (JOA) cervical spine scoring scale, and JOA lumbar spine scoring scale].
- Hospital Anxiety and Depression Scale (HADS).
- Patient satisfaction questionnaire.

(4) Preoperative preparation:

- Guidance on wearing appropriate clothing and personal hygiene.
- Preparation of items required for surgery.
- Preoperative functional exercises: axial turning, rehabilitation tool-wearing training, deep breathing, and effective coughing and sputum evacuation.

(5) Surgical approaches:
All procedures under general anesthesia for microchannel or vertebroplasty surgery.

(6) Intraoperative care:

- Catheterization after anesthesia and positioning in the prone position.
- Maintaining the operating room temperature at 22–26℃.
- Monitoring of patient's body temperature at the start and end of the surgery.

(7) Postoperative care:

- Level I nursing care.
- Cardiac monitoring and low-flow oxygen on the day of surgery.
- Airway maintenance.
- Observation of muscle strength, sensation, and limb movement upon awakening from anesthesia.
- Monitoring for any blood or fluid oozing from the surgical incision.
- Administration of medication as prescribed.

(8) Documentation:
Improvement in all nursing documents, including nursing orders, temperature sheets, and notification letters.

(9) Discharge:

- Dietary guidance.
- Rest and activity guidance.
- Discharge medication instructions.
- Follow-up and rehabilitation exercise guidance.

(10) Follow-up:

- Scheduled follow-ups 1 month, 3 months, and 6 months after the surgery.
- Assessment of functional status (KPS, JOA cervical spine scoring scale, and JOA lumbar spine scoring scale).
- Pain assessment (NRS numerical scoring method).
- Patient satisfaction questionnaire.
- Monitoring for the occurrence of complications.

This revised version provided a more structured and concise overview of the standardized perioperative care protocols and procedures.

Training techniques

Active cycle of breathing technique [20]:

- Patients were trained to follow their natural breathing pace while seated.
- Emphasis was placed on relaxing the chest and shoulders during training.
- Inhalation involved a slow and deep breath, holding for 3 s at the end, followed by a slow exhalation.
- Patients practiced inhaling a small amount and then performing a forceful inhale.
- Training was conducted in the hospital and continued until discharge.

Neck rehabilitation training exercises [21]:

- Patients assumed an upright posture with feet apart.
- Small head movements were repeated for 10 repetitions, with training lasting up to 5 min.
- Patients performed shoulder movements by lifting and rotating the shoulders backward, with training lasting up to 3 min.
- Head movements were repeated while using both hands to create opposing movements, with 10 rep-

etitions of different movements, within a training time of 5 min.
– Patients engaged in clockwise or counterclockwise circular neck movements, with training lasting up to 2 min.

Stress injury chain management model [22]:

– Dynamic assessment of stress injury risk in admitted patients.
– Seamless management during patient transfer and handover.
– Comprehensive management of surgical patients.
– Focused management of intensive care unit patients.
– Continuation of care management for discharged patients.

Baseline data collection

The baseline data collection included the following information:

– Demographic information
– Admission diagnosis
– Admission date
– Surgery date
– Discharge date
– Postoperative hospital stays
– Inpatient costs

This information was diligently recorded by a bedside nurse and research assistant on the day of surgery (Table 3).

Primary study endpoints

Karnofsky (Kahl, KPS, percent method) functional status score [23] The Karnofsky score assessed functional status, with higher scores indicating better health and a greater likelihood of complete treatment. Scores above 80 are generally considered independent, 50–70 semi-independent, and below 50 dependent. Patients with scores above 80 tended to have better postoperative outcomes and longer survival periods.

Secondary research endpoints

JOA Rating Scale [24] The JOA scale evaluates neurological function. JOA scores were recorded at admission, before postoperative discharge, and during three follow-up visits. The score comprised the cervical JOA score and the thoracolumbar JOA score scale.

Cervical JOA scores ranged from 0 to 17. Postoperative improvement rate was calculated as [(total postoperative score − total preoperative score)/(17 − total preoperative score)] × 100%. Treatment improvement rate categories were as follows:

– ≥ 75%: Excellent
– 50–74%: Good
– 25–49%: Moderate
– 0–24%: Poor

The total score of the thoracolumbar JOA scale was 29. Postoperative improvement rate was calculated as [(total postoperative score − total preoperative score)/(29 − total preoperative score)] × 100%. Treatment improvement rate categories were the same as for the cervical JOA scale.

NRS – Pain Assessment Pain assessment used a numerical grading method ranging from 0 to 10, where 0 represented no pain and 10 indicated severe pain. Pain level grading criteria were as follows:

– 0: No pain
– 1–3: Mild pain
– 4–6: Moderate pain
– 7–10: Severe pain

Table 3 General information

Name	Sex		Age
Education level	Career		Marital status
Admission diagnosis		Admission date	
Operation date		Discharge date	
Postoperative hospital stays		Phone number	
Discharge costs	DRG ☐ Medical insurance ☐ Self-pay ☐ Total cost Actual cost DRG		

Note: DRG, diagnosis-related group

Postoperative hospital stay The postoperative hospital stay is defined as the difference in days between the surgery date and the date of discharge from the hospital.

Postoperative indwelling catheter duration The catheter was removed immediately after the surgery for patients without a risk of urinary retention. For those at risk, catheter removal followed the principle of early removal on the second postoperative day.

Patient satisfaction questionnaire A self-developed satisfaction questionnaire assessed patient satisfaction using a 5-point scale (1–5 points). The criteria were as follows:

- 1 point: Very dissatisfied
- 2 points: Dissatisfied
- 3 points: Neutral
- 4 points: Satisfied
- 5 points: Very satisfied

The scale had a score range of 20–100, with a total score of ≥ 80 considered satisfactory. It covered areas such as communication, health promotion, nursing techniques, and symptom control. The evaluation took place at the time of discharge using a hospital-specific questionnaire.

Nutritional status assessment (NRS2002 Scale) This questionnaire employs the NRS2002 Scale to assess an individual's nutritional status. The scale utilizes a 5-point system (1–5 points) for scoring, outlined as follows:

1 point: Very malnourished.
2 points: Malnourished.
3 points: Adequate nutrition.
4 points: Well-nourished.
5 points: Very well-nourished.

The total score ranges from 10 to 50 points, with a score of ≥ 40 considered indicative of good nutritional status. The scale encompasses various aspects of an individual's nutritional intake, absorption, status, and the impact of illness. Assessment will be conducted at specific time points to understand the individual's nutritional status.

Bed fall/fall risk assessment The assessment encompasses various factors including the following: Mobility: Assessing the individual's ability to move independently or with assistance within the bed or surrounding area. Cognition: Evaluating cognitive function and awareness to understand potential risks related to confusion or disorientation. Muscle Strength and Balance: Examining the individual's muscle strength, balance, and coordination, which are crucial factors in preventing falls. Environmental Factors: Identifying any environmental hazards within the bed area that could increase the risk of falls. Medical History: Reviewing past medical history and current conditions that may contribute to fall risk, such as medications, sensory impairments, or history of falls.

The assessment utilizes a scoring system to categorize individuals into different risk levels, ranging from low to high risk. Based on the assessment findings, appropriate interventions and preventive strategies will be implemented to minimize the risk of falls and ensure the safety of the individual.

Pressure sore risk assessment (Braden Scale) The assessment considers six key factors:

- Sensory Perception: Evaluates the individual's ability to respond meaningfully to pressure-related discomfort or pain.
- Moisture: Assesses the degree to which the individual's skin is exposed to moisture, which can increase susceptibility to pressure sores.
- Activity: Considers the individual's level of physical activity and mobility, which can affect the distribution of pressure on the body.
- Mobility: Examines the individual's ability to change and control body position, reducing the duration of pressure on vulnerable areas.
- Nutrition: Assesses the individual's nutritional status, as poor nutrition can impair tissue repair and increase the risk of pressure sores.
- Friction and Shear: Considers the effects of friction and shear forces on the skin, which can contribute to tissue damage.

Each factor is scored on a scale from 1 to 4 or 1 to 3, with lower scores indicating higher risk. The total score ranges from 6 to 23, with higher scores indicating lower risk of pressure sore development. Based on the assessment findings, appropriate preventive measures and interventions can be implemented to reduce the risk of pressure sores and promote skin integrity.

Thrombosis risk assessment (Caprini Scale) This questionnaire utilizes the Caprini Scale to assess the risk of thrombosis (blood clot formation) among individuals in various clinical settings. Developed by Dr. Joseph A. Caprini, the Caprini Scale is a widely recognized tool for evaluating thrombotic risk and guiding thromboprophylaxis strategies.

The assessment considers numerous risk factors associated with thrombosis, including:

- Patient History: Evaluating the individual's medical history, including previous thrombotic events, comorbidities, and surgical interventions.
- Risk Factors: Assessing specific risk factors such as advanced age, obesity, immobility, hormone therapy, and presence of malignancy.
- Surgical Procedures: Considering the type and duration of surgical procedures, as well as associated risk factors such as anesthesia and postoperative immobility.
- Medications: Reviewing medications that may increase the risk of thrombosis, such as hormonal contraceptives or anticoagulants.
- Laboratory Values: Incorporating laboratory values such as platelet count and coagulation parameters to further refine thrombotic risk assessment.

Each risk factor is assigned a score based on its severity, and the total score provides an overall assessment of thrombotic risk. Based on the Caprini Scale score, appropriate thromboprophylaxis measures can be implemented, including pharmacological interventions, mechanical prophylaxis, and early ambulation protocols.

Functional status assessment of activities of daily living (Barthel Scale) The assessment covers a range of essential ADLs, including:

- Feeding: Ability to independently consume meals and drinks.
- Bathing: Capacity to perform personal hygiene tasks, including washing and grooming.
- Grooming: Ability to maintain personal appearance, such as brushing hair and cleaning teeth.
- Dressing: Capability to dress and undress oneself, including managing buttons and zippers.
- Toilet Use: Independence in using the toilet, including getting on and off and maintaining hygiene.
- Bladder Control: Control over bladder function and ability to manage urinary continence.
- Bowel Control: Control over bowel function and ability to manage bowel continence.
- Transfers: Capacity to move between surfaces, such as from bed to chair, with or without assistance.
- Mobility: Ability to move independently, including walking or using mobility aids.

Each ADL is assessed based on the individual's level of independence, with scores ranging from 0 (dependent) to 10 (independent). The total score provides an overall measure of functional status, with higher scores indicating greater independence in ADLs.

Sleep assessment (PSQI Pittsburgh Scale) The assessment covers seven components of sleep:

- Subjective Sleep Quality: Self-rated perception of sleep quality, including factors such as sleep depth and restfulness.
- Sleep Latency: Time taken to fall asleep after going to bed.
- Sleep Duration: Total hours of sleep obtained per night.
- Sleep Efficiency: Percentage of time spent asleep while in bed, reflecting sleep continuity.
- Sleep Disturbances: Frequency of disturbances during sleep, such as waking up in the middle of the night or difficulty breathing.
- Use of Sleep Medication: Frequency of using medication to aid sleep.
- Daytime Dysfunction: Impairment in daytime functioning attributed to sleep problems, including issues with concentration, energy levels, and mood disturbances.

Each component is scored on a scale from 0 to 3, with higher scores indicating poorer sleep quality. The total PSQI score ranges from 0 to 21, with scores greater than 5 indicating significant sleep disturbances.

Hospital Anxiety and Depression Scale (HADS) The assessment consists of 14 items, with 7 items each for anxiety and depression. Participants are asked to rate the severity of their symptoms over the past week. The questionnaire covers symptoms such as:

- Anxiety:
- Feeling tense or wound up
- Worrying excessively
- Feeling restless
- Having a sense of dread
- Feeling of apprehension
- Difficulty relaxing
- Feeling panicky
- Depression:
- Feeling down or low
- Having lost interest in activities
- Feeling pessimistic about the future
- Feeling that life is not worth living
- Feeling discouraged

- Feeling joyless
- Feeling of being slowed down

Each item is scored on a 4-point scale (0 to 3), with higher scores indicating greater levels of anxiety or depression. The total scores for anxiety and depression can range from 0 to 21, with scores categorized as follows: 0–7: Normal; 8–10: Borderline abnormal (mild); 11–14: Abnormal (moderate); 15–21: Severe.

Complication rate

Recent postoperative complications: The recent postoperative complications were as follows:

- Postoperative incision infection
- Cerebrospinal fluid leakage
- Hematoma in the operative area
- Severe pain
- Pressure skin injuries
- Pneumatosis
- Urinary tract infection
- Deep vein thrombosis

Postoperative long-term complications: The postoperative long-term complications were as follows:

- Neurological impairment
- Recurrence of spinal canal tumor
- Spinal instability

Plans to promote participant retention and complete follow-up {18b}

We will contact patients on a weekly basis to understand their intervention status, and contact them 1 week before the assessment to improve the visit rate. Researchers will contact patients who are absent from scheduled appointments and request to reschedule another appointment within 1 week.

Data management {19}

Data entry, coding, security, and storage:

Data entry: Both paper-based and electronic data entry methods will be utilized in this trial. Data will be collected by bedside nurses and research assistants.

Data entry for screening and randomization: Data collected by bedside nurses and research assistants will be entered into the database for screening and randomization purposes. This data entry will be performed by designated personnel responsible for managing the trial's database.

Data coding: Data will be coded according to predefined criteria to ensure consistency and standardization across entries. This coding process will facilitate data analysis and interpretation.

Data security: Strict security measures will be implemented to safeguard the confidentiality and integrity of trial data. Access to the database will be restricted to authorized personnel only, with password protection and user-specific access levels enforced.

Data storage: Trial data will be stored securely in electronic format within the trial's database. Regular backups will be performed to prevent data loss. Additionally, paper-based Case Report Form (CRF) data will be securely delivered to the Trial Office for data entry, ensuring the integrity of the data transfer process.

Data quality assurance processes:

Double data entry: To enhance data quality, a double data entry process will be employed, where data entered by one individual will be independently verified by another to minimize errors and discrepancies.

Range checks for data values: Range checks will be implemented to validate data values and identify any outliers or inconsistencies. This will help ensure the accuracy and reliability of the collected data.

Reference to data management procedures:

Detailed data management procedures, including data entry, coding, security, and storage protocols, will be documented in the Data Management Plan (DMP). The DMP will outline the specific steps and guidelines to be followed throughout the trial to maintain data quality and integrity.

In summary, the trial will employ both paper-based and electronic data entry methods, with stringent security measures in place to protect data confidentiality. Data quality will be ensured through processes such as double data entry and range checks, with detailed procedures documented in the Data Management Plan.

Confidentiality {27}

The privacy of all participants will be safeguarded by assigning their information a unique trial identification code, and the study data will be securely stored in a password-protected file accessible only to the data manager of the research team.

Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular analysis in this trial/future use {33}

There will be no biological specimens collected.

Statistical methods

Statistical methods for primary and secondary outcomes {20a}

Primary outcome analysis

The primary outcome (length of hospital stay) was compared between the two groups. If the data were normally distributed, an independent-sample t test was used. However, if the data did not follow a normal distribution, a Mann–Whitney *U* test, which was a nonparametric test, was employed.

Secondary outcome analysis

The secondary outcomes were analyzed based on their nature.

Binary outcomes, such as complication rates, were compared using a chi-squared test or Fisher's exact test, depending on the specific circumstances of the data.

Continuous outcomes, such as quality-of-life scores, were compared using a t test if the data were normally distributed. If the data did not meet the assumption of normality, a Mann–Whitney *U* test, which was a nonparametric test, was used.

Assessment of data normality

Various methods were employed, including the Shapiro–Wilk test and Q-Q plots, to determine whether the data were normally distributed. If the data were not normally distributed, appropriate nonparametric tests were used.

Adjustment for confounders

Multivariable regression analyses were conducted to adjust for potential confounding factors. Variables such as age, sex, and baseline comorbidities were included in the regression models to account for their potential influence on the outcomes.

Significance level

All statistical analyses were conducted using a statistical software package. A P value of less than 0.05 indicated a statistically significant difference between the two groups for the analyzed outcome.

This comprehensive statistical analysis aimed to thoroughly evaluate the primary and secondary outcomes, ensuring that the results were robust and reliable. It also considered potential confounding factors that might affect the outcomes, helping to control for these variables in the analysis.

Interim analyses {21b}

When approximately 10% of our samples complete subsequent evaluations, a mid-term analysis will be conducted. The preliminary research results will be announced at the meeting to promote our research.

Methods for additional analyses (e.g., subgroup analyses) {20b}

Other analysis will include the analysis of the sub-group to estimate the therapeutic effect of women and male participants.

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

We will primarily conduct an intent-to-treat (ITT) analysis as stated in the protocol. However, we acknowledge the possibility of non-adherence to the intervention among participants randomized to the intervention arm. In such cases, we will perform sensitivity analyses using imputation techniques to assess the robustness of our results to missing data assumptions. Imputation methods such as multiple imputation or model-based imputation will be employed to estimate missing data values based on observed data and underlying assumptions. Additionally, we may consider using mixed models to handle missing data and account for within-subject correlation. These analyses will provide a comprehensive evaluation of the intervention's effectiveness while addressing potential biases introduced by missing data.

Plans to give access to the full protocol, participant-level data, and statistical code {31c}

The protocol has been uploaded to ClinicalTrials. gov. The data for this study will also be obtained from the main researchers upon reasonable request.

Oversight and monitoring

Composition of the coordinating center and trial steering committee {5d}

We established an independent Data and Safety Monitoring Board (DSMB) for this study, which was not funded by any particular organization. The committee consists of a physician and a statistician who will oversee trial design and adherence to standard guidelines.

1. Composition and responsibilities:

Coordinating Center:

The Coordinating Center, based at Fujian medical union hospital, comprises experienced researchers, project managers, and data analysts. Its responsibilities include overall trial management, coordination of site activities, data management, and communication with stakeholders.

Trial Steering Committee (TSC):

The TSC consists of key stakeholders, including principal investigators, statisticians, independent experts, and

patient representatives. This committee oversees trial conduct, safety, and progress, making decisions to ensure the integrity of the trial.

Day-to-Day Support Groups:

Various support groups, such as recruitment teams, consent teams, data managers, and administrative staff, provide essential day-to-day support. They facilitate recruitment, ensure informed consent processes, manage data collection, and handle administrative tasks.

2. Local organization and recruitment:

Local teams at each trial site are responsible for organizing recruitment efforts, identifying potential participants, and obtaining informed consent.

These teams receive training and ongoing supervision to ensure adherence to trial protocols and ethical guidelines.

3. Supervision and meeting frequency:

A designated supervisory body, led by Chief of Neurosurgery in Fujian medical union hospital, oversees the trial's progress and compliance with regulations.

Supervisors meet bi-weekly to review trial data, address any emerging issues, and make decisions regarding trial conduct and adjustments to protocols.

The TSC convenes monthly to monitor trial progress, review safety data, and ensure adherence to protocols. Additional ad hoc meetings may be scheduled as needed.

Composition of the data monitoring committee, its role and reporting structure {21a}

Trial design and adherence to standard guidelines will be overseen by DSMB. It is governed by the DSMB charter, which outlines its purpose and terms of reference. The DSMB consists of a surgeon (Chair), a statistician, and a nurse. Confidentiality will be strictly maintained throughout all phases of DSMB review and deliberations. Only voting members of the DSMB will have access to interim analyses of outcome data by treatment group. Exceptions for access to interim analyses, and the reasons for granting them, will be documented in the Closed Session Report. DSMB members are committed to maintaining strict confidentiality regarding all privileged study results provided to them. The DSMB reviews data only with masked study group identifiers. Whenever masked data are presented to the DSMB, the key to the group coding must be readily available for immediate unmasking. Members of the DSMB are prohibited from direct participation in the research, and they must not have any potential to influence the financial, proprietary, professional, or other interests of the DSMB for fair and independent decision-making.

Adverse event reporting and harms {22}

All serious adverse events (SAEs) must be reported immediately to the Principal Investigator, Ethics Committee and DSMB within 24 h of onset, and include postoperative incision infection, cerebrospinal fluid leakage, hematoma in the operative area, severe pain, pressure skin injuries, pneumatosis, urinary tract infection, deep vein thrombosis, neurological impairment, recurrence of spinal canal tumor, and spinal instability. After thorough discussion and evaluation of these issues by the DSMB and the Principal Investigator, they will have the right to decide at their discretion whether it is necessary to discontinue the trial.

Frequency and plans for auditing trial conduct {23}

The DSMB will convene regularly to conduct ongoing reviews of the trial's progress, both at scheduled intervals every 3 months and throughout the duration of the trial. The DSMB is responsible for ensuring the timeliness, completeness, and accuracy of trial data, thereby necessitating investigators to promptly address any deficiencies or inaccuracies in their reporting. Additionally, a coordinating center will assume responsibility for managing day-to-day operations and providing comprehensive organizational support.

Plans for communicating important protocol amendments to relevant parties (e.g., trial participants, ethical committees) {25}

Any modifications to the trial protocol must be communicated to and approved by the Ethics Committee of Beijing Rehabilitation Hospital before being implemented. In cases where important protocol modifications may affect the study's conduct, they will also be reported to the trial registries.

Dissemination plans {31a}

The results of the research will be published in the journal of peer review, and immediately spread to medical care professionals, public and other related groups after the results are announced. Investors have no effect or restrictions in the publishing decision.

Discussion

This trial represented a significant milestone in evaluating perioperative rapid rehabilitation for intradural extramedullary spinal tumors [25]. To date, no similar RCTs have addressed this specific topic. The primary hypothesis of this trial was that perioperative rapid rehabilitation demonstrated superior efficacy compared with standard care.

Rapid perioperative rehabilitation in spine surgery, often referred to as ERAS, has gained considerable attention due to its potential to improve patient outcomes by reducing the body's stress response to surgery and maintaining postoperative physiological function. This approach encompassed various aspects of patient care, starting from optimizing preoperative health, including nutrition and education, and extending through standardized anesthesia and surgical procedures, to effective postoperative pain management and early mobilization.

The benefits of implementing ERAS protocols are substantial, including enhanced patient outcomes and satisfaction, reduced hospital stay duration, cost-effectiveness, quicker return to normal function, minimized surgical stress response, and improved pain management. By adopting ERAS, healthcare providers can deliver more efficient care, leading to faster recovery, increased patient satisfaction, and significant cost savings. However, fewer clinical studies have focused on perioperative rapid rehabilitation for intradural extramedullary spinal tumors compared with conventional care, leading to a lack of consistency in its effectiveness.

Patients were randomly assigned to either the rapid rehabilitation or conventional care group after tumor resection in this trial. The primary aim was to examine and compare the clinical outcomes in patients with intradural extramedullary spinal tumors following surgery. This RCT is expected to provide high-quality evidence regarding the effectiveness of rapid rehabilitation during the perioperative period for intradural extramedullary spinal tumors.

In conclusion, this multicenter RCT represented a critical step in assessing the effectiveness of rapid rehabilitation during the postoperative period for intradural extramedullary spinal tumors. If the hypothesis is confirmed upon completion of the trial, it has the potential to promote the widespread adoption of rapid rehabilitation, ultimately improving patient prognosis.

Trial status

The current trial protocol is version V1.0 dated 2022–04-03. The recruitment period is "2022–09-01 to 2024–01-01." The end date for study completion is 2024–07 -01.

Abbreviations

ERAS	Enhanced recovery after surgery
PCER	Perioperative Care of Enhanced Recovery
CPC	Conventional perioperative care protocols
RCT	Randomized controlled trial
MRI	Magnetic resonance imaging
CT	Computed tomography
EDC	Electronic data capture
JOA	Japanese Orthopedic Association
HADS	Hospital Anxiety and Depression Scale

Acknowledgements
The authors thank all the participants in this study.

Authors' contributions {31b}
JC and LC wrote the grant application and designed the trial. JC and LC conducted the power analysis and wrote the analytic plan in consultation with an independent statistician. XH and ZX will supervise the implementation of the study. YS and FL will oversee study recruitment and data collection efforts. The project staff will meet monthly (at a minimum) to coordinate and monitor recruitment and data collection activities. JC and LC contributed to writing the first drafts of this manuscript. JC and LC have contributed equally to this work and are co-first-authors. All authors edited and approved the final manuscript.

Funding {4}
This work was funded by Technology and Innovation Foundation of Fujian, China (grant No.2021Y0021 to RW).

Availability of data and materials {29}
The data that support the findings of this study are available on request from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate {24}
This study received ethical approval from the ethics committee of Union Hospital, Fujian Medical University, China (Grant No. 2020YF034-01), and is registered with the China Clinical Trials Registry (Project No: ChiCTR2000040508).

Consent for publication {32}
Not applicable—no identifying images or other personal or clinical details of participants are presented here or will be presented in reports of the trial results. The participant information materials and informed consent form are available from the corresponding author on request.

Competing interests {28}
The authors declare that they have no ccompeting interests.

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Received: 13 December 2023 Accepted: 3 June 2024
Published online: 24 August 2024

References

1. Qin TY, Wang LC. A study of surgical approaches for intradural tumors. J Medical Letter [J]. 2019;22:35–8.
2. Meola A, Soltys S, Schmitt A, et al. Stereotactic Radiosurgery for Benign Spinal Tumors [J]. Neurosurg Clin N Am. 2020;31(2):231–5.
3. Gui-Huai Wang. Intradural tumors. J Chinese Journal of Modern Neurological Diseases [J]. 2013;12:983–5.
4. Zhao JZ. Neurosurgery [M]. Beijing: People's Health Publishing House; 2019.
5. Schellinger KA, Propp JM, Villano JL, et al. Descriptive epidemiology of primary spinal cord tumors [J]. J Neurooncol. 2008;87(2):173–9.
6. Wang XG, Ding LSM. Clinical efficacy analysis of laminoplasty and laminectomy combined with nail rod internal fixation in the resection of intravertebral tumors. J Medical Review [J]. 2020;11:2270–4.
7. Zhao Huanyan,Gou Haichao,Li Jihua,et al. Microsurgical treatment of intravertebral canal tumors under neurophysiological monitoring. J Modern Instruments and Medicine [J].2019,01:33–6.
8. Xia LL, Tang J, Huang SL. Primary intraspinal benign tumors treated surgically: an analysis from China. Br J Neurosurg. 2021;35(5):603–6. https://doi.org/10.1080/02688697.2021.1923648. (Epub 2021 Jun 4 PMID: 34085892).

9. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation [J]. British journal of anaesthesia. 1997;78(5):606–17.
10. Nygren J, Thacker J, Carli F, et al. Guidelines for perioperative care in elective rectal/pelvicsurgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations[J]. Clinical nutrition (Edinburgh,Scotland). 2012;31(6):801–16.
11. Sun TS, Shen JX, Liu ZJ, et al. Accelerated rehabilitation of spine surgery in China - expert consensus on perioperative management strategies [J]. Chinese Journal of Bone and Joint Surgery. 2017;10(004):271–9.
12. Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP) [J]. Arthritis care & research. 2011;63 Suppl 11:S240-52.
13. Poulia KA, Klek S, Doundoulakis I, Bouras E, Karayiannis D, Baschali A, Passakiotou M, Chourdakis M. The two most popular malnutrition screening tools in the light of the new ESPEN consensus definition of the diagnostic criteria for malnutrition. Clin Nutr. 2017;36(4):1130–5.
14. Morse JM. Preventing patient falls: establishing a fall intervention program[M]. Springer Publishing Company; 2009. https://api.semanticscholar.org/CorpusID:57199224.
15. Bergstrom N, Braden BJ, Laguzza A, Holman V. The Braden Scale for Predicting Pressure Sore Risk. Nurs Res. 1987;36(4):205–10.
16. Caprini JA. Thrombosis risk assessment as a guide to quality patient care. Dis Mon. 2005;51(2–3):70–8.
17. Katz S. Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. J Am Geriatr Soc. 1983;31(12):721–7.
18. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213.
19. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand. 1983;67(6):361–70.
20. Huang Y, Lv Y, Wang DM. Effect of active respiratory circulation technique on pulmonary function rehabilitation in patients with chest trauma[J]. Chinese Journal of Lung Diseases (Electronic Version). 2021;14(6):749–52.
21. Yang L. Application and efficacy of cervical traction combined with cervical rehabilitation exercise training in the rehabilitation of patients with cervical spondylosis [J]. World abstract of the latest medical information. 2019;19(39):111–4.
22. Zhang Yu. Study on the application of perioperative pressure injury chain management in patients undergoing prone surgery in spine surgery [D]. Jilin: Jilin University of Nursing; 2020.
23. Terret C, Albrand G, Moncenix G, et al. Karnofsky Performance Scale (KPS) or Physical Performance Test (PPT)? That is the question [J]. Crit Rev Oncol Hematol. 2011;77(2):142–7.
24. Kato S, Oshima Y, Oka H, et al. Comparison of the Japanese Orthopaedic Association (JOA) score and modified JOA (mJOA) score for the assessment of cervical myelopathy: a multicenter observational study [J]. PLoS ONE. 2015;10(4):e0123022.
25. Wang Y, Liu B, Zhao T, et al. Safety and efficacy of a novel neurosurgical enhanced recovery after surgery protocol for elective craniotomy: a prospective randomized controlled trial[J]. J Neurosurg. 2018;130(5):1680-91. https://pubmed.ncbi.nlm.nih.gov/29932379/.

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