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REVIEW

Evidence Summary of Early Enteral Nutrition Support for Adult Patients with Extracorporeal Membrane Oxygenation (ECMO)

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Objective: This study aims to systematically review and summarize the evidence on early enteral nutrition (EEN)support for Extracorporeal Membrane Oxygenation (ECMO)patients, Offer evidence-based guidance to healthcare professionals, including doctors and nurses, to inform their clinical practices.

Methods: Using the "6S"evidence-based model, we searched multiple databases including UpToDate, Best Practice, Guideline International Network (GIN), National Guideline Clearinghouse (NGC),Registered Nurses' Association of Ontario (RNAO), Joanna Briggs Institute (JBI), Evidence-Based Healthcare Center database, the Cochrane Library, PubMed, Embase, Web of Science, China National Knowledge Infrastructure (CNKI),Wanfang Database, and Chinese Biomedical Literature Database (CBM). Aiming to find evidence on early enteral nutrition support for adult patients with extracorporeal membrane oxygenation. The search included clinical decisions, guidelines, systematic reviews, evidence summaries, and expert consensus. The time frame for the search was from the inception of the databases to September 10, 2024.Two researchers evaluated the quality of the collected literature and extracted data and summarized evidence from publications that met the quality criteria.

Results: We retrieved 13 relevant documents, consisting of 6 guidelines, 3 expert consensus papers, 2 clinical decision-making articles, and 2 cohort studies. Through summarization and induction, a total of 26 best evidence pieces were obtained across five aspects: the establishment of nutritional support plans; strategies and risk assessment for enteral nutrition; the implementation of early enteral nutrition supplementation strategies; the amount and composition of nutrients reaching standard intake; and prevention of enteral nutrition-related complications.

Conclusion: This study has summarized the evidence regarding early enteral nutrition support for adult patients with extracorporeal membrane oxygenation (ECMO). It provides an evidence-based foundation for the practice of nursing and assists medical staff in developing personalized nutrition management plans for enteral nutrition support in ECMO patients.

Keywords: extracorporeal membrane oxygenation, ECMO, early enteral nutrition, nutrition support, evidence summary

Introduction

Extracorporeal Membrane Oxygenation (ECMO) is an advanced extracorporeal life support system widely used in the treatment of patients with cardiopulmonary failure.[1] Most patients receiving ECMO support are critically ill. As of April 2024, the total number of adult lung resuscitation, heart resuscitation, and extracorporeal cardiopulmonary resuscitation (ECPR) cases reported in the global ECMO patient registry by Extracorporeal Life Support Organization (ELSO) is 131,036. The average mortality rate associated with these cases is between 30–40%.[2]

Patients supported by ECMO are critically ill, and in a state of high metabolic breakdown, with increased protein metabolism, insulin resistance, and negative nitrogen balance. Inadequate nutritional support may lead to depletion of energy reserves, muscle loss, and an increased risk of infection, thereby affecting the patient's recovery and prognosis.

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Most ECMO patients, due to coma, shock, electrolyte disorders, and related infections, are unable to eat orally or receive parenteral nutritional support, and their nutritional needs change as the disease progresses. Therefore, Enteral Nutrition (EN) is more in line with the nutritional needs of ECMO patients. EN can stimulate the secretion of gastrointestinal hormones, prevent bacterial translocation, and maintain normal intestinal immune function, making it the preferred route for nutritional intake.[3]

The European Society for Clinical Nutrition and Metabolism (ESPEN) has published nutritional guidelines for critically ill patients,[4] and the Chinese expert consensus on enteral nutritional treatment for critically ill patients[5] both recommend Early Enteral Nutrition (EEN) for ECMO-supported patients. It is suggested to initiate EN within 24 to 48 hours of ICU admission, which can help alleviate the problem of insufficient nutritional intake.[6] Additionally, a retrospective study indicated that early enteral nutrition (EEN) is associated with a reduction in hospital mortality.[7] Multiple guidelines and studies recommend implementing early enteral nutrition (EEN) for patients receiving extracorporeal membrane oxygenation (ECMO) treatment, but research on the current status and effectiveness of early enteral nutrition in ECMO patients in China is still relatively limited. Especially in some intensive care units (ICUs), although standardized feeding protocols for critically ill patients have been established, significant individual differences exist among patients. To achieve optimal treatment outcomes, individualized nutritional support must be implemented. Therefore, this paper systematically reviews the evidence related to early enteral nutritional support for ECMO patients both domestically and internationally, and summarizes the relevant evidence, aiming to provide a reference for early individualized enteral nutritional support for ECMO patients.

Materials and Search Methods

Formulation of the Research Question

The research question was formulated using the PIPOST model developed by the Shanghai Fudan University Evidence based Nursing Center.[8] We formulated the research question using the PIPOST model (Population, Intervention, Professionals, Outcome, Setting, Type of evidence). Compared to traditional frameworks such as PICO or SPIDER, the PIPOST model was selected for its ability to address multidisciplinary clinical questions and enhance the applicability of evidence in complex settings. "P" (population) refers to the target population of evidence use, which in our study is adult patients supported by ECMO; "I" (intervention) refers to early enteral nutrition or nutrition supplementation and support; "P" (professional) represents the personnel who use the evidence, including nurses, doctors, dietitians, patients and family members; "O" (outcome) refers to outcome indicators such as malnutrition, enteral nutrition intolerance, diarrhea, and interruption of nutrient intake; "S" (setting) refers to the place where the evidence is applied, such as intensive care units(ICU); "T" (type of evidence) refers to the type of evidence, such as clinical decision-making, best practices, guidelines, evidence summaries, systematic reviews, expert consensus statements, and randomized controlled trials.

Literature Search Strategy

Following the "6S" evidence model, a systematic search was conducted across various databases including UpToDate, Best Practice, Guideline International Network(GIN), National Guideline Clearinghouse(NGC),Registered Nurses' Association of Ontario(RNAO),Joanna Briggs Institute (JBI), Evidence-Based Healthcare Center database, the Cochrane Library, PubMed, Embase, Web of Science, National Institute for Health and Care Excellence(NICE),China National Knowledge Infrastructure(CNKI), Wanfang Database, CBM (Chinese Biomedical Literature Database), and other clinical decision support systems, as well as the website of the Extracorporeal Life Support Organization (ELSO), European Society for Clinical Nutrition and Metabolism(ESPEN), American Society for Parenteral and Enteral Nutrition (ASPEN), European Society of Intensive Care Medicine(ESICM),and the German Society for Nutritional Medicine (DGEM),Chinese Society for Parenteral and Enteral Nutrition(CSPEN).The search included all evidence related to early enteral nutrition for ECMO patients, such as guidelines, expert consensus, clinical decisions, recommended practices, evidence summaries, systematic reviews, and relevant original research. The English search terms were "extracorporeal membrane oxygenation* / ECMO / artificial membrane lung / Yeke Membrane / extracorporeal life support /

extracorporeal life support therapy" and "early enteral nutrition / enteral nutrition / nutritional support / nutritional therapy / nutrition / EEN / enteral feeding / force feeding / tube feeding / gastric feeding tube", and "meta-analysis / guideline / evidence / practical guidance / expert consensus / systematic review". The search period was from the inception of the databases up to September 10, 2024.

Inclusion and Exclusion Criteria

Inclusion Criteria

Studies involving adult ECMO-supported patients; research related to early enteral nutrition or nutritional supplementation and support; document types including guidelines, evidence summaries, recommended practices, systematic reviews, and original research; language limited to Chinese or English.

Exclusion Criteria

Duplicated documents, research proposals or reports, incomplete content information, and evidence that did not pass the quality assessment.

Criteria for Evaluating the Quality of Literature

Guidelines were evaluated using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) system from 2012.[9] Expert consensus was assessed using the relevant quality assessment tools from the JBI Evidence-Based Healthcare Center (2016).[10] Systematic reviews were evaluated using the AMSTAR 2 (A Measure Tool to Assess Systematic Reviews) tool.[11,12] Evidence summaries, clinical decision-making tracing the original literature in the best evidence summaries or clinical decision-making, the corresponding JBI Center for Evidence-Based Health Care-recommended quality assessment tool was selected for quality assessment based on the type of original literature.[13]

Process of Literature Quality Evaluation

Two appraisers with a research background in evidence-based nursing independently conducted the quality evaluation of the selected literature. In cases where the two raters came to different conclusions about a piece of literature, a third professional was invited to rate the piece and collaboratively decide on its inclusion or exclusion. When there were conflicting conclusions from different sources of evidence, the appraisers followed the rule of prioritizing evidence-based evidence, prioritizing high-quality evidence, and prioritizing the most recent published evidence. Guidelines were evaluated by at least four professionals, and other literature was evaluated independently by two researchers with evidence-based training, and in case of disagreements, a third researcher with a background in evidence-based medicine made the decision.

Results

General Information of Included Literature

A total of 359 documents were retrieved, and 13 were included in the study, consisting of 6 guidelines,[4,14–18] 3 expert consensus documents,[5,19,20] 2 clinical decision-making papers,[21,22] and 2 cohort studies.[23,24] The process of literature screening is depicted in Figure 1.

Basic Details of the Included Literature

Literature extraction and evidence grading results: We extracted the following details from the included literature: Author, title of the article, year of publication, source, type, and topic. These details are shown in Table 1.

Results of Literature Quality Assessment

Results of Quality Evaluation of Guidelines

After comprehensively evaluating the quality of the articles in question, we utilized the AGREE II tool to conduct a systematic assessment of the included guidelines, and the results are presented in detail in Table 2.

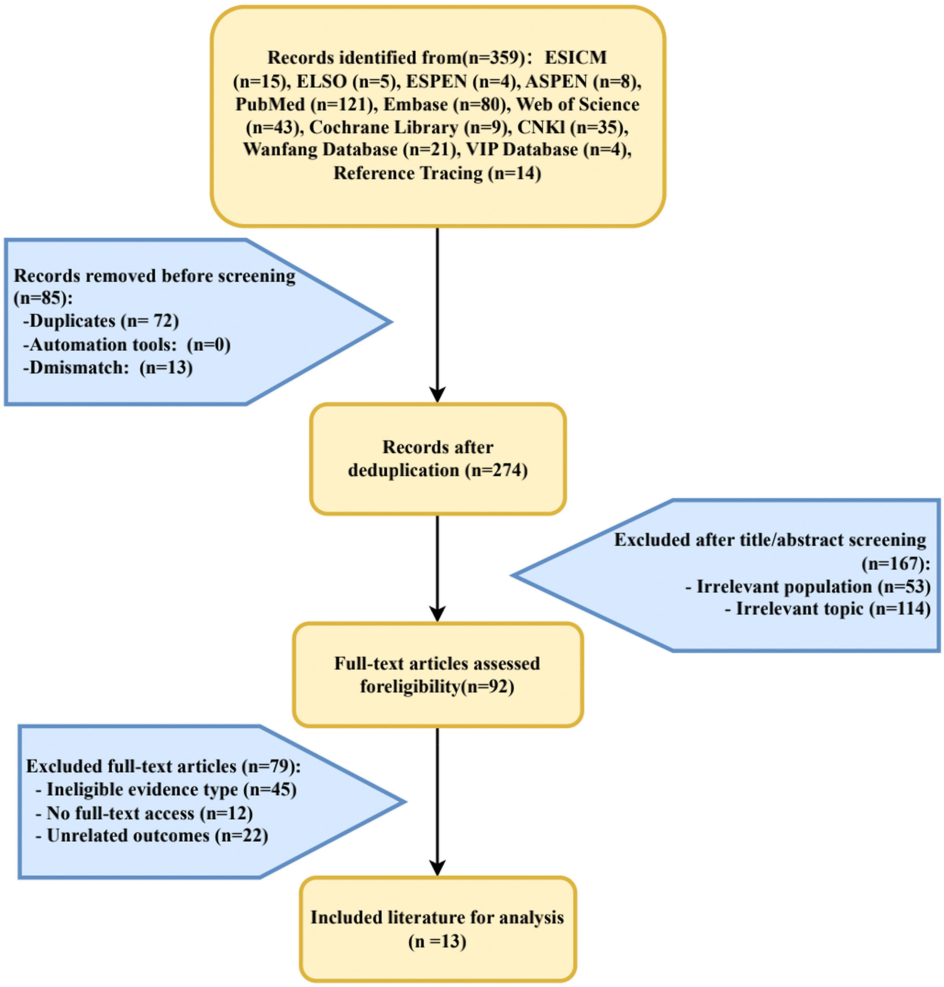

Figure 1 Screening flow chart for literature.
Abbreviations: ESICM, European Society ofIntensive Care Medicine; ELSO, Extracorporeal Life Support Organization; ESPEN, European Society for Clinical Nutrition and Metabolism; ASPEN, American Society for Parenteral and Enteral Nutritio; CNKI, China National Knowledge Infrastructure; VIP, China Science and Technology Journal Database.

This table visually shows the scores of each guideline across different dimensions. Through a comprehensive analysis of these scores, it is possible to clearly understand the quality level of each guideline in key aspects such as scope and purpose, stakeholder involvement, rigour of development, clarity of presentation, applicability, and editorial independence. Judging from the overall score distribution, guidelines of different quality levels can be effectively distinguished.

Table 1 General Characteristics of Included Literature (n=13)

Included Literature	Literature Source	Publication Year	Literature Topic	Literature Type
Elke[14]	DGEM	2019	Clinical Nutrition in Critical Care Medicine	Guideline
Tonna[15]	ELSO	2021	Management of Adult Patients on Venovenous Extracorporeal Membrane Oxygenation (VV-ECMO)	Guideline
McClave[16]	PubMed	2016	Guidelines for the Provision and Assessment of Nutrition Support Therapy in Adult Critically Ill Patients	Guideline

(*Continued*)

Table 1 (Continued).

Included Literature	Literature Source	Publication Year	Literature Topic	Literature Type
Berger[17]	ESPEN	2022	Micronutrient Guidelines	Guideline
Singer[4]	ESPEN	2023	Clinical Nutrition in the Intensive Care Unit	Guideline
Wunderle[18]	ESPEN	2023	Nutrition Support Guidelines for Polymorphic Hospitalized Patients	Guideline
Zhang et al[5]	CMA	2022	Chinese Expert Consensus on Enteral Nutritional Treatment for Critically Ill Patients in the Emergency Department	Expert consensus
Mi et al[19]	CMA	2021	Chinese Expert Consensus on the Prevention and Management of Common Complications in Enteral Nutritional Support for Critically Ill Patients (2021 Edition)	Expert consensus
Sun et al[20]	CMA	2018	Chinese Expert Consensus on Clinical Practice of Early Enteral Nutrition for Critically Ill Patients	Expert consensus
David et al[21]	UpToDate	2024	Nutritional Support in Critically Ill Patients: Enteral Nutrition	Best clinical practice guideline
Darryl et al[22]	UpToDate	2024	Management of Venovenous Extracorporeal Membrane Oxygenation (V–V ECMO)	Best clinical practice guideline
Gutierrez et al[23]	PubMed	2021	Outcomes Associated with Delayed Enteral Feeding After Cardiac Arrest Treated with Venoarterial Extracorporeal Membrane Oxygenation and Targeted Temperature Management	Cohort Studies
Ohbe et al[24]	PubMed	2018	Early Enteral Nutrition for Cardiogenic or Obstructive Shock Requiring Venoarterial Extracorporeal Membrane Oxygenation: A Nationwide Inpatient Database Study	Cohort Studies

Abbreviations: DGEM, German Society for Nutritional Medicine; ELSO, Extracorporeal Life Support Organization; ESPEN, European Society for Clinical Nutrition and Metabolism; CMA, Chinese Medical Association.

Table 2 AGREE II Scores of the Included Guidelines (n=6)

Guidelines	Scope and Purpose	Involved Personnel	Preciseness of Guideline Development	Clarity of Presentation	Applicability	Independence of Writing	Number of Domains/ Criteria ≥60%	Number of Domains/ Criteria ≥30%	Recommendation Level
Elke[14]	77.77	69.66	71.24	46.29	54.16	72.22	4	6	B
Tonna[15]	85.18	64.81	66.66	62.96	69.44	80.55	6	6	A
McClave[16]	79.62	62.96	54.86	53.70	62.50	69.44	4	6	B
Berger[17]	83.33	70.37	70.83	68.14	66.66	63.88	6	6	A
Singer[4]	87.03	74.07	61.80	66.66	69.44	77.77	6	6	A
Wunderle[18]	81.48	64.81	76.38	57.40	54.16	60.32	4	6	B

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This provides valuable data support for the rational selection and reference of these guidelines in subsequent research, practical applications, and other aspects.

Quality Assessment of Clinical Decisions

A total of 2 clinical decisions[21,22] were included in this study, both from UpToDate, with a high overall quality and thus included.

Quality Assessment of Expert Consensus and Cohort Studies

A total of 3 expert consensus papers were included, as well as 2 cohort studies. The inclusion of literature with a complete study design and appropriate data analysis methods indicates a high quality of literature. The results are detailed in Table 3 and Table 4.

Best Evidence Summaries

This study categorizes the evidence for enteral nutrition support into five aspects, specifically referencing the following guidelines and consensus:Setting of Nutrition Support Plan for ECMO Patients: Refer to the recommendations for multidisciplinary team collaboration in the study by Karpasiti et al;[25] Enteral Nutrition Strategy and Risk Assessment: Refer to the nutritional risk screening process in the study by Al-Dorzi & Arabi;[26] Implement the early enteral nutrition supplementation strategy: According to the ESPEN guidelines on the timing and method of initiation;[4] The target amount of nutrients taken in and the nutrient components: Combining ASPEN guidelines and Chinese expert consensus on macronutrient and micronutrient recommendations;[17] Prevention of Enteral Nutrition - related Complications: Integrating ELSO consensus and Chinese expert consensus on the management of enteral nutrition-related complications.[5,19] Through summarization and induction, five aspects of enteral nutrition support are ultimately obtained: establishing nutritional support plans, enteral nutrition strategies and risk assessment, implementation of early enteral nutrition supplementation strategies, nutrient target quantity and composition balance, and prevention of enteral nutrition-related complications. The classification into five aspects is meaningful in covering the full-cycle needs of ECMO patient nutrition management, from plan establishment to complication prevention, all referencing complementary recommendations from international guidelines and local consensus, as seen in Table 5.

Table 3 Quality Evaluation Results of Expert Consensuses (n=3)

Expert Consensus	①	②	③	④	⑤	⑥
Zhang et al[5]	Yes	Yes	Yes	Yes	Yes	Yes
Mi et al[19]	Yes	Yes	Yes	Yes	Yes	Yes
Sun et al[20]	Yes	Yes	Yes	Yes	Yes	Yes

Table 4 Quality Evaluation Results of Cohort Studies (n=2)

Cohort Studies	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
Gutierrez et al[23]	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Ohbe et al[24]	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Yes	Yes

Table 5 Summary of Evidence for Early Enteral Nutrition Support in Adult Patients with Extracorporeal Membrane Oxygenation (ECMO)

Category	Evidence Content	Evidence Level	Recommendation Level
Setting of Nutrition Support Plan for ECMO Patients	1. It is recommended that a multidisciplinary nutritional management team be established to systematically assess and manage the nutrition of patients with ECMO, including intensivists, dietitians, perfusionists, and nurses specializing in ECMO.[14]	Level 5	B
	2. For patients at risk, a more detailed assessment and planning should be conducted to facilitate early and adequate nutritional treatment and to determine quality outcome indicators.[4]	Level 5	B
Enteral Nutrition Strategy and Risk Assessment	3. All ECMO patients who stay in the ICU for more than 48 hours should be considered to be at risk of malnutrition;[4] early enteral nutrition can, to some extent, reduce the mortality rate of ECMO patients.[23]	Level 4	B
	4. It is recommended to use the Nutritional Risk Screening 2002 (NRS2002) and the Nutrition Risk in Critically Ill (NUTRIC) score to conduct nutritional risk assessments for ECMO patients.[20]	Level 5	B
	5. It is recommended to adopt the Acute Gastrointestinal Injury (AGI) criteria to assess the gastrointestinal function of patients. If the AGI level is grade I–III, enteral nutrition (EN) should still be actively initiated. If the AGI level is grade IV, EN should be postponed. During the EN process, a dynamic assessment of AGI should be carried out.[5]	Level 5	A
	6. It is recommended to use the ICU aspiration risk assessment scale to evaluate ECMO patients, and it is suggested that enteral nutrition (EN) should be administered through the postpyloric route, mainly the jejunum route.[4,19,20]	Level 5	A
	7. For ECMO patients using mechanical ventilation, indirect calorimetry should be used to measure energy expenditure.[4]	Level 5	A
Implement the early enteral nutrition supplementation strategy	8. It is recommended to record the nutritional plans of ECMO patients every day.[4]	Level 5	B
	9. For adult ECMO patients who are unable to take food orally, early enteral nutrition (EN) should be initiated within 48 hours. Moreover, to avoid overfeeding, it is not advisable to conduct full-dose EN for early ECMO patients. Instead, the target should be gradually achieved within 3 to 7 days after admission to the ICU. For those who have not reached 60% of the target feeding amount, it is recommended to supplement parenteral nutrition.[4,19]	Level 4	B
	10. For patients with hemodynamic stability (mean arterial pressure > 65mmHg, norepinephrine ≤1μg/(kg·min) and in the process of dose reduction), EN should be initiated as early as possible within 24 to 48 hours as appropriate.[5]	Level 3	A
	11. It is recommended to place nasogastric or nasojejunal tubes for ECMO patients, with the gastric route being the preferred option. For patients at high risk of aspiration or those who are intolerant to gastric EN despite the use of prokinetic drugs, postpyloric feeding is recommended. The average feeding time is approximately 13 hours.[4,5,20]	Level 1	B
	12. The infusion rate is recommended to start at 10–20 mL/h. If the gastrointestinal function can tolerate it, the speed can be gradually increased. For severe ECMO patients, the infusion rate of carbohydrates in EN should not exceed 5 mg/kg/min.[4,5]	Level 5	A
	13. There is no need to provide supplemental parenteral nutrition in the first 7 days of ICU hospitalization.[16]	Level 4	B

(*Continued*)

Table 5 (Continued).

Category	Evidence Content	Evidence Level	Recommendation Level
The target amount of nutrients taken in and the nutrient components	14. The initial caloric intake for ECMO patients should be 8–10 kcal/(kg·day). For most stable patients, the goal is to reach 25–30 kcal/(kg·day) after one week (calculated based on ideal body weight).[16]	Level 4	A
	15. After the third day of ICU admission, energy intake should achieve 80–100% of measured Energy Expenditure (EE).[4]	Level 3	B
	16. The recommended protein requirement is 1.2 to 2.0 grams/(kg·day); for obese patients (BMI 25–29.9 kg/m²), it should be increased to 2.0 to 2.5 grams/kg·day.[16]	Level 5	B
	17. For ECMO patients with intact or recovering gastrointestinal function, whole protein formulas are recommended; for those with gastrointestinal dysfunction, peptide-based formulas are preferred.[5,16]	Level 4	A
	18. For every 1500 kcal of enteral nutrition (EN) per day, 1.5–3 mg of Vitamin B1, at least 100 mg of Vitamin C, and at least 1000 IU (25 micrograms) of Vitamin D should be provided.[17] ***Note: Vitamin dosages should be adjusted based on the patient's laboratory test results**.	Level 5	B
	19. In ECMO patients with pressure ulcers, the addition of specific amino acids (arginine and glutamic acid) and calcium beta-hydroxy-beta-methylbutyrate to enteral feeding can accelerate the healing of pressure ulcers.[18]	Level 4	A
	20. For patients with acute respiratory failure, high-fat/low-carbohydrate formulations are not recommended. Formulas containing omega-3 fatty acids are also not routinely recommended.[5]	Level 5	A
	21. For patients undergoing ECMO combined with CRRT (Continuous Renal Replacement Therapy), it is advised to provide standard feeding (with an enteral nutritional formula containing approximately 40g of intact (non-hydrolyzed) protein per 1000 kcal) and to restrict fluids as necessary.[21]	Level 3	B
Prevention of Enteral Nutrition - related Complications	22. It is recommended that ECMO patients should be placed in a position with the head of the bed elevated at an angle of 30°- 45°, use sedatives as little as possible, receive continuous and slow enteral nutrition (EN) infusion, have the gastric residual volume (GRV) monitored once every 4 hours, and undergo continuous suction above the cuff of the artificial airway, etc.[15,20]	Level 5	A
	23. For patients at risk of refeeding syndrome: It is recommended that the maximum target at the start of nutrition should be 40% - 50% of the target calories.[5]	Level 5	B
	24. Early enteral nutrition will not increase the incidence of aspiration and intestinal intolerance in patients;[23] it is recommended to optimize analgesia, sedation, fluid status and reduce gastrointestinal irritation for patients with feeding intolerance or at high risk so as to improve the tolerance of enteral nutrition.[5]	Level 4	A
	25. For patients with blood glucose higher than 10 mmol/L, it is recommended that intravenous infusion of insulin should be the first choice to control blood glucose. The blood glucose should be measured at least once every 4 hours within the first two days after admission to the ICU. When the blood glucose is difficult to control, a formula with a low glycemic index can be adopted.[4,5]	Level 5	A
	26. It is recommended to use the Hart diarrhea scoring method to conduct diarrhea assessment; the temperature of the nutrient solution should be adjusted to be close to body temperature. For elderly patients with diarrhea, the temperature of the nutrient solution should be maintained at 38–42°C. It is recommended to relieve diarrhea by changing the nutrition formula/plan, such as adding soluble fiber (20 g/L) to enteral nutrition preparations.[19,20]	Level 5	A

Discussion

Nutritional Risk Screening and Nutrition Plan Setting Before EEN Initiation in ECMO Patients

During the implementation of ECMO, ECMO can cause changes in the patient's hemodynamics and the exposure of blood to the ECMO circuit, triggering the release of a large number of inflammatory factors, which increases the risk of infection and coagulation dysfunction in ECMO patients. In this state of stress, the metabolic rate of the body is further increased, leading to insulin resistance and negative nitrogen balance.[25] To prevent patients from developing complications related to malnutrition, it is necessary to establish a multidisciplinary nutritional management team to systematically assess, set, and manage the nutritional plans for ECMO patients. Relying solely on a single nutritional management model, such as one formulated only by physicians or dietitians, may not fully consider individual differences, changes in condition, and physical status. A multidisciplinary nutritional management team can comprehensively assess the patient's condition from multiple perspectives and formulate a precise and comprehensive nutritional management plan to provide patients with adequate nutritional treatment early on and to establish quality outcome indicators.[4]

The guidelines suggest that the multidisciplinary nutritional management team should include intensive care physicians, dietitians, perfusionists, and ECMO team members.[14] According to ELSO, ECMO team members include ECMO physicians, interventional cardiologists, vascular surgeons, perfusionists, intensive care unit nurses, respiratory therapists, and ECMO specialists. Among them, ECMO specialists are a special existence. They can be registered nurses (RN), respiratory therapists (RT), or perfusionists, who have received special training in managing ECMO at the patient's bedside. Intensive care unit nurses, as registered nurses with unique skills in caring for critically ill patients, are bedside nurses in some centers. In summary, through the close collaboration between the multidisciplinary nutritional management team and the ECMO team, patient safety and quality of recovery in complex treatment environments are further ensured.[27]

Considerations for the Implementation of Enteral Nutrition in ECMO Patients

The guidelines published by ESPEN recommend that ECMO patients who have been in the ICU for more than 48 hours be considered at risk of malnutrition.[4] Medical staff should place great importance on and conduct assessments and monitoring of enteral nutrition to provide patients with scientific and effective nutritional support. However, for critically ill patients requiring ECMO support, who often have multiple conditions and are in a state of coma and bed rest, it is not suitable to solely use Body Mass Index (BMI) to assess nutritional status, nor can accurate recent weight loss and food intake be obtained from the patients. Therefore, the American Society for Parenteral and Enteral Nutrition (ASPEN) recommends using the Nutritional Risk in Critically Ill (NUTRIC) score for individualized nutritional assessment. It is also recommended in to use the Acute Gastrointestinal Injury (AGI) criteria to assess gastrointestinal function;[5] if AGI is at levels I to III, enteral nutrition (EN) should be actively initiated, and if AGI is at level IV, EN should be temporarily postponed, with dynamic assessment of AGI during the EN process. In addition, during the period of ECMO support, it is recommended to record the nutritional plan, urea to creatinine ratio, physical and cognitive function, blood sugar levels (blood glucose levels, insulin dosage), electrolytes, liver function levels, and fluid balance parameters (central venous pressure, intake and output) daily.[4,25,26]

Furthermore, the guidelines[4] recommend that for ECMO patients on mechanical ventilation, indirect calorimetry should be used to measure energy expenditure. The assessment and monitoring system for enteral nutrition plays a crucial role in medical practice, helping medical staff to identify patients at risk of malnutrition early and accurately, ensuring that patients receive timely and effective nutritional support, and promoting their recovery process. Moreover, grasping the timing of initiating enteral nutrition is key to its proper implementation. The guidelines published by ELSO[25] state that once the clinical condition is stable, it is advocated to start enteral nutrition within 48 hours of ECMO support. Early enteral nutrition support can promote intestinal motility in ECMO patients, improve blood perfusion in the digestive tract, help maintain the integrity and barrier function of the intestinal mucosa, and reduce the incidence of hospital-acquired infections.[28] Currently, there are no prospective, randomized, controlled studies with large samples on the

optimal timing of EN support for ECMO patients, but some observational studies have found that early enteral nutrition is safe and effective.[29,30] Especially in the study by Lu et al,[31] the proportion of patients successfully weaned from ECMO in the early EN group (80.6%) was higher than that in the delayed EN group (48.3%). In terms of survival and discharge, the early EN group had a survival rate of 52.8%, significantly higher than that of the delayed EN group. Implementing early enteral nutrition support for critically ill ECMO patients can not only significantly promote the repair and recovery of the gastrointestinal mucosa, effectively reduce the probability of gastrointestinal bleeding, but also significantly reduce the risk of infection and mortality during hospitalization.

The methods of enteral nutrition infusion mainly include continuous infusion with a nutritional pump and intermittent infusion, and the guidelines recommend the use of continuous feeding for ECMO patients.[4] The infusion rate should start at 10–20 mL/h and can be gradually increased if gastrointestinal function tolerates it; the infusion rate of carbohydrates in EN should not exceed 5 mg/kg/min.[4,5] Therefore, for patients requiring ECMO support, given the rapid changes in their condition, it is necessary for the multidisciplinary nutritional management team must adhere to comprehensive and meticulous principles, assess the patient's nutritional needs from multiple aspects and dimensions, and pay close attention to the patient's nutritional intake, regularly monitor changes in nutritional indicators, and adjust the route and speed of enteral nutrition support promptly, on time according to the patient's condition.

Assessment of Nutritional Intake and Balance of Nutrients to Ensure ECMO Patients' Balanced Nutrition

In terms of nutritional components for early enteral nutrition support, it is suggested that the initial caloric intake for critically ill patients be 8–10 kcal/(kg·day)[16] and for most stable patients, the goal is to reach 25–30 kcal/(kg·day) after one week (calculated based on ideal body weight); the recommended protein requirement is 1.2 to 2.0 grams/(kg·day), and for obese patients (BMI 25–29.9 kg/m²), it should be increased to 2.0 to 2.5 grams/kg·day. In addition to daily caloric and protein intake, micronutrients are also crucial for critically ill patients. The European Society for Clinical Nutrition and Metabolism (ESPEN) has published the ESPEN Micronutrient Guideline in 2024 to improve medical quality, standardize the use of micronutrients, and promote the standardization and scientific nature of clinical decision-making.[17] It is recommended that all patients receiving medical nutrition therapy, under the premise of safety and effectiveness, should be supplemented according to the results of vitamin laboratory tests, following the guidelines. Specifically, for every 1500 kcal of enteral nutrition (EN) per day, 1.5–3 mg of Vitamin B1, at least 100 mg of Vitamin C, and at least 1000 IU (25 μg) of Vitamin D should be provided. Laboratory tests are an important prerequisite to ensure individualized supplementation, to avoid the risks of deficiency or excess.

Due to the severe condition of ECMO patients, who are connected to numerous medical devices and have limited mobility, requiring long-term bed rest for treatment, the prolonged pressure on the skin can easily lead to pressure ulcers. Improving the nutritional status of patients is a key aspect of preventing pressure ulcers, as good nutritional levels can enhance the patient's resistance and reduce the risk of pressure ulcers. The guidelines[18] suggest that for ECMO patients with pressure ulcers, adding specific amino acids (arginine and glutamic acid) and calcium beta-hydroxy-beta-methylbutyrate to enteral feeding can accelerate the healing of pressure ulcers. By improving the nutritional status of patients, the incidence of pressure ulcers in those with malnutrition can be reduced.

Timely Analysis and Management of Related Complications to Provide Strong Support for Patient Recovery

An early, standardized, and safe feeding process will reduce the incidence of complications from enteral nutrition, shorten the length of hospital stays, and improve the quality of life for patients. Studies have shown[32] that interruptions in enteral nutrition (EN) are common in critically ill patients, with feeding intolerance being a frequent cause. A systematic review study indicates that early initiation of enteral nutrition for ECMO patients does not necessarily lead to gastrointestinal intolerance,[33] and most cases of gastrointestinal intolerance can be effectively managed with prokinetic drugs. Medical staff should strengthen the assessment of patients' tolerance to nutrition to optimize clinical nutritional outcomes.

Additionally, the guidelines recommend[5] that for patients at risk of refeeding syndrome, the initial nutritional goal should be 40% to 50% of the target caloric intake, and postpyloric feeding should be considered for patients who are intolerant to feeding or at high risk, with optimization of analgesia, sedation, fluid status, and reduction of gastrointestinal irritation to improve tolerance to enteral nutrition. Currently, there is no unified assessment tool for enteral nutrition tolerance, and there is a lack of a standardized and authoritative evaluation system to accurately determine the extent of patients' tolerance to enteral nutrition, which requires further research. To prevent feeding-related diarrhea in ECMO patients,[19,20] the Hart Diarrhea Score is recommended for assessing diarrhea, with the temperature of the nutritional solution for elderly patients with diarrhea maintained at 38 to 42°C.

In diabetic patients with poor glycemic control, feeding-associated diarrhea can be ameliorated by implementing enteral nutrition in combination with continuous insulin infusion; changes in nutritional formulas/programs to alleviate diarrhea, such as increasing the amount of soluble fibers (20 g/L) in enteral nutrition preparations, are also recommended. Feeding-associated diarrhea can lead to a range of clinical problems, such as electrolyte imbalance, fecal incontinence, and pressure sores, all of which can add to the patient's healthcare burden. Therefore, healthcare professionals must be highly responsible and perceptive in detecting feeding-related complications in a timely manner and take prompt and effective measures to provide strong support and safeguard the patient's recovery.

Conclusion

This paper systematically summarizes 26 key pieces of evidence on the management of early enteral nutrition in adult ECMO patients, covering the development of a nutrition support plan, enteral nutrition strategies and risk assessment, implementation of early enteral nutrition supplementation strategies, the amount and composition of nutrients to meet targets, and measures to prevent enteral nutrition-related complications. Several studies have shown that ECMO patients receiving enteral nutrition at an early stage do not significantly increase the incidence of high levels of gastric remnants, intestinal intolerance, or serious abdominal complications, while making it easier to achieve target feeding rates and contributing to a reduction in patient morbidity and mortality. Thus, early enteral nutrition is a safe and effective intervention for ECMO patients, with a positive impact on their prognosis.

However, there are still limited data on nutritional support for adult ECMO patients, and in particular, in-depth studies on the correlation between nutritional support and patient prognosis are lacking. In addition, there may be differences in the response to nutritional strategies between patients treated with VV-ECMO and VA-ECMO. Until more high-quality data are available, it is recommended that treatment plans be developed based on existing nutritional guidelines for critically ill patients with individualized needs. Meanwhile, future studies should focus on the differences in nutritional strategies between VV-ECMO and VA-ECMO patients and their impact on prognosis, in order to further promote precise nutritional management of ECMO patients.

This study only included publicly available literature in English and Chinese, and did not include research literature in other languages, and thus may have some degree of geographic and cultural adaptation limitations. In translating this evidence into clinical practice guidelines, it is recommended that healthcare professionals conduct a structured and comprehensive assessment that includes factors such as the patient's own nutritional needs, gastrointestinal functional status, type of traumatic surgery, body immune status, level of sedation and analgesia, and blood glucose level, in order to formulate nursing interventions and preventive and control programs that are tailored to the individual situation. By applying the best evidence to guide clinical practice, patient outcomes can be effectively improved.

Future studies should pay more attention to the effects of nutritional management practices under different medical resource conditions, provide a basis for the development of more widely applicable clinical guidelines, and promote the standardization and standardization of nutritional management of ECMO patients to further enhance the level of treatment and quality of survival of critically ill patients. In addition, the effects of nurse-led nutritional assessment and related studies on the prevention of feeding-related complications in ECMO patients should be further explored to

provide higher-quality nursing services for critically ill patients and to help optimize and develop clinical nursing practice.

Date Sharing Statement

Data is available on request from the corresponding author.

Ethics Approval and Consent to Participate

An ethics statement is not applicable because this study is based exclusively on published literature.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Yang F, Wang LS. Expert consensus on circulatory support with extracorporeal membrane oxygenation in adults. *Chin J Crit Care Med*. 2018;4(2):114–122. doi:10.3877/cma.j.issn.2096-15372018.02.003
2. Extracorporeal Life Support Organization. ECLS international summary of statistics. 2024. Available from: https://www.elso.org/registry/internationalsummaryandreports/internationalsummary.aspx. Accessed February 18, 2025.
3. O'Leary-Kelley C, Bawel-Brinkley K. Nutrition support protocols: enhancing delivery of enteral nutrition. *Critical Care Nurse*. 2017;37(2):e15–e23. doi:10.4037/ccn2017650
4. Singer P, Blaser AR, Berger MM, et al. ESPEN practical and partially revised guideline: clinical nutrition in the intensive care unit. *Clin Nutr*. 2023;42(9):1671–1689. doi:10.1016/j.clnu.2023.07.011
5.. Chinese Expert Consensus Group on Enteral Nutrition Therapy for Emergency and Critical Ill Patients in China. Chinese expert consensus on enteral nutrition therapy for emergency and critical III patients in China. *Chin J Emerg Med*. 2022;31(3):281–290. doi:10.3760/cma.j.issn.1671-0282.2022.03.004.
6. Scott LK, Boudreaux K, Thaljeh F, Grier LR, Conrad SA. Early enteral feedings in adults receiving venovenous extracorporeal membrane oxygenation. *J Parenter Enteral Nutr*. 2004;28(5):295–300. doi:10.1177/0148607104028005295
7. Sua K, Kang SJ, Jinwook H, et al. Early enteral nutrition and factors related to in-hospital mortality in people on extracorporeal membrane oxygenation. *Nutrition*. 2021;89:111222. doi:10.1016/j.nut.2021.111222
8. Zhu Z, Hu Y, Xing W, Zhou Y, Gu Y. Composition of the different types of evidence-based problems. *J Nurses Training*. 2017;32(21):1991–1994. doi:10.16821/j.cnki.hsjx.2017.21.025
9. AGREE Enterprise. Appraisal of guidelines for research & evaluation II (AGREE II): users manual and 23-item Instrument. 2017. Available from: https://www.agreetrust.org/about-the-agree-enterprise/. Accessed February 18, 2025.
10. The Joanna Briggs Institute. Critical Appraisal Tools. 2024. Available from: https://joannabriggs.org/critical-appraisal-tools. Accessed February 18, 2025.
11. Shea BJ, Grimshaw JM, Wells GA, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Med Res Methodol*. 2007;7(1):10. doi:10.1186/1471-2288-7-10
12. Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomized or non-randomized studies of healthcare interventions, or both. *BMJ*. 2017;358(sep21 16):j4008. doi:10.1136/bmj.j4008
13. Gu Y, Zhang HW, Zhou YF, Hu Y, Xing WJ. Quality assessment tools of jbi evidence-based health care center for different types of research - quality assessment of analytical studies (I). *J Nurs Train*. 2018;33(05):400–403. doi:10.16821/j.cnki.hsjx.2018.05.005
14. Elke G, Hartl WH, Kreymann KG, et al. Clinical nutrition in critical care medicine – guideline of the German society for nutritional medicine (DGEM). *Clin Nutr ESPEN*. 2019;33:220–275. doi:10.1016/j.clnesp.2019.05.002
15. Tonna JE, Abrams D, Brodie D, et al. Management of adult patients supported with venovenous extracorporeal membrane oxygenation (VV ECMO): guideline from the Extracorporeal Life Support Organization (ELSO). *ASAIO j*. 2021;67(6):601–610. doi:10.1097/mat.0000000000001432
16. McClave SA, Taylor BE, Martindale RG. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: society of critical care medicine (SCCM) and American society for parenteral and enteral nutrition (ASPEN). *JPEN J Parenter Enteral Nutr*. 2016;40(8):1200. doi:10.1177/0148607115621863
17. Berger MM, Shenkin A, Amrein K, et al. ESPEN micronutrient guideline. *Clin Nutr*. 2022;41(6):1357–1424. doi:10.1016/j.clnu.2022.02.015
18. Wunderle C, Gomes F, Schuetz P, et al. ESPEN guideline on nutritional support for polymorbid medical inpatients. *Clin Nutr*. 2023;42(9):1545–1568. doi:10.1016/j.clnu.2023.06.023
19. Mi YY, Huang HY, Shang Y, et al. Chinese expert consensus on prevention and management of common complications of enteral nutrition support in critical III patients in China (2021 edition). *Chin Crit Care Med*. 2021;33(8):897–911. doi:10.3760/cma.j.cn121430-20210310-00357

20. Sun RH, Jiang RL, Huang M, Cai GL. Expert consensus on clinical practice of early enteral nutrition in critical III patients. *Chin Crit Care Med*. 2018;30(8):715–721. doi:10.3760/cma.j.issn.2095-4352.2018.08.001
21. David Seres PEP. Nutrition support in intubated critically III adult patients: enteral nutrition. 2024. Available from: https://www.uptodate.cn/contents/zh-Hans/nutrition-support-in-critically-ill-adult-patients-enteral-nutrition?search=Nutrition%20Support%20in%20Intubated%20Critically%20Ill%20Adult%20Patients%3A%20Enteral%20Nutrition&source=search_result&selectedTitle=2%7E150&usage_type=default&display_rank=2. Accessed February 18, 2025.
22. Darryl Abrams CA. Extracorporeal life support in adults: management of venovenous extracorporeal membrane oxygenation (V-V ECMO). 2024. Available from: https://www.uptodate.cn/contents/zh-Hans/extracorporeal-life-support-in-adults-management-of-venovenous-extracorporeal-membrane-oxygenation-v-v-ecmo?search=Extracorporeal%20Life%20Support%20in%20Adults%3A%20Management%20of%20Venovenous%20Extracorporeal%20Membrane%20Oxygenation%20%28V-V%20ECMO%29&source=search_result&selectedTitle=1%7E150&usage_type=default&display_rank=1. Accessed February 18, 2025.
23. Gutierrez A, Carlson C, Kalra R, Elliott AM, Yannopoulos D, Bartos JA. Outcomes associated with delayed enteral feeding after cardiac arrest treated with veno-arterial extracorporeal membrane oxygenation and targeted temperature management. *Resuscitation*. 2021;164:20–26. doi:10.1016/j.resuscitation.2021.04.029
24. Ohbe H, Jo T, Yamana H, Matsui H, Fushimi K, Yasunaga H. Early enteral nutrition for cardiogenic or obstructive shock requiring veno-arterial extracorporeal membrane oxygenation: a nationwide inpatient database study. *Intensive Care Med*. 2018;44(8):1258–1265. doi:10.1007/s00134-018-5319-1
25. Karpasiti T. A narrative review of nutrition therapy in patients receiving extracorporeal membrane oxygenation. *ASAIO J*. 2022;68(6):763–771. doi:10.1097/mat.0000000000001540
26. Al-Dorzi HM, Arabi YM. Enteral nutrition safety with advanced treatments: extracorporeal membrane oxygenation, prone positioning, and infusion of neuromuscular blockers. *Nutr Clin Pract*. 2021;36(1):88–97. doi:10.1002/ncp.10621
27. Extracorporeal Life Support Organization. Understanding the ECMO team members & their roles. 2024. Available from: https://www.elso.org/extracorporeal-membrane-oxygenation.aspx. Accessed February 18, 2025.
28. Tong HJ, Deng HS, Peng W, et al. Expert consensus on infection prevention and control during adult extracorporeal membrane oxygenation assistance. *Chin Circ J*. 2024;39(03):209–216. doi:10.3969/j.issn.1000-3614.2024.03.001
29. Umezawa Makikado LD, Flordelís Lasierra JL, Pérez-Vela JL, et al. Early enteral nutrition in adults receiving venoarterial extracorporeal membrane oxygenation: an observational case series. *J Parenter Enteral Nutr*. 2013;37(2):281–284. doi:10.1177/0148607112451464
30. Wang XH, Meng SP, Hu YL, Liu FR, Liu C, Feng T. Effect of early enteral nutrition on the short-term prognosis of adult patients with veno-arterial extracorporeal membrane oxygenation after cardiac surgery. *Chin J Crit Care Med*. 2023;43(8):628–631. doi:10.3969/j.issn.1002-1949.2023.08.008
31. Lu GY, Xu H, Li JH, Chen JK, Ning YG. Safety and outcome of early enteral nutrition in patients receiving extracorporeal membrane oxygenation. *Clin Nutr*. 2023;42(9):1711–1714. doi:10.1016/j.clnu.2023.07.021
32. Heyland DK, Ortiz A, Stoppe C, et al. Incidence, risk factors, and clinical consequence of enteral feeding intolerance in the mechanically ventilated critically ill: an analysis of a multicenter, multiyear database. *Crit Care Med*. 2020;49(1):49–59. doi:10.1097/ccm.0000000000004712
33. Ai SS, Niu PL, Wang Y, Xiao WJ, Xu GJ. Systematic review on the safety and efficacy of early enteral nutrition in patients with extracorporeal membrane oxygenation. *Chin J Emerg Crit Care Nurs*. 2024;5(8):741–746. doi:10.3761/j.issn.2096-7446.2024.08.014