

Original Article

Development of an early mobilization practice for critically ill patients in intensive care units: a Delphi method study

Biantong Jiang, Huan Liu, Yao Liu, Yongming Tian, Mengzhen Nie, Wenwen Jing, Aiping Du

Department of Critical Care Medicine, West China Hospital/West China School of Nursing, Sichuan University, Chengdu 610041, Sichuan, China

Received April 2, 2024; Accepted June 19, 2024; Epub August 15, 2024; Published August 30, 2024

Abstract: Objective: To develop a comprehensive and evidence-based early rehabilitation framework for critically ill patients, aiming to establish a systematic and scientifically grounded rehabilitation system. Methods: A Delphi survey study was conducted, involving two rounds of consultations with 24 experts from critical care medicine, nursing, respiratory therapy, and rehabilitation medicine. Based on evidence from the literature, a draft rehabilitation system was created and evaluated using a Likert 5-point scale. Entries were refined based on expert feedback, with criteria for inclusion being a mean score ≥ 4 , a coefficient of variation < 0.25 , and agreement (percentage of ratings as “very important” or “important” and “very operative” or “strong operability”) $\geq 75\%$. Entries were modified or deleted according to expert suggestions. Results: The survey achieved recall rates of 95.8% (23/24) and 86.9% (20/23) in the first and second rounds, respectively. The experts’ judgment basis, familiarity, and authority coefficients were 0.96, 0.94, and 0.95, respectively. Following the initial round, 20 questionnaire entries were amended, 14 new entries were added, and 1 was deleted. The second round of Delphi consultations resulted in an early rehabilitation system consisting of 5 primary indicators, 21 secondary indicators, and 56 tertiary indicators, totaling 82 entries. Conclusions: This study established the first Chinese early rehabilitation system for critically ill patients based on the scientific Delphi method. It provides a structured framework that can serve as a reference for early rehabilitation practices in settings for critically ill patients.

Keywords: Critically ill patients, early rehabilitation, Delphi method

Introduction

With advancements in emergency resuscitation and organ support technologies, the scope of critical care medicine has broadened significantly. Beyond saving lives, enhancing patient outcome, and extending survival, there is a growing emphasis on improving quality of life. Early mobilization in critical care, widely endorsed by specialists, has been increasingly integrated into clinical practice as a vital component of holistic treatment for critically ill patients. Numerous studies have demonstrated that early rehabilitation aids in recovery from dysfunction, enhances quality of life, and facilitates a quicker return to society [1-3].

Early rehabilitation for critically ill patients requires a multidisciplinary approach to pro-

vide comprehensive, rapid, and precise rehabilitation services. This includes timely assessment, safety screening, robust nutritional support, appropriate sedation and analgesia, cardiopulmonary and exercise rehabilitation, psychological support, and health education [4]. However, practical implementation faces significant challenges due to limitations in manpower, equipment, and medical reimbursement [5, 6]. The involvement of multidisciplinary teams and the allocation of resources are major impediments. Often, early rehabilitation practices focus primarily on early exercise and pulmonary rehabilitation, which may not fully meet the actual needs of patients and lack standardized quality control and management. The configuration of human resources, equipment availability, facility conditions, and tailoring interventions to individual patient levels are

Early mobilization in ICUs

critical factors influencing the effective execution of early rehabilitation.

A survey of 444 ICUs in China revealed that 55 ICUs did not implement early rehabilitation. 167 ICUs had partially implemented or were experimenting with early rehabilitation involving both active and passive patient activities in bed, and only 86 ICUs practiced comprehensive early rehabilitation [7].

Early rehabilitation in ICUs requires careful consideration of human resources, equipment, facility conditions, and patient-specific needs. Our study aims to develop and standardize a multidirectional, multimodal early rehabilitation system for critically ill patients by synthesizing existing research. This effort seeks to serve as a reference for standardized clinical management and quality control for early rehabilitation.

Methods

Design

Literature review: A comprehensive literature review was conducted using databases such as PubMed, Web of Science, Embase, CINAHL, China National Knowledge Infrastructure, Wanfang, Chinese BioMedical Database, and guideline repositories including National Guideline Clearinghouse, Registered Nurses' Association of Ontario, Scottish Intercollegiate Guidelines Network, New Zealand Guidelines Group, National Institute for Health and Care Excellence, Society of Critical Care Medicine, European Respiratory Society, European Society of Intensive Care Medicine, and Chinese Medical Association. Manual searches were also performed. The search terms included combinations of "critical illness/ICU/intensive care unit", "early", and "rehabilitation/exercise/activity". Literature screening spanned from the inception of each database to January 2023. Following this, 11 studies [8-20], comprising 5 guidelines and 6 consensus documents, were selected. Based on these documents, a draft early rehabilitation system for critically ill patients was developed, aligned with the objectives of this study. The study received ethical approval from the Ethics Committee on Biomedical Research at West China Hospital of Sichuan University (No. 2021-813).

Pilot survey: Prior to initiating the Delphi process, a pilot survey was conducted with five experts from Critical Care Medicine, Rehabilitation Medicine, and Critical Care Nursing to assess the readability and feasibility of the draft early rehabilitation system. Feedback from this preliminary survey was used to finalize the first version of the Delphi questionnaire. The questionnaire was structured into three sections:

Instructions: Provides background, objectives, and detailed guidance on how to complete the questionnaire.

Early rehabilitation System Chart (Draft): Presents the early rehabilitation system for critically ill patients, including items at all levels, their significance and operability, and a column for expert opinion. Each item's significance and operability are rated on a 5-point Likert scale, ranging from "very unimportant" to "very important" and "no operability" to "strong operability".

Expert Information: This gathers data on the authority and general background of the experts involved.

Participants

The inclusion criteria for Delphi experts were established prior to recruitment. Eligible experts were required to hold at least a medium-grade professional title and a bachelor's degree. Additionally, they needed to have a minimum of 10 years of experience in Critical Care Medicine, Critical Care Nursing, Respiratory Therapy, or Rehabilitation Medicine, or possess significant academic influence in these fields. Participation was voluntary, with a strong emphasis on high motivation.

Delphi method

First round of the Delphi process: The initial questionnaire was distributed by email to 24 experts. They were asked to rate the significance and operability of 70 items and provide suggestions for modifications or deletions. We received 23 completed questionnaires. Items meeting the criteria of an average score ≥ 4 , a coefficient of variation < 0.25 , and an agreement percentage (proportion of ratings as "Very Important"/"Important" or "Highly Operable"/

Early mobilization in ICUs

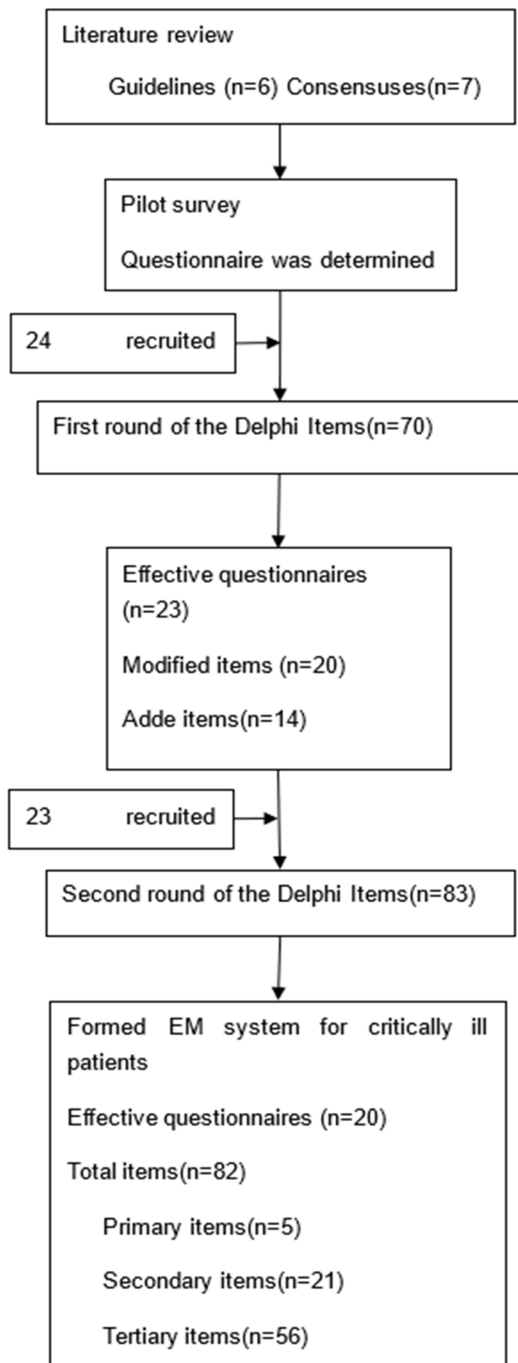


Figure 1. Flow diagram of Delphi process. EM, early mobilization.

“Operable”) $\geq 75\%$ were retained. Items were then deleted or modified based on expert feedback, and a second-round questionnaire was developed.

Second round of the Delphi process: The second round was conducted similarly to the first,

with the revised questionnaire containing 82 items. It was emailed to the same 23 experts, and 20 valid responses were collected. After two rounds, a consensus was reached, concluding the inquiry process (**Figure 1**).

Data analysis

Data entry was performed by two individuals using EpiData 3.1, and statistical analysis was conducted using Excel and SPSS 17.0. Descriptive statistical analysis of the experts' general situation included frequency and agreement percentage. The authority and reliability of the consultation results were assessed using the positive coefficient of experts, the degree of experts' authority, and the consistency of experts' opinions.

Results

Expert information, enthusiasm, and authority

In the first Delphi round, 24 questionnaires were distributed, with 23 valid responses received, resulting in an effective recovery rate of 95.8%. The expert authority coefficient (Cr) was 0.95. In the second round, 23 questionnaires were distributed, and 20 valid responses were collected, giving a recovery rate of 86.9% with the same expert authority coefficient. The Delphi experts' fields of expertise included Critical Care Medicine, Critical Care Nursing, Respiratory Therapy, and Rehabilitation Medicine. **Table 1** displays the demographic characteristics of the experts.

Results of the first round of correspondence

From the first round, the coefficient of variation for item significance was 0.039, with an average consistency percentage of 96.54%. The operability evaluation consistency percentage for the five primary indicators was 90.46%. The secondary indicators, comprising 19 items, showed consistency percentages of 97.05% for significance and 93.38% for operability. The tertiary indicators included 46 items, with coefficients of variation for significance and operability at 0.053 and 0.108, respectively. These results are detailed in **Table 2**.

Based on feedback from the 23 experts and subsequent group discussions, several items were revised as follows:

Early mobilization in ICUs

Table 1. Demographic characteristics of the Delphi expert group

	First round (n=23)	Second round (n=20)
Age (years old), n (%)		
≤39	2 (8.70%)	1 (5.00%)
40-49	17 (73.91%)	15 (75.00%)
≥50	4 (17.39%)	4 (20.00%)
Education, n (%)		
Bachelor	9 (39.12%)	8 (40.00%)
Master	4 (17.4%)	4 (20.00%)
Ph.D	10 (43.48%)	8 (40.00%)
Professional title, n (%)		
Medium-grade	1 (4.34%)	0
Senior	22 (95.66%)	20 (100%)
Working years, n (%)		
10-19	5 (21.74%)	4 (20.00%)
20-29	13 (56.52%)	11 (55.00%)
≥30	5 (21.74%)	5 (25.00%)
Working field, n (%)		
Rehabilitation medicine	6 (26.09%)	3 (15.00%)
Critical medicine	2 (8.7%)	2 (10.00%)
Critical care	14 (60.87%)	14 (70.00%)
Respiratory therapy	1 (4.34%)	1 (5.00%)

Item Revisions: (1) “Early rehabilitation organization and management” was updated to “Early Rehabilitation Practice Organization and Management”. (2) For the item “1.1.1 Multidisciplinary Rehabilitation Team”, the term “nurse” was replaced with “psychological consultant” and “leading member or practice initiator”, resulting in the revised item: “1.1.1 The multidisciplinary rehabilitation team primarily includes clinicians, nurses, and rehabilitation therapists. Respiratory therapists, psychotherapists, or family members can also participate”. (3) “1.2 Personnel Training” was expanded to “1.2 Personnel Training and Assessment”, incorporating the development of rehabilitation learning content and assessment requirements for different team members. (4) “1.3 Emergency Plan Formulation and Exercise” and its subordinate items were revised to: “1.3 Development of Early Rehabilitation Practice Process and Management Specifications; 1.3.1 Practice Process: Evaluation-Solution Formulation-Implementation-Effect Evaluation; 1.3.2 Management Specifications: Quality Evaluation, Emergency Plan, etc.”. (5) Regarding the item “2.4 Safety Screening Contraindications”,

experts suggested revisions due to the lack of objective evaluation methods and unclear sequence in contraindication items. The item was subsequently revised to: “2.4 Safety Screening, the following are contraindications, and meeting one or more items indicates a contraindication; 2.4.3 Severe respiratory and/or circulatory instability: or heart rate >140 beats/min; or heart rate <40 beats/min; or pulse oxygen saturation <88%; or respiratory rate >40 or <10/min; 2.4.4 Patient safety cannot be guaranteed due to non-patient factors”. (6) “Psychological rehabilitation” was revised to “psychological support”, and the order of the “three early rehabilitation practice solutions” was updated to: “Pain management and Sedation, Position management, exercise rehabilitation, cardiopulmonary rehabilitation, psychological support”. Additionally, “muscle strength” in the patient status assessment was updated to “limb muscle strength”. (7) For item 3.1 level 1, “upper and lower limb joint mobilization exercise” was modified to “exercise of joint range of motion and muscle strength”. Item 3.1.5, Cardiopulmonary rehabilitation, was updated to include “chest tapping, intercostal muscle mobilization, chest mobilization; airway clearance technology; external diaphragm pacing training; lung recruitment training”. (8) For 3.2 level 2, “superior solution” was revised to “level 1”. (9) For 3.3 level 3, “superior solution” was revised to “level 2”, and item 3.3.4, exercise rehabilitation, was revised to include “conduct bedside and out-of-bed activities and transfer training to achieve bedside sitting, bed and chair transfer, bedside standing, assisted walking, and autonomous walking, based on the secondary solution”. Item 3.3.5, cardiopulmonary rehabilitation, was updated to “cough training, breathing training, lung recruitment training, six-minute walk test, based on the secondary solution”. (10) Pause indicators were refined: 4.3 respiratory rates adjusted to “<10 or >40/min”; 4.5 was revised to “Richmond Agitation and Sedation Scale (RASS) ≥+2 points or aggressive behavior”; 4.6 was updated to “the patient complained of intolerance; or the patient showed discomfort or refusal to the medical staff through gestures and expressions”. (11) In the rehabilitation practice evaluation, 5.1.3 was initially revised as “medical staff/bed ratio (e.g., doctor/patient, nurse/patient, and technician/patient)”. It was later updated to “early rehabilitation assessment

Early mobilization in ICUs

Table 2. Consistency of expert opinions in the first round

Item	Significance			Operability		
	Mean ± SD	CV	Agreement percentage	Mean ± SD	CV	Agreement percentage
Primary indicators (5 items)	4.95±0.19	0.039	96.54%	4.89±0.28	0.058	90.46%
Secondary indicators (19 items)	4.95±0.04	0.038	97.05%	4.89±0.34	0.071	93.38%
Tertiary indicators (46 items)	4.92±0.26	0.053	95.70%	4.78±0.51	0.108	84.80%

rate within 24 h” following expert feedback that the original expression was inappropriate.

Additions and deletions: (1) “2.5 Order early rehabilitation medical advice” was added as a new item. (2) “Environmental awareness exercise” was included in “3.1.6 Psychological support”. (3) Items 3.1.7, 3.1.8, and 3.1.9 were added to tailor the level of individualization, varying the intensity from weak to strong, the duration from short to long, and the frequency from less to more. (4) “Heart position” was incorporated into item 3.2.3, and “family member accompaniment (or via video call)” was added to item 3.2.6. (5) “Fiberoptic bronchoscopy” was removed from the tertiary solution in item 3.1.5, and “moderate analgesia” was added to item 3.3.2 in sedation and analgesia management. (6) “4.7 adverse events occurred” was introduced as a new item. (7) Outcome indicators such as “incidence of ICU acquired weakness (ICU-AW), Pressure Injury (PI), Venous Thromboembolism (VTE), and ICU hospitalization cost” were added to further define the study’s objectives and outcomes.

Results of the second round of correspondence

In response to the first round’s feedback, we modified 20 items, added 14, and deleted 1 from the questionnaire. Consequently, the revised draft featured 5 primary indicators, 21 secondary indicators, and 56 tertiary indicators, totaling 82 items. The second round of the Delphi inquiry was conducted through correspondence (see **Table 3**). The significance consistency for the item “1.2.5 Training and Assessment of Other Personnel, Knowledge, and Skills Related to Critical Care Rehabilitation” was approximately 75.00%. After group discussions, this indicator was deemed crucial to the study’s content and was retained. The item “5.2.4 Early Rehabilitation Compliance Rate”, which includes the compliance rates for

passive and active exercise rehabilitation and correct postural therapy implementation, had an operability consistency of about 70%. Despite initial concerns about its limited operability, it was ultimately retained following discussions that affirmed its relevance in evaluating early rehabilitation compliance.

After two rounds of Delphi inquiries, a structured early rehabilitation system for critically ill patients was established, comprising 5 primary indicators, 21 secondary indicators, and 56 tertiary indicators (**Table 3**).

Discussion

This study represents the first effort to standardize the management of early mobilization for critically ill patients in China. Drawing on an extensive literature review, we engaged clinical experts from Critical Care Medicine, Nursing, Respiratory Therapy, and Rehabilitation Medicine. The Delphi survey method was utilized to ensure the methodology’s authority and rigor. All participating experts were affiliated with third-grade first-class hospitals and possessed at least a bachelor’s degree, an intermediate or higher professional title, and extensive experience in severe clinical and critical care rehabilitation. Their deep understanding of early mobilization for critically ill patients allowed them to provide authoritative opinions and recommendations for developing effective rehabilitation solutions. This approach yielded a high level of consistency in expert opinions, underscoring the robustness of the findings and the proposed early mobilization system.

Previous studies on early mobilization of critically ill patients primarily focused on the implementation of patients’ early mobilization or lung rehabilitation protocols, often overlooking crucial aspects such as organizational management, personnel and equipment preparation, quality control, and evaluative measures [21-

Early mobilization in ICUs

Table 3. Items in the consensus on early rehabilitation for critically ill patients

Item	Significance			Operability		
	Mean ± SD	CV	Agreement percentage	Mean ± SD	CV	Agreement percentage
1. Organization and management of early rehabilitation practice	4.90±0.31	0.063	90.00%	4.95±0.22	0.045	95.00%
1.1 Establishment of a multidisciplinary team	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
1.1.1 The multidisciplinary rehabilitation team mainly includes clinicians, nurses and rehabilitation therapists. Respiratory therapists, psychotherapists or family members can also participate	4.95±0.22	0.045	95.00%	4.80±0.41	0.085	80.00%
1.1.2 Development of team members' responsibilities and management system	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
1.2 Training and assessment	4.95±0.23	0.045	95.00%	4.90±0.31	0.063	90.00%
1.2.1 Development of knowledge of rehabilitation and assessments for various team members	4.90±0.31	0.063	90.00%	4.90±0.31	0.063	90.00%
1.2.2 Training and assessment of clinicians: theories and skills related to critical care rehabilitation medicine	4.85±0.37	0.076	85.00%	4.85±0.37	0.076	85.00%
1.2.3 Training and assessment of nurses: theories and skills related to critical care rehabilitation nursing	4.90±0.31	0.063	90.00%	4.95±0.22	0.045	95.00%
1.2.4 Training and assessment of rehabilitation therapist: theories and skills related to Rehabilitation Medicine of critical illness patients	4.90±0.32	0.063	90.00%	4.85±0.37	0.076	85.00%
1.2.5 Training and assessment of other personnel: knowledge and skills related to Rehabilitation Medicine of critical illness patients	4.75±0.44	0.094	75.00%*	4.80±0.41	0.085	80.00%
1.3 Formulation of practice process and management specifications of early rehabilitation	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
1.3.1 Early mobilization process: evaluation, formulation of solution, implementation and effect evaluation	5.00±0.00	0.000	100.00%	4.85±0.37	0.076	85.00%
1.3.2 Management specifications: quality evaluation and emergency plan	4.95±0.22	0.045	95.00%	4.80±0.52	0.109	85.00%
2. Practice preparation for early rehabilitation	4.95±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
2.1 Informed consent of patients (or family members)	4.85±0.50	0.101	90.00%	4.95±0.22	0.045	95.00%
2.2 Preparation of team members involved in early rehabilitation	4.90±0.31	0.063	90.00%	4.80±0.41	0.085	80.00%
2.3 Rehabilitation equipment, rescue equipment, and environmental preparation	4.90±0.31	0.063	90.00%	4.95±0.22	0.045	95.00%
2.4 Safety screening revealed the followings contraindications, and meeting one or more of them was the contraindication	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
2.4.1 Richmond Agitation-Sedation Scale ≥+2 points or patients in an aggressive tendency	4.95±0.23	0.045	95.00%	4.95±0.22	0.045	95.00%
2.4.2 Patients were in rescue status	4.95±0.24	0.045	95.00%	5.00±0.00	0.000	100.00%
2.4.3 Severe respiratory and (or) circulatory instability: heart rate >140 beats/min, or heart rate <40 beats/min, or pulse oxygen saturation <88%, or respiratory rate >40 or 10/min	4.95±0.25	0.045	95.00%	4.90±0.31	0.063	90.00%
2.4.4 Patient safety could not be guaranteed due to non-patient factors	4.95±0.26	0.045	95.00%	4.85±0.49	0.101	90.00%
2.5 Medical advice for early rehabilitation	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%
3. Early rehabilitation program	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
3.1 Level 1	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.1.1 Patient status: Richmond Agitation-Sedation Scale ≤2; or oxygenation index ≤100 mmHg or patients have unstable circulation and need vasoactive drugs, or limb muscle strength < Level 2	4.90±0.31	0.063	90.00%	4.90±0.31	0.063	90.00%
3.1.2 Pain management and Sedation: Target-oriented individualized analgesia and sedation	4.85±0.37	0.076	85.00%	4.85±0.37	0.076	85.00%
3.1.3 Position management: Raising the head of the bed by 30°-45°, left and right lateral recumbent position, slope recumbent position, prone position, cardiac position, and other therapeutic positions as required	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%
3.1.4 Exercise rehabilitation: to increase joint range of motion and muscle strength prioritizing passive activities; acupuncture therapy; and neuromuscular electrical stimulation	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%

Early mobilization in ICUs

3.1.5 Cardiopulmonary rehabilitation: Chest tapping, intercostal muscle loosening, chest loosening, airway clearance technology, diaphragm pacing training in vitro, and lung re-expansion training	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%
3.1.6 Psychological support: Cognitive training (time, space, and self), hearing training, and environmental awareness training	4.85±0.49	0.101	90.00%	4.85±0.37	0.076	85.00%
3.1.7 The rehabilitation solutions described above were gradually developed based on the level of individualization, with the intensity ranging from weak to strong, the implementation time running from short to long, and the implementation frequency differing from less to more	4.95±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
3.2 Level 2	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.2.1 Patient status: -1≤ Richmond Agitation-Sedation Scale ≤1, or 100 mmHg < oxygenation index ≤200 mmHg, or the relatively stable circulation, or Level 2≤ limb muscle strength ≤ Level 3	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.2.2 Sedation and analgesia management: With painless comfort as the goal, sleep management was improved, and analgesic and sedative sleep was administered as needed	4.90±0.31	0.063	95.00%	4.85±0.37	0.076	85.00%
3.2.3 Position management: Based on Level 1, postural adaptability training was performed, including 90° side position, side prone position, heart position, bed sitting position	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.2.4 Exercise rehabilitation: Based on level 1, active training was performed, which included grip strength training, resistance training, chest-expanding exercise, bridge-style movement, active joint training, ankle pump exercise, bed bicycle, and bedside transfer training	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.2.5 Cardiopulmonary rehabilitation: Based on level 1, bed bicycle training, active breathing and circulation technology, cough training, and bedside transfer training were performed	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
3.2.6 Psychological support: Based on level 1, attention, thinking, and activities of daily living training were carried out, as well as family member accompaniment (or via video), anti-anxiety/depression, and confidence-building	5.00±0.00	0.000	100.00%	4.90±0.31	0.063	90.00%
3.2.7 The rehabilitation solutions described above were gradually developed based on the level of individualization, with the intensity ranging from weak to strong, the implementation time running from short to long, and the implementation frequency differing from less to more	4.95±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
3.3 Level 3	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
3.3.1 Patient status: -1≤ Richmond Agitation-Sedation Scale ≤1, oxygenation index >200 mmHg, stable circulation, and limb muscle strength > Level 3	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
3.3.2 Sedation and analgesia management: Moderate analgesia and the normal schedule were gradually improved	4.95±0.22	0.045	95.00%	4.90±0.31	0.063	90.00%
3.3.3 Position management: Based on level 2, autonomous postural training was conducted	5.00±0.00	0.000	100.00%	4.90±0.31	0.063	90.00%
3.3.4 Exercise rehabilitation: Based on level 2, bedside and out-of-bed activities and transfer training were conducted to achieve bedside sitting, bed chair transfer, bedside standing, assisted walking, and autonomous walking	5.00±0.00	0.000	100.00%	4.85±0.37	0.076	85.00%
3.3.5 Cardiopulmonary rehabilitation: Based on level 2, cough training, breathing training, lung re-expansion training, and six-minute walk test were conducted	4.95±0.22	0.045	95.00%	4.70±0.47	0.100	70.00%*
3.3.6 Psychological support: Based on level 2, encourage patients to express their feelings and rebuild life skills	4.95±0.22	0.045	95.00%	4.80±0.52	0.109	85.00%
3.3.7 The rehabilitation solutions described above were gradually developed based on the level of individualization, with the intensity ranging from weak to strong, the implementation time running from short to long, and the implementation frequency differing from less to more	4.95±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
4. Pause indicators of early rehabilitation practice	4.96±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
4.1 Deterioration of consciousness	5.00±0.00	0.000	100.00%	4.90±0.45	0.091	95.00%
4.2 Severe (or new) arrhythmia, myocardial infarction; or heart rate >140 beats/min, or heart rate <40 beats/min	5.00±0.00	0.000	100.00%	4.85±0.49	0.101	90.00%
4.3 Pulse oxygen saturation <88%, or respiratory rate <10, or >40/min	5.00±0.00	0.000	100.00%	4.90±0.45	0.091	95.00%
4.4 Blood pressure increased (or decreased) by 20% compared with the previous stage	5.00±0.00	0.000	100.00%	4.90±0.45	0.091	95.00%
4.5 Richmond Agitation-Sedation Scale ≥+2 or aggressive behavior	5.00±0.00	0.000	100.00%	4.85±0.49	0.101	90.00%
4.6 Patients complained of intolerance, or they showed discomfort or refusal to the medical personnel through gestures and expressions	5.00±0.00	0.000	100.00%	4.90±0.45	0.091	95.00%
4.7 Adverse events	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
5. Practice evaluation of early rehabilitation	4.90±0.31	0.063	90.00%	4.95±0.22	0.045	95.00%

Early mobilization in ICUs

5.1 Structure indicators	5.00±0.00	0.000	100.00%	4.90±0.45	0.091	95.00%
5.1.1 Participation in multidisciplinary team	4.95±0.22	0.045	95.00%	4.85±0.49	0.101	90.00%
5.1.2 Systematic early mobilization protocol	4.95±0.22	0.045	95.00%	4.95±0.22	0.045	95.00%
5.1.3 Medical staff/bed ratio (e.g., doctor/patient, nurse/patient, and technician/patient)	4.95±0.22	0.045	95.00%	4.70±0.66	0.140	80.00%
5.1.4 Rehabilitation auxiliary equipment	4.85±0.36	0.076	85.00%	4.80±0.41	0.085	80.00%
5.2 Process indicators	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.2.1 Evaluation rate of early rehabilitation within 24 h	5.00±0.00	0.000	100.00%	4.95±0.22	0.045	95.00%
5.2.2 Starting time of early rehabilitation	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.2.3 Implementation rate of early rehabilitation	4.95±0.22	0.045	95.00%	4.85±0.37	0.076	85.00%
5.2.4 Compliance rate of early rehabilitation: passive exercise, active exercise, and therapeutic positions	4.95±0.22	0.045	95.00%	4.75±0.44	0.094	75.00%
5.2.5 Out of bed activity rate of patients	4.90±0.31	0.063	90.00%	4.80±0.41	0.085	80.00%
5.3 Outcome indicators	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.1 Incidence of adverse events (e.g., unplanned extubation, falling, acute shedding of deep vein thrombosis, and cardiac arrest)	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.2 Incidence of delirium	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.3 Duration of mechanical ventilation	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.4 Artificial airway retention time	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.5 Success rate of ventilator withdrawal at one time	5.00±0.00	0.000	100.00%	5.00±0.00	0.000	100.00%
5.3.6 Reintubation rate	4.90±0.31	0.063	90.00%	4.80±0.41	0.085	80.00%
5.3.7 Constraint rate	4.95±0.22	0.045	95.00%	4.80±0.41	0.085	80.00%
5.3.8 Duration/dosage of analgesics and sedatives	4.95±0.22	0.045	95.00%	4.75±0.55	0.116	80.00%
5.3.9 Incidence of pressure injure	4.90±0.31	0.063	90.00%	5.00±0.00	0.000	100.00%
5.3.10 Incidence of venous thromboembolism	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%
5.3.11 Incidence of Intensive Care Unit-Acquired Weakness	4.90±0.31	0.063	90.00%	4.90±0.31	0.063	90.00%
5.3.12 Length of stay in Intensive Care Unit	4.95±0.22	0.045	95.00%	5.00±0.00	0.000	100.00%
5.3.13 Intensive Care Unit costs	4.80±1.52	0.109	85.00%	4.90±0.31	0.063	90.00%
5.3.14 Improvement of patients' self-care ability	4.90±0.31	0.063	90.00%	4.85±0.37	0.076	85.00%
5.3.15 Satisfaction of patients/family members	4.90±0.31	0.063	90.00%	4.90±0.45	0.091	95.00%

*Percent agreement ≤75%.

Early mobilization in ICUs

24]. This study broadens the scope by incorporating organization and management, pre-practice preparations, safety assessments, issuance of medical orders, graded protocols, pause indicators, and effectiveness evaluation indicators. It comprehensively covers the assessment of team member capabilities, pre-practice preparation of human and material resources, patient safety assessments, patient grading, issuance of medical orders, implementation of standard rehabilitation programs, and process and result evaluations. Additionally, quality control and standardized management of the rehabilitation process are emphasized to enhance the scientific rigor and comprehensiveness of the content.

Historically, early mobilization for critically ill patients was primarily focused on early physical activities, promoting movement whether active or passive. With ongoing research and clinical application, early mobilization has evolved beyond mere physical activities. It now includes timely assessments as a foundational step, with strong support from adequate nutrition, appropriate sedation and analgesia, critical cardiopulmonary rehabilitation, and essential psychological support and health education [4].

In this study, leveraging both literature and clinical practice insights, we introduced the “L3P5 Rehabilitation Program” for critically ill patients for the first time. Here, “P5” represents five pillars of comprehensive patient care: Pain management and Sedation, Position Management, Physiotherapeutic interventions, Pulmonary Rehabilitation, and Psychological Support. Patients are categorized into three levels based on a comprehensive evaluation including RASS scores, oxygenation index, circulatory status, and muscle strength grading. Each level corresponds to specific 5P rehabilitation content tailored to their needs. This “L3P5 Rehabilitation Program” aims to achieve early mobilization for all patients in the most efficient manner. Initial safety assessments are mandatory for all patients before starting early mobilization to ensure there are no contraindications. The comprehensive evaluation and “level-3 classification” enable coverage for all patients, extending beyond traditional early exercises to include pain management, sedation, position management, pulmonary rehabilitation, and psychological support. This integration of rehabilitation

and critical care not only fosters multidisciplinary cooperation but also addresses the clinical challenge of limited human resources.

Based on the dynamic real-time status of patients, practitioners can flexibly choose appropriate rehabilitation content from the “L3P5 Program”, tailored to the unique needs of each patient. This program allows for “single or multiple superpositions”, adapting to the composition of human resources, equipment, facility conditions, and the individualized levels of patients. Unlike traditional models, the implementation of rehabilitation programs in this study is not constrained by fixed times, frequencies, or intensities. Instead, it varies according to each patient’s baseline level and tolerance, with intensities ranging from weak to strong, durations from short to long, and frequencies from less to more. The “L3P5 Rehabilitation Program” enables comprehensive assessment of staff capabilities, facilitating all-encompassing and multi-level development to deliver 100% early mobilization services to patients.

Assessment and evaluation form a crucial part of the management system, serving not only to gauge the quality of clinical practice but also as vital reference points for clinical managers to conduct quality management [25]. Outcome indicators, reflecting the final effects achieved by patients, function as quality feedback mechanisms and help correct deviations [26]. Drawing from evidence-based literature and key sensitive indicators in clinical practice, the chosen indicators accurately reflect the quality of early mobilization practice. Additionally, process indicators such as the 24-hour rehabilitation assessment rate, activation time of rehabilitation practice, actual implementation rate, and compliance rate of rehabilitation content are employed to monitor, evaluate, and continuously improve the adherence to standards and codes of conduct in rehabilitation services and other supplementary activities.

Multiple clinical studies have indicated that the involvement of multidisciplinary teams, allocation of human resources, and availability of auxiliary rehabilitation equipment significantly impact early mobilization [27]. Thus, assessing and evaluating the organizational structure can indirectly reflect the rehabilitation team’s serviceability. The outcomes of such evaluations

can guide the rational optimization of resource allocation in clinical settings, enhancing the overall effectiveness of rehabilitation programs.

The innovative “L3P5 Rehabilitation Program” for critically ill patients introduces a new perspective for healthcare providers. As the first program of its kind in China, it serves as a benchmark for standardized clinical practice management and quality control in the early rehabilitation of critically ill patients. The program has demonstrated authority and reliability, offering a valuable reference for the implementation of early rehabilitation practices within Chinese healthcare settings.

Despite its contributions, this study has several limitations. Firstly, the development of early mobilization varies significantly across different countries and regions. Our study was tailored to the current circumstances in China, suggesting that the early mobilization protocol may be specifically suited to Chinese critically ill patients. Adaptations and improvements might be necessary for application in other international contexts. Secondly, the study primarily focuses on the theoretical construction of early mobilization practices. Further empirical validation and related research are required to assess its effectiveness in clinical settings.

In conclusion, utilizing the Delphi method, we developed an early rehabilitation system for critically ill patients, centered around the “L3P5 Rehabilitation Program”. This system has successfully standardized the management and quality control of early rehabilitation practices. Its authoritative and reliable content provides a foundational model for enhancing early rehabilitation practices for critically ill patients in China, potentially guiding future adaptations and applications in diverse clinical environments.

Acknowledgements

This research received grants from West China Nursing Discipline Development Special Fund Project of Sichuan University (HXHL21048 and HXHL19027).

Disclosure of conflict of interest

None.

Address correspondence to: Yongming Tian, Department of Critical Care Medicine, West China Hospital/West China School of Nursing, Sichuan University, No. 37 Guoxue Alley, Wuhou District, Chengdu 610041, Sichuan, China. Tel: +86-028-85422506; E-mail: tianyongming@scu.edu.cn

References

- [1] Liu K, Ogura T, Takahashi K, Nakamura M, Ohtake H, Fujiduka K, Abe E, Oosaki H, Miyazaki D, Suzuki H, Nishikimi M, Komatsu M, Lefor AK and Mato T. A progressive early mobilization program is significantly associated with clinical and economic improvement: a single-center quality comparison study. *Crit Care Med* 2019; 47: e744-e752.
- [2] Wang J, Ren D, Liu Y, Wang Y, Zhang B and Xiao Q. Effects of early mobilization on the prognosis of critically ill patients: a systematic review and meta-analysis. *Int J Nurs Stud* 2020; 110: 103708.
- [3] Zang K, Chen B, Wang M, Chen D, Hui L, Guo S, Ji T and Shang F. The effect of early mobilization in critically ill patients: a meta-analysis. *Nurs Crit Care* 2020; 25: 360-367.
- [4] Han R and Li X. Research progress in early rehabilitation of ICU patients. *Journal of Mudanjiang Medical University* 2019; 40: 125-127+150.
- [5] Tadyanemhandu C, van Aswegen H and Ntsiea V. Organizational structures and early mobilization practices in South African public sector intensive care units-a cross-sectional study. *J Eval Clin Pract* 2021; 27: 42-52.
- [6] Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, Kaltwasser A and Needham DM. Barriers and strategies for early mobilization of patients in intensive care units. *Ann Am Thorac Soc* 2016; 13: 724-730.
- [7] Liu H, Tian Y, Jiang B, Song Y, Du A and Ji S. Early mobilization practice in intensive care units: a large-scale cross-sectional survey in China. *Nurs Crit Care* 2023; 28: 510-518.
- [8] Aquim EE, Bernardo WM, Buzzini RF, Azeredo NSG, Cunha LSD, Damasceno MCP, Deucher RAO, Duarte ACM, Librelato JT, Melo-Silva CA, Nemer SN, Silva SDFD and Verona C. Brazilian guidelines for early mobilization in intensive care unit. *Rev Bras Ter Intensiva* 2019; 31: 434-443.
- [9] Devlin JW, Skrobik Y, Gélinas C, Needham DM, Slooter AJC, Pandharipande PP, Watson PL, Weinhouse GL, Nunnally ME, Rochweg B, Balas MC, van den Boogaard M, Bosma KJ, Brummel NE, Chanques G, Denehy L, Drouot X, Fraser GL, Harris JE, Joffe AM, Kho ME, Kress JP, Lanphere JA, McKinley S, Neufeld KJ, Pisani

Early mobilization in ICUs

- MA, Payen JF, Pun BT, Puntillo KA, Riker RR, Robinson BRH, Shehabi Y, Szumita PM, Winkelman C, Centofanti JE, Price C, Nikayin S, Misak CJ, Flood PD, Kiedrowski K and Alhazzani W. Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Crit Care Med* 2018; 46: e825-e873.
- [10] Murray MJ, DeBlock H, Erstad B, Gray A, Jacobi J, Jordan C, McGee W, McManus C, Meade M, Nix S, Patterson A, Sands MK, Pino R, Tescher A, Arbour R, Rochweg B, Murray CF and Mehta S. Clinical practice guidelines for sustained neuromuscular blockade in the adult critically ill patient. *Crit Care Med* 2016; 44: 2079-2103.
- [11] Bein T, Bischoff M, Brückner U, Gebhardt K, Henzler D, Hermes C, Lewandowski K, Max M, Nothacker M, Staudinger T, Tryba M, Weber-Carstens S and Wrigge H. S2e guideline: positioning and early mobilisation in prophylaxis or therapy of pulmonary disorders: revision 2015: S2e guideline of the German Society of Anaesthesiology and Intensive Care Medicine (DGAI). *Anaesthesist* 2015; 64 Suppl 1: 1-26.
- [12] Expert consensus writing committee for cardiac rehabilitation after coronary artery bypass grafting at the National Cardiovascular Center. Expert consensus on cardiac rehabilitation after coronary artery bypass grafting. *Chinese Circulation Journal* 2020; 35: 4-15.
- [13] Ni YY, Wang SH, Song WQ and Li BQ. Consensus of Chinese experts on neurocritical rehabilitation (I). *Chinese Journal of Rehabilitation Medicine* 2018; 33: 7-14.
- [14] Ni YY, Wang SH, Song WQ and Li BQ. Consensus of Chinese experts on neurocritical rehabilitation (II). *Chinese Journal of Rehabilitation Medicine* 2018; 33: 164-268.
- [15] Ni YY, Wang SH, Song WQ and Li BQ. Consensus of Chinese experts on neurocritical rehabilitation (III). *Chinese Journal of Rehabilitation Medicine* 2018; 33: 130-136.
- [16] Wu L, Guo Q, Hu L, Huang LF, Wang MH, Yu PM and Yuan Y. Consensus of experts on respiratory rehabilitation technology in China. *Chinese Journal of Geriatric Care* 2018; 16: 3-11.
- [17] Wang QY, Bian RX, Rong J, Liu CW, Zhu JH and Tang P. Consensus of severe rehabilitation experts in Zhejiang province. *Zhejiang Medical Journal* 2017; 39: 2191-2196+2209.
- [18] Sommers J, Engelbert RH, Dettling-Ihnenfeldt D, Gosselink R, Spronk PE, Nollet F and van der Schaaf M. Physiotherapy in the intensive care unit: an evidence-based, expert driven, practical statement and rehabilitation recommendations. *Clin Rehabil* 2015; 29: 1051-1063.
- [19] Hodgson CL, Stiller K, Needham DM, Tipping CJ, Harrold M, Baldwin CE, Bradley S, Berney S, Caruana LR, Elliott D, Green M, Haines K, Higgins AM, Kaukonen KM, Leditschke IA, Nickels MR, Paratz J, Patman S, Skinner EH, Young PJ, Zanni JM, Denehy L and Webb SA. Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults. *Crit Care* 2014; 18: 658.
- [20] Gosselink R, Bott J, Johnson M, Dean E, Nava S, Norrenberg M, Schönhofer B, Stiller K, van de Leur H and Vincent JL. Physiotherapy for adult patients with critical illness: recommendations of the European Respiratory Society and European Society of Intensive Care Medicine Task Force on Physiotherapy for Critically Ill Patients. *Intensive Care Med* 2008; 34: 1188-1199.
- [21] Sibilla A, Nydahl P, Greco N, Mungo G, Ott N, Unger I, Rezek S, Gemperle S, Needham DM and Kudchadkar SR. Mobilization of mechanically ventilated patients in Switzerland. *J Intensive Care Med* 2020; 35: 55-62.
- [22] Jolley SE, Moss M, Needham DM, Caldwell E, Morris PE, Miller RR, Ringwood N, Anders M, Koo KK, Gundel SE, Parry SM and Hough CL; Acute Respiratory Distress Syndrome Network Investigators. Point prevalence study of mobilization practices for acute respiratory failure patients in the United States. *Crit Care Med* 2017; 45: 205-215.
- [23] Wu Q, Zhang L and Zheng J. Rehabilitation nursing in ICU in 62 class III grade I hospitals in Guangdong Province (in Chinese). *Chin J Nurse* 2017; 24: 39-42.
- [24] Fontela PC, Lisboa TC, Forgjarini-Júnior LA and Friedman G. Early mobilization practices of mechanically ventilated patients: a 1-day point-prevalence study in southern Brazil. *Clinics (Sao Paulo)* 2018; 73: e241.
- [25] Zhang W, Gao YF, Nian WJ, Zhang XZ, Yang LL and Li ZH, Zhang W, Gao Y, Nian W, Zhang X, Yang L and Li Z. Construction of training programs for anesthetic master of nursing specialist. *Chinese Nursing Research* 2019; 33: 1313-1319.
- [26] Ma Y, Ye JR, Huang ZJ, Xia ZC, Xu D, Deng AP, Liu MH, Luo SL and Zhang JL. Construction of evidence-based sensitive indicators of psychiatric nursing quality. *Journal of Nursing (China)* 2020; 27: 27-32.
- [27] Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, Kaltwasser A and Needham DM. Barriers and strategies for early mobilization of patients in intensive care units. *Ann Am Thorac Soc* 2016; 13: 724-730.