Original Article

The impact of daily use of an enteral feeding checklist on clinical outcomes in shock patients: a retrospective cohort study

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Background and Objectives: The optimal delivery of enteral nutrition in shock patients has an important prognostic clinical value; thus, checklists for standardizing enteral nutrition should be developed. This study examined whether the use of an enteral feeding checklist can improve enteral nutrition in shock patients. **Methods and Study Design:** A retrospective cohort study was conducted. A multidisciplinary working group developed an enteral feeding checklist. Information on patients' demographics, checklist items, and clinical outcomes was collected. **Results:** In total, 148 patients were included. The checklist was used for 35 patients but not for the remaining 113 patients. Patients in the checklist group received enteral nutrition earlier (2.6 vs 4.6 days, p=0.017) and had a lower mechanical ventilation rate (62.9% vs 85.0%, p=0.004). The checklist group had shorter intensive care unit stay (mean 17.3 vs 25.7 days, p=0.043). No significant differences were observed in 28- and 90-day mortality, mechanical ventilation duration, and intolerance to enteral nutrition. **Conclusions:** The use of an enteral feeding checklist in shock patients was associated with earlier enteral nutrition delivery and decreased intensive care unit stay.

Key Words: enteral feeding, checklist, shock patients, retrospective cohort

INTRODUCTION

Shock patients often have inadequate enteral intake and hypocatabolism, which increase the risks of malnutrition and mortality.[1,2] Malnutrition and underfeeding may exist in more than 40% of critically ill patients.[3] Providing appropriate nutritional support to critically ill patients can prevent malnutrition and improve clinical outcomes. Nutrition delivery methods for critical patients mainly include parenteral nutrition (PN) and enteral nutrition (EN). Being widely accepted, EN is preferred over PN. However, optimized EN delivery is delayed due to many reasons, such as physicians' delay in making decisions, underestimated energy demand, interrupted feeding, recent abdominal surgery, hemodynamic instability, and gastrointestinal abnormality.[4-6] Several clinical practice guidelines have standardized EN delivery by involving a battery of interventions and procedures for nutrition therapy.[7-9] In addition, enteral feeding protocols were introduced to improve clinical outcomes in many studies. However, although EN feeding protocols could increase the proportion of EN feeding, they failed to reduce mortality, the incidence of nosocomial infection, and the duration of mechanical ventilation (MV).[2,4]

Checklists help in preventing omission errors and are useful while performing tasks, ranging from simple shopping to flying an airplane.[10,11] The use of checklists has also extended to intensive care units; for example, checklists are used while transferring critically ill patients,[12] reducing the incidence of catheter-related blood stream infection,[13] maintaining hand hygiene compliance,[14] reducing extubation failure,[15] scheduling physical rehabilitation consultations, and conducting daily rounds. However, studies exploring the use of checklists for improving

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EN in shock patients are limited. Therefore, the present study investigated the effect of using an EN checklist on shock patients.

METHODS

Study design

In this single-center retrospective cohort study, a before–after study design was used. The study protocol was approved by the Ethics Committee of PLA General Hospital (approval No. 2017-054-01). This study was conducted in accordance with the STROBE checklist.

Setting

The Department of Critical Care Medicine of PLA General Hospital is a multidisciplinary 20-bed unit and had an average of 800 annual admissions in December 1, 2015-Jun 30, 2017 and Jul 1, 2017-February 30, 2018.

Participants

All shock patients (age ≥18 years) who were admitted to the intensive care unit (ICU) and received EN and vasopressors were potentially eligible. We excluded patients who had contraindications to EN, including bowel obstruction, massive gastrointestinal bleeding, acute phase of severe pancreatitis, and post gastrointestinal operation; had received EN in the previous week; underwent percutaneous endoscopic jejunostomy; and had an estimated lifespan of <24 h.

Use of a checklist

We designed a preliminary form that included patient's demographic data, studied practices, and other items for EN therapy assessment. Five staff physicians, who were responsible for the ICU and the implementation of the checklist, reviewed the draft form. We conducted a pilot test for this preliminary form between June 1, 2017, and July 30, 2017. Modifications were made in the design of the preliminary form according to the findings of the pilot test. The final checklist was confirmed by five staff physicians before its implementation (Figure 1).

Items in the checklist included hemodynamic data, acute gastrointestinal injury (AGI) score, nutritional risk assessment, method of nutrition, assessment of the aspiration risk, feeding route of EN, the EN product, caloric density of the EN product (kcal/mL), speed of EN delivery, assessment of EN tolerability, adjustment of EN project, and total dose of EN delivery (Figure 1). The calculation of the aspiration risk score was modified from a previous study (Supplement table 1).[16]

Variables and outcomes

Variables included patient demographics, Acute Physiology and Chronic Health Evaluation (APACHE) II score, and Sequential Organ Failure Assessment (SOFA) score over the first 24 h of admission to the ICU. The primary outcome was 28-day mortality. Secondary outcomes were 90-day mortality, length of stay in the ICU, duration of MV, and intolerance to EN feeding.

Statistical methods

All patients were divided into checklist and control groups. We reported quantitative variables as means with standard deviations (SDs) for outcome measures with a normal distribution and as interquartile ranges for those with an abnormal distribution and categorical variables as rates. We performed the univariate analysis to determine statistical differences in these variables between the two groups. The univariate analysis included Student's t test, chi-square test, and Fisher's exact test, and $p<0.05$ was considered significant. Multivariable logistic regression models were used to estimate the role of checklist use in clinical outcomes, and adjusted ORs with 95% CIs were calculated to estimate risks. Statistical analyses were performed using Empower (R) (http://www.empowerstats.com; X&Y Solutions Inc, Boston, Mass) and R software, version 3.1.2 (http://www.R-project.org).

RESULTS

A total of 148 patients were included in this study. The checklist was used in 35 (23.65 %) patients. The checklist assessment was not performed in the remaining 113 (76.35%) patients (Figure 2). The demographics of patients are listed in Table 1. No significant differences in sex, age, BMI, APACHE II score, SOFA score, and AGI score were found between the two groups in the univariate analysis (Table 1).

Compared with the control group, the checklist group received EN earlier, with a mean of 2.6 days versus 4.6 days (p=0.017), and had a lower rate of MV (62.9% vs 85.0%, p=0.004; Table 1).

The results of the univariate analysis of clinical outcomes are shown in Table 2. No significant difference was found between the two groups in 28-day mortality (20.0% vs 23.9%, p=0.632), 90-day mortality (25.7% vs 31.9%, p=0.490), duration of MV (mean 13.4 days vs 16.6 days; p=0.395), and intolerance to EN (17.1% vs 23.0%, p=0.461). However, the checklist group had shorter ICU stay (mean 17.3 vs. 25.7 days; p=0.043). The result of the multivariable logistic regression model also showed no significant difference in 28-day mortality, 90-day mortality, duration of MV, and intolerance to EN between the two groups. However, the checklist group still had significantly shorter ICU stay after adjustment for confounders (Table 3).

DISCUSSION

The results of this retrospective cohort study demonstrated that the EN checklist could reduce the length of ICU stay. However, a decrease was not observed in 28- and 90-day mortality or the durations of MV and hospitalization. In terms of baseline differences, only the MV rate differed. Enteral feeding was provided earlier in the checklist group. Other studies[17,18] on EN protocols have also reported similar findings that support early EN.

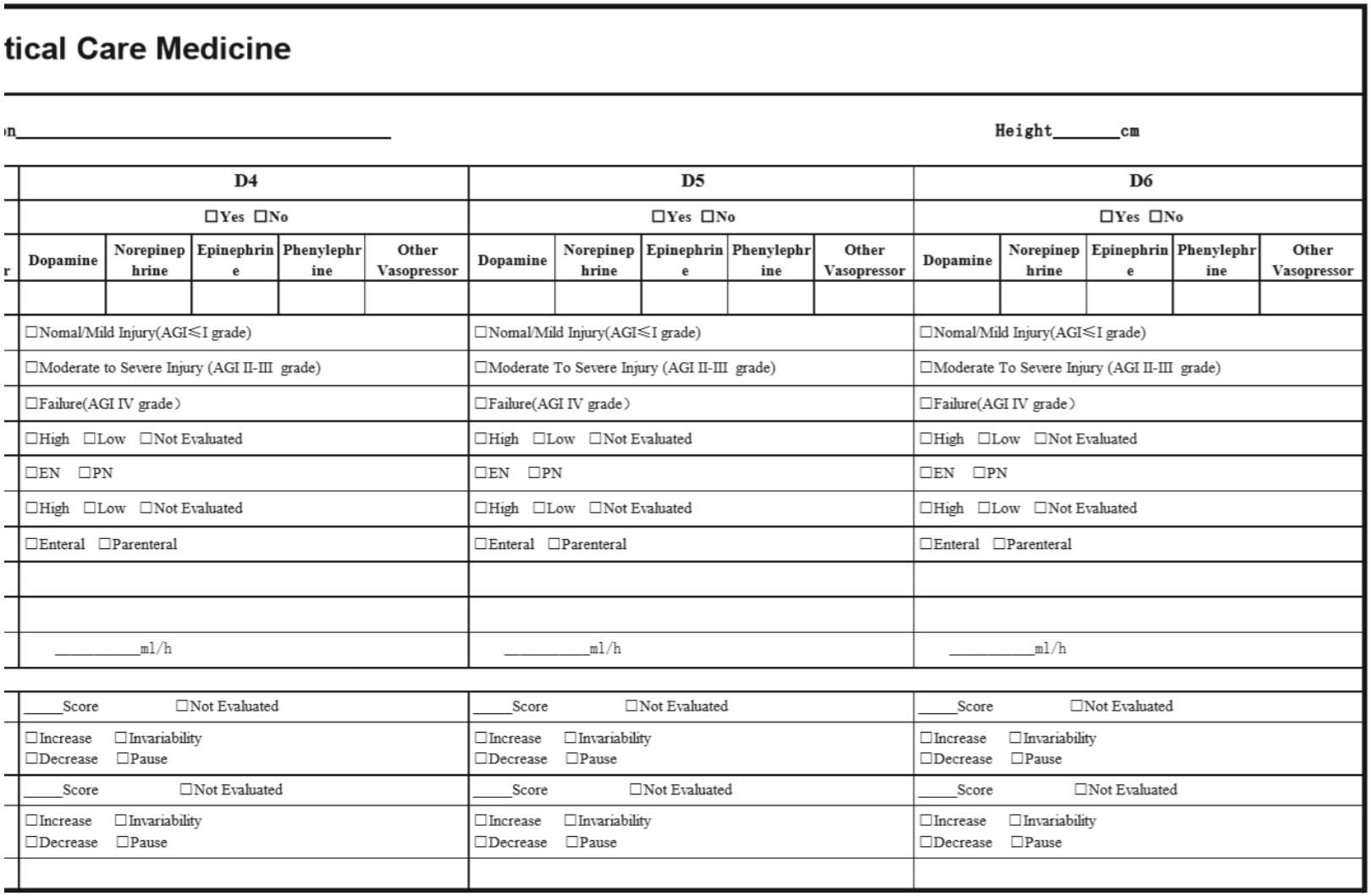
The idea of using a checklist to prevent mistakes in an ICU was inspired by the inventory checks used in aviation. The daily management of ICU patients has many similarities to that of the aviation industry. For example, both industries involve timely assessment and management of complex multisystem objects, and minor errors may lead to serious adverse consequences. We referred to previous studies on the use of checklists in an ICU and adopted pre- and post-control study methods. The check-

Checklist of Nutrition Management In Criti

Data
Name_____ ID_____ Date Of ICU Admission(Y/M/D)_____/_____/_____ The Dignosis Of ICU Admision_
Wight_____kg Energy Object_____kcal/d Protein Object_____g/d

	D1					D2					D3				
Hemodynamic Stabilization(MAP>65mmHg, and The Dose of Vasopressor Is Decreased)	☐Yes ☐No					☐Yes ☐No					☐Yes ☐No				
	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor
Assessment of Gastrointestinal Function	☐Nomal/Mild Injury(AGI≤I grade)					☐Nomal/Mild Injury(AGI≤I grade)					☐Nomal/Mild Injury(AGI≤I grade)				
	☐Moderate To Severe Injury (AGI II-III grade)					☐Moderate To Severe Injury (AGI II-III grade)					☐Moderate To Severe Injury (AGI II-III grade)				
	☐Failure(AGI IV grade)					☐Failure(AGI IV grade)					☐Failure(AGI IV grade)				
EN intolerance risk	☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated				
Method of Ntrition	☐EN ☐PN					☐EN ☐PN					☐EN ☐PN				
Assessment of Aspiration Risk	☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated				
Feeding Route of EN	☐Enteral ☐Parenteral					☐Enteral ☐Parenteral					☐Enteral ☐Parenteral				
Name of The EN product															
Caloric Density of The EN product (kcal/ml)															
The Speed of Enteral Nutrition Delivered	_____ml/h					_____ml/h					_____ml/h				
Assessment of EN Tolerability															
First Assessment of EN Tolerability	_____Score ☐Not Evaluated					_____Score ☐Not Evaluated					_____Score ☐Not Evaluated				
Adjustment of EN Project	☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause				
	_____Score ☐Not Evaluated					_____Score ☐Not Evaluated					_____Score ☐Not Evaluated				
	☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause				
The Total Dose of Enteral Nutrition Delivered (ml)															

Figure 1. Checklist of nutrition management in critical care medicine. Energy object: 25-30 kcal / kg (standard body weight)/d; (standard body weight (female) = Height (cm) - 105; (standard body weight (male) = height (cm)-110). Protein object: 1.2-2.0 g/kg (standard body weight) / d. Time record: time of admission to ICU is D0, the next day from beginning 8:00 am is D1, et al. Time of filling the form: 10:00 and 23:00. *EN intolerance high risk is defined as a patient having gastric residue >250 ml, vomiting, abdominal plain film or abdominal CT positive, intestinal ischemia or perforation.



tical Care Medicine

n_____ Height_____cm

	D4					D5					D6				
	☐Yes ☐No					☐Yes ☐No					☐Yes ☐No				
r	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor	Dopamine	Norepinephrine	Epinephrine	Phenylephrine	Other Vasopressor
	☐Nomal/Mild Injury(AGI≤I grade)					☐Nomal/Mild Injury(AGI≤I grade)					☐Nomal/Mild Injury(AGI≤I grade)				
	☐Moderate to Severe Injury (AGI II-III grade)					☐Moderate To Severe Injury (AGI II-III grade)					☐Moderate To Severe Injury (AGI II-III grade)				
	☐Failure(AGI IV grade)					☐Failure(AGI IV grade)					☐Failure(AGI IV grade)				
	☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated				
	☐EN ☐PN					☐EN ☐PN					☐EN ☐PN				
	☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated					☐High ☐Low ☐Not Evaluated				
	☐Enteral ☐Parenteral					☐Enteral ☐Parenteral					☐Enteral ☐Parenteral				
	_____ml/h					_____ml/h					_____ml/h				
	_____Score ☐Not Evaluated					_____Score ☐Not Evaluated					_____Score ☐Not Evaluated				
	☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause				
	_____Score ☐Not Evaluated					_____Score ☐Not Evaluated					_____Score ☐Not Evaluated				
	☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause					☐Increase ☐Invariability ☐Decrease ☐Pause				

Figure 1. Checklist of nutrition management in critical care medicine (cont.). Energy object: 25-30 kcal / kg (standard body weight)/d; (standard body weight (female) = Height (cm) - 105; (standard body weight (male) = height (cm)-110). Protein object: 1.2-2.0 g/kg (standard body weight) / d. Time record: time of admission to ICU is D0, the next day from beginning 8:00 am is D1, et al. Time of filling the form: 10:00 and 23:00. *EN intolerance high risk is defined as a patient having gastric residue >250 ml, vomiting, abdominal plain film or abdominal CT positive, intestinal ischemia or perforation.

Table 1. Baseline characteristics in each group

	Checklist Group	Control Group	*p*-value
N	35	113	
Sex			0.736
Female	11 (31.4%)	39 (34.5%)	
Male	24 (68.6%)	74 (65.5%)	
Age	59.4±18.8	60.5±19.3	0.764
Height (cm)	166.2±7.3	168.5±7.6	0.117
Weight (kg)	64.3±11.4	64.5±11.2	0.921
BMI	23.7±3.6	23.0±3.7	0.273
CRRT			0.255
No	24 (72.7%)	70 (61.9%)	
Yes	9 (27.3%)	43 (38.1%)	
MV			0.004
No	13 (37.1%)	17 (15.0%)	
Yes	22 (62.9%)	96 (85.0%)	
MAP (mmHg)	76.3±7.5	77.1±8.7	0.613
Abdominal diseases			0.407
No	27 (77.1%)	79 (69.9%)	
Yes	8 (22.9%)	34 (30.1%)	
EN start time (d)	2.6±2.3	4.6±4.7	0.017
Feeding way			0.050
No	10 (28.6%)	16 (14.2%)	
Yes	25 (71.4%)	97 (85.8%)	
EN total (ml)	500 (250-500) †	500 (250-500) †	0.541
EN Speed (ml/h)	25 (25-50) †	25 (20-50) †	0.309
Creatinine (mmol/L)	89 (73.6-98) †	86 (64-156) †	0.266
IL-6 (pg/ml)	108 (68-183) †	80.8 (30.0-227) †	0.144
Lactate (mmol/L)	1.8±1.1	2.0±1.7	0.498
SOFA	8.5±3.9	9.1±3.8	0.404
APACHE	18.7±8.0	17.7±7.7	0.504
AGI			0.335
1	25 (71.4%)	80 (70.8%)	
2	5 (14.3%)	21 (18.6%)	
3	3 (8.6%)	11 (9.7%)	
4	2 (5.7%)	1 (0.9%)	

AGI: acute gastrointestinal abbreviated injury; APACHE: acute physical and chronic health assessment; CRRT: continuous renal replacement therapy; EN: enteral nutrition; MV: mechanical ventilation; SOFA: sequential organ failure assessment.
†Non-parametric test, median (interquartile range).

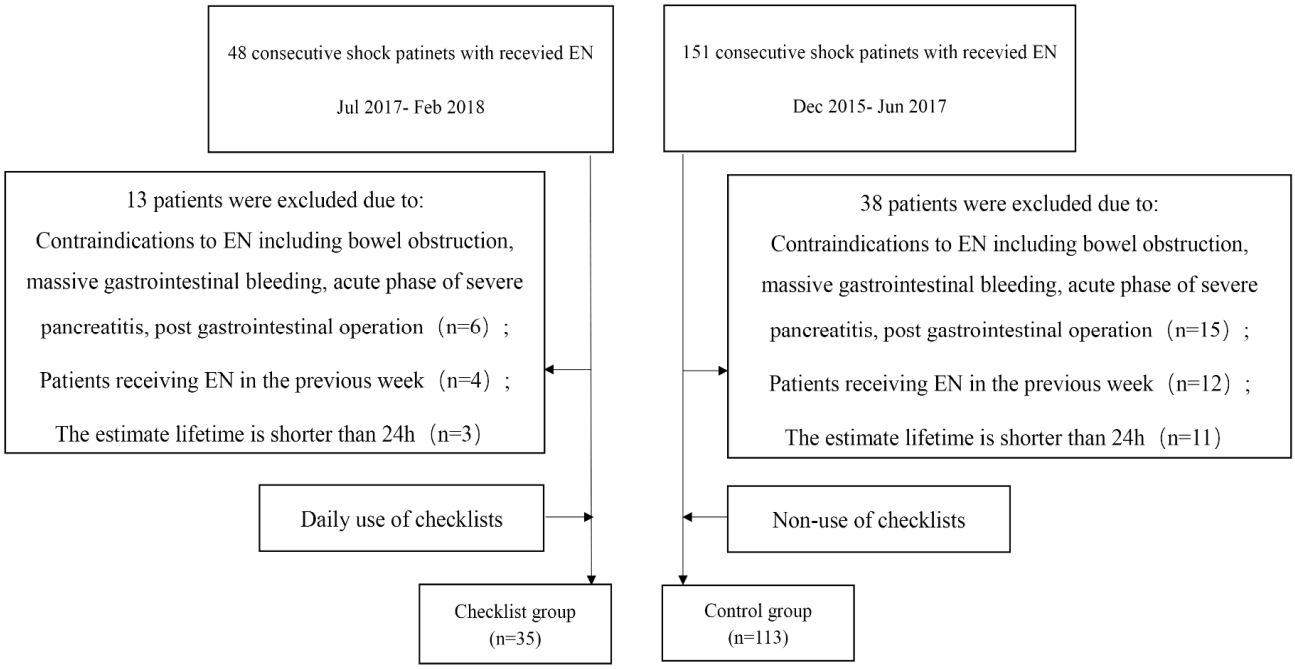


Figure 2. Patients included in study cohorts.

Table 2. The comparison of characteristics and outcomes between checklist group and control group

	Checklist Group	Control Group	*p*-value
N	35	113	
Hospital stay (d)	33.7±22.5	39.0±25.2	0.275
ICU stay (d)	17.3±18.1	25.7±21.9	0.043
Duration of MV(d)	13.4±16.6	16.6±20.0	0.395
28-days mortality	7 (20.0%)	27 (23.9%)	0.632
90-days mortality	9 (25.7%)	36 (31.9%)	0.490
Intolerance of EN feeding	6 (17.1%)	26 (23.0%)	0.461

ICU: intensive care unit; MV: mechanical ventilation.

Table 3. The comparison of characteristics and outcomes between Checklist group and control group in multivariate analysis

Exposure	Non-adjusted	Adjust I	Adjust II
ICU stay (d)			
Control group	0	0	0
Checklist group	-8.3 (-16.3, -0.3) 0.043	-5.2 (-10.0, -0.5) 0.033	-5.0 (-9.8, -0.1) 0.048
Hospital stay (d)			
Control group	0	0	0
Checklist group	-5.2 (-14.5, 4.1) 0.275	-3.0 (-11.1, 5.1) 0.468	-2.7 (-10.9, 5.6) 0.527
Intolerance of EN feeding			
Control group	1.0	1.0	1.0
Checklist group	0.7 (0.3, 1.8) 0.463	1.0 (0.4, 2.9) 0.954	1.0 (0.3, 2.8) 0.952
28-days mortality			
Control group	1.0	1.0	1.0
Checklist group	0.8 (0.3, 2.0) 0.633	1.5(0.5, 4.1) 0.483	1.0 (0.3, 3.2) 0.959
90-days mortality			
Control group	1.0	1.0	1.0
Checklist group	0.7 (0.3, 1.7) 0.491	1.4 (0.5, 3.5) 0.520	0.9 (0.3, 2.7) 0.793

APACHE: acute physical and chronic health assessment; EN: enteral nutrition; ICU: intensive care unit; MV: mechanical ventilation.
Data in the table: OR (95% CI) p-value.
Model I：Non-adjusted.
Model II adjust for: duration of MV, EN start time, MV, Abdominal diseases.
Model III adjust for: duration of MV, EN start time, MV, APACHE II Abdominal diseases.

list was based on studies focusing on hemodynamic stabilization, gastrointestinal function assessment, AGI, aspiration risk assessment, nutrition initiation, speed, risk assessment, and intolerance.

The hemodynamic status of shock patients was assessed in our checklist. Unstable hemodynamic status and vasopressors often cause gastrointestinal dysfunction and intolerance to feeding.[19] Mancl et al[20] reported that the tolerance rate of EN in shock patients who received 12.5 μg•min-1 of norepinephrine was 75%. Therefore, the dose of vasopressors was also recorded in our checklist.

The AGI grading system was proposed by the European Society of Intensive Care Medicine (ESICM) in 2012. The AGI grading system has been associated with the severity of gastrointestinal dysfunction and mortality.[21,22] The checklist included the AGI grading system as an item.

Intolerance to feeding, which is a major cause of insufficient nutrition, is associated with mortality.[20,23] The assessment of feeding intolerance included nausea, vomiting, constipation, diarrhea, gastrointestinal hemorrhage, and positive abdominal imaging findings. In addition, our EN checklist encourages staff to promptly treat feeding intolerance by adjusting the EN speed after the first assessment of EN tolerability.

Many studies have been conducted on the use of checklists in an ICU; however, no study has evaluated the benefits of using an EN checklist in ICU patients. Most of the studies on the implementation and management of EN have used an EN protocol. Li et al designed an EN protocol for critically ill patients and conducted a before and after study. They reported that EN could not reduce the mortality rate and MV duration.[2] Kim et al. also reported that the EN protocol could begin enteral nutrition early but did not affect mortality.[4] Wikjord et al demonstrated that the EN protocol increased the proportion of early EN but did not affect clinical outcomes, such as length of ICU stay.[3] Volume-based EN adjusts feeding depending on the hourly situation. However, no significant improvement was noted in indicators such as mortality, length of ICU stay, and MV duration.[24]

Previous studies on the use of checklists in an ICU have involved nutrition management. Weiss et al[25] designed a daily checklist that contained an item on nutrition; that is, the percentage of nutrition goals achieved. The results of this study can be applied to a single-centre MICU to improve medical quality and reduce disease severity, mortality, and hospitalization duration. Centofanti et al[26] conducted a mixed methods study to investigate the effect of a daily goals checklist on rounds. In their checklist, EN assessment was included as one of the

items. They found that the daily goals checklist enhanced patient safety. Brunsveld-Reinders et al[12] also introduced EN evaluation in the post-transfer part of their transport checklist. However, few studies have performed the nutrition assessment of shock patients.

This study has some limitations. First, because this is a retrospective cohort study, all limitations and bias of the retrospective cohort study were unavoidable. The checklist group had a higher MV rate and earlier EN start; this might have confounded the causality. However, the multivariate analysis confirmed the results. Second, the generalizability of this single-center study may be limited. Third, because this is a pilot study, the sample size was small. Thus, larger studies with prospective randomized controlled trial design are needed.

Conclusion

The implementation of the EN checklist for shock patients in an ICU could reduce the length of ICU stay. However, the use of the EN checklist did not improve mortality, MV duration, and intolerance to EN feeding.

AUTHOR DISCLOSURES

The authors declare that they have no conflicts of interest.

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Supplemental table 1. Aspiration risk score

Scores	1	2	3
Age	10-49 years	50-80 years	>80 years or<10 years
Consciousness	Conscious	Conscious and sedation	Coma
Sputum	Little	More and thickness	More and thin
Alzheimer's disease, cerebrovascular accident, myasthenia gravis, Parkinson's disease	None	One	More than one
Diet	Abrosia	Normal	Liquid or semiliquid diets
Body position	Semireclining position ≥30°	Semireclining position <30°	Horizontal position
Water swallow test	1 grade	2 grade	≥3 grade
Artificial airway and mechanical ventilation	None	Positive	/
Aspiration history	None	/	Positive

Aspiration risk are classified as: Low, 0-10; High, 11-26.