Original Article

Nutrition support for critically ill patients in China: role of the pharmacist

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Background and Objectives: The participation of a nutrition support pharmacist (NSP) in a multidisciplinary team (MDT) for patients receiving nutrition support therapy (NST) may lead to more favourable outcomes and fewer complications and adverse events. However, few studies have demonstrated the role of NSPs in MDTs in China. To investigate pharmacy interventions and physician acceptance of these interventions for patients receiving NST in an intensive care unit (ICU). **Methods and Study Design:** A prospective study over a 12-month period was conducted in an ICU at an academic hospital in China. Interventions were documented and divided into the following categories: indication of NST, parenteral nutrition (PN) prescription and delivery, enteral nutrition (EN) route and formulation, fluids and electrolytes, laboratory test monitoring, nutritional supplements, and other medication-related problems. Data regarding the intervention categories, timing, acceptance rates, and methods of communication to discuss pharmacy interventions were collected. **Results:** In total, 247 interventions for 120 patients were identified. The overall acceptance rate of interventions was 85.0% (210/247), and more than half of the interventions (143, 57.9%) were performed during daily follow-up. The most common intervention categories were PN prescription and delivery (81/247, 32.8%), EN route and formula (33/247, 13.4%), indication of NST (33/247, 13.4%), and nutritional supplements (30/247, 12.1%). The most accepted intervention category was PN prescription and delivery (79/81, 97.5%), and the most common method of communication was oral communication during MDT rounds (201/247, 81.4%). **Conclusions:** This study demonstrated the unique perspectives offered and importance of having pharmacists as members of MDTs.

Key Words: critically ill patient, nutrition support pharmacist, pharmacy intervention, physician acceptance, China

INTRODUCTION

Nutrition support therapy (NST) is a key aspect of pharmaceutical care for intensive care unit (ICU) patients. Poor nutritional status has been associated with the complications of increased infectious morbidity, multiple organ dysfunction, prolonged hospitalization, and high mortality in critically ill patients.[1] Medication administration for NST patients is also challenging, especially when medications must be administered intravenously or through enteral feeding tubes concurrently with NST. Thus, the stability and compatibility of medications used alongside NST must first be evaluated.[2-4] In addition, ICU patients receiving NST often experience complications or disease states such as organ dysfunction, malnutrition, hypervolemia, and hemodilution. These conditions may alter the pharmacokinetics, pharmacodynamics, and bioavailability of medications and nutrients, and this could pose challenges to clinicians who provide NST to such patients.[5]

Medical centers are increasingly establishing multidisciplinary teams (MDTs) to perform NST; each such team contains a nutrition support pharmacist (NSP) to care for patients receiving specialized nutrition support, including parenteral nutrition (PN) and enteral nutrition (EN). The NSP is engaged in direct patient care and is responsible for promoting the maintenance and recovery of a patient's optimal nutritional status and designing or modifying treatments according to the needs of said patient.[4,6,7] Studies have demonstrated that patients can benefit from pharmaceutical care and interventions provided by an NSP.[4,8-12] One study demonstrated that through pharmacist interventions, drug-related problems were identified in almost 30% of patients receiving NST, and 85% of those interventions yielded positive clinical outcomes.[13]

Although clinical pharmacy services related to NST were first introduced over four decades ago in Western countries,[4,11] such services have only recently been intro-

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duced in China, after the Ministry of Health implemented new policies concerning clinical pharmacists. Nutrition support was not officially considered as a clinical pharmacy specialty in China until 2012, when four teaching hospitals were given approval to begin specialty training of pharmacists for nutrition support. The pharmacy cooperative group of Chinese Society of Parenteral and Enteral Nutrition (CSPEN) was established in 2014, and thus little is known about the clinical nutrition support–related activities and practices of NSPs in China, and considerable practical variations in clinical pharmacy services for NST remain. Interventions performed by pharmacists during patient-specific NST in critical care settings require investigation to support the improvement of clinical NST pharmacy services in China.

METHODS

Study aim

The main objective of this study was to demonstrate the pharmacist's role in NST for ICU patients by investigating pharmacy interventions and physicians' acceptance of recommendations.

Ethical approval

This study was approved by the Ethics Committee of The First Affiliated Hospital of Chongqing Medical University

Description of nutrition support pharmacy services

Pharmacy participation in the aforementioned MDTs was provided by a board-certified NSP (accredited by China's National Health and Family Planning Commission) and three pharmacy residents on a nutrition support rotation. Other team members included ICU attending physicians, resident physicians, and dietitians. The physicians and dietitians were responsible for prescribing NST formulas, and the NSP assessed patients and made recommendations regarding NST. The ICU physicians were ultimately responsible for the NST of each patient.

Patients were visited daily by members of the pharmacy team and twice weekly during MDT rounds. In collaboration with other health care professionals, the NSP and/or pharmacy residents performed initial and daily follow-up assessments of NST and made appropriate pharmacy recommendations when opportunities for intervention arose.

Study design and data collection

This study was conducted at The First Affiliated Hospital of Chongqing Medical University, a tertiary care teaching hospital in Chongqing and one of the first four certified training hospitals for NSPs in China. The investigation was a prospective observational study conducted in a 30-bed ICU from January 2016 to December 2016. All pharmacy interventions were recorded in Microsoft Excel® for statistical analysis. The following information was recorded for each intervention:

1. Patient demographics: age, sex, body mass index, reason for ICU admission, disease states, length of ICU stay, and duration of NST
2. Principal indication for a specific type of NST
3. Timing of the intervention with respect to NST: beginning of NST, follow-up, or end of NST
4. NST type: total parenteral nutrition (TPN), total EN, or partial EN combined with supplemental PN
5. Category of interventions:
   a. Indication of NST
   b. PN prescription and delivery
   c. EN feeding route and formulation
   d. Fluids and electrolytes
   e. Laboratory test monitoring
   f. Nutritional supplements
   g. Medication-related problems (MRPs) discovered during NST
6. Subcategories of interventions under each intervention category (shown in Table 1)
7. Acceptance of interventions: complete, partial, or no acceptance
8. Methods of intervention communication: during medical rounds, by phone, through messages, through consultation papers, or other
9. Remarks: other data of interest.

RESULTS

Patient characteristics

A total of 120 patients receiving NST during the study period were included in our analysis. Table 2 shows the demographic and clinical characteristics of these patients. Their average age was 59.6 years, and 67.5% were male. The average lengths of ICU stay and NST were 28.8 and 17.6 days, respectively. The top three reasons for ICU admission were severe acute pancreatitis (16.7%), gastrointestinal disorders (15.8%), and sepsis or septic shock (15.0%). Most of the patients (76.6%) exhibited two or more disease states. The top three comorbidities were respiratory distress (44.2%), abnormal liver function (39.2%), and renal insufficiency (30.0%).

Pharmacist interventions

The pharmacy team conducted 247 interventions for these 120 patients, yielding an average of approximately 2.06 recommendations per patient (Table 3). More than half of the interventions (57.9%) were conducted during daily follow-up for patient-specific nutritional care plans. Regards types of interventions, 83.9% were PN, and 16.2% were EN. The most common intervention categories and subcategories were 1) PN prescription and delivery (81/247, 32.8%), with 44.4% (36/81) for adjustment of compatibility and/or stability; 2) EN route and formula (33/247, 13.4%), with 45.5% (15/33) for changes to dosing or formulations; 3) indications of NST (33/247, 13.4%), with 57.6% (19/33) for changes to different modalities or combinations of modalities of NST; and 4) nutritional supplements (30/247, 12.1%), with 56.7% (17/30) for adding water and/or lipid-soluble vitamins (Tables 1 and 4). In addition, 8.1% (20/247) of the interventions were for MRPs; this category included recommendations for changing medication dosages, route and formulation, and the commencement or discontinuation of medications. The medications involved included insulin, propofol, acid suppression agents, prokinetic agents, and antidiarrheal agents.

Table 1. Distribution of subcategories of pharmacist interventions under each category

Type of intervention	Interventions, n	Interventions, %†
1.Indication of nutrition		
1.1 Change nutrition to a different modality or a combination of modalities (TPN,PEN,SPN,TEN)	19	7.7
1.2 Postpone nutrition care plan	7	2.8
1.3 Suspend nutrition treatment	6	2.4
1.4 Prolong nutrition duration	1	0.4
Total	33	13.4
2. PN prescription and delivery		
2.1 Adjust for PN compatibility/stability	36	14.6
2.2 Adjust according to co-morbidity/complication	27	10.9
2.3 Change intravenous accesses (routes)	12	4.9
2.4 Adjust for volume balance control	6	2.4
Total	81	32.8
3. EN route and formula		
3.1 Change dose/category of formulations	15	6.1
3.2 Change rate and mode of administration	11	4.5
3.3 Change device/route of feeding access	7	2.8
Total	33	13.4
4. Fluids and electrolytes		
4.1 Correct electrolyte abnormalities	14	5.7
4.2 Change type and volume of IV fluids	5	2.0
4.3 Increase/change rate of IV fluids	4	1.6
Total	23	9.3
5. Laboratory test monitoring		
5.1 Monitor electrolytes	9	3.6
5.2 Monitor hepatic panel and serum prealbumin	8	3.2
5.3 Monitor blood glucose and lipids levels	8	3.2
5.4 Monitor renal function	2	0.8
Total	27	10.9
6. Nutritional supplements		
6.1 Add water/lipid-soluble vitamins	17	6.9
6.2 Add immune-modulating formulas	10	4.1
6.3 Add other micronutrients	3	1.2
Total	30	12.2
7. Other medication-related problems		
7.1 Change dose	8	3.2
7.2 Start or discontinue medications	6	2.4
7.3 Change route or medication formulation	6	2.4
Total	20	8.1

TPN: total parenteral nutrition; PEN: partial enteral nutrition; SPN: supplemental parenteral nutrition; TEN: total enteral nutrition; IV: intravenous.
†Proportion of the 247 interventions under each category.

Physician acceptance of pharmacy recommendations

The overall acceptance rate for pharmacy recommendations by physicians was 85.0% (210/247), with 178 recommendations completely accepted and 32 partially accepted. Although only 11.3% of the interventions were performed toward the end of patients' NST, the acceptance rate for these interventions was high compared with that of those performed upon initiation of NST or during follow-up. Most interventions performed under the category of PN prescription and delivery were accepted, yielding a high acceptance rate of 97.5% (79/81). As shown in Table 5, of these 79 accepted recommendations, therapy adjustment for PN compatibility or stability and changes made based on patients' comorbidities and/or complications accounted for 78.5% (62/79). Examples of adjusting PN compatibility or stability included limiting the amount of calcium and magnesium cations in the PN solution and adjusting the dosage of amino acids to maintain a final concentration of ≥4% in the total nutrient admixture (TNA). The rationale behind this intervention category was to assure the safety of the admixture as a complex system combining amino acids, dextrose, fat emulsion, electrolytes, vitamins, and trace elements. Examples of adjustment of PN regimens made based on patients' comorbidities or complications included adjusting the dextrose dosage or rate of administration for better glycemic control in patients with diabetes and the prevention or treatment of intestinal failure–associated liver disease (IFALD) through adjustment of the dose and/or type of intravenous fat emulsion for patients with abnormal liver function. The second highest acceptance rate was for the MRP category, with 90.0% (18/20), and the third highest was for the EN route and formula category, with 87.9% (29/33). The acceptance rates for recommendations of fluids or electrolytes and laboratory test monitoring were also above 80%, with 87.0% (20/23) and 85.2% (23/27), respectively (Table 4).

The least acceptable intervention category was nutritional supplements (56.7%, 13/20). Recommendations in this category included the addition of vitamins, immune-

Table 2. Demographic and clinical characteristics of the analyzed critically ill patients

Characteristics	Values (N=120)
Gender	
Male, n (%)	81 (67.5)
Female, n (%)	39 (32.5)
Age (mean, SD) , year	59.6±17.9
Body mass index (mean, SD), kg/m^2	20.6±15.0
Length of ICU stay (mean, SD), day	28.8±27.8
Duration of nutrition therapy (mean, SD), day	17.6±25.5
Primary diagnosis for ICU admission, n (%)	
Severe acute pancreatitis	20 (16.7)
Gastrointestinal disorder	19 (15.8)
Sepsis/septic shock	18 (15.0)
Cardiac disorder	14 (11.7)
Severe multiple injury/trauma	14 (11.7)
Neurological disorder	11 (9.17)
Respiratory disorder	10 (8.33)
Malignancy	10 (8.33)
Others	4 (3.33)
Primary co-morbidities†, n (%)	
Respiratory distress	53 (44.2)
Abnormal liver function	47 (39.2)
Renal insufficiency	36 (30.0)
Hypertriglyceridemia	27 (22.5)
Electrolyte disturbance/acid—base imbalance	27 (22.5)
Diabetes	23 (19.2)
Coagulopathy	23 (19.2)

Data are expressed as number (percentage) or mean±standard deviation.
†Two or more comorbidities were observed in 92 patients

Table 3. Correlation between the timing of pharmacist interventions and their acceptance

Moment of intervention	Interventions, n	Complete acceptance, n	Partial acceptance, n	No acceptance, n	Acceptance† rate
Beginning	76	54	4	18	76.3%
Follow-up	143	109	17	17	88.1%
End	28	15	11	2	92.9%
Total	247	178	32	37	85.0%

†Acceptance refers to both complete and partial acceptance.

Table 4. Categories of pharmacist interventions and their acceptance

Intervention Category	Interventions, n	Complete acceptance, n	Partial acceptance, n	No acceptance, n	Acceptance† rate
Indication of nutrition	33	19	5	9	72.7%
Parenteral nutrition prescription and delivery	81	71	8	2	97.5%
Enteral nutrition route and formula	33	23	6	4	87.9%
Fluids and electrolytes	23	19	1	3	87.0%
Laboratory test monitoring	27	23	0	4	85.2%
Nutritional supplements	30	9	8	13	56.7%
Other medication-related problems	20	14	4	2	90.0%

†Acceptance refers to both complete and partial acceptance.

modulating formulas, and other micronutrients for patients at high risk or with manifestations of nutrient deficiency or other specific clinical conditions. Of the 37 nonaccepted interventions, 14 (37.8%) were not accepted because of the team's concern that the recommendations would be unable to resolve acute issues for specific patients, and 7 (18.9%) were because of limited convenience or knowledge regarding specific areas such as the estimated protein needs of critically ill patients undergoing continuous renal replacement therapy. Except for 8 (21.6%) non-accepted PIs with unclear reasons, the rest 8 (21.6%) recommendations were not accepted because of economic concerns, psychosocial issues, or unavailable pharmaceutical formulations.

Methods of communication for pharmacy recommendations

The methods of communication for the 247 pharmacy recommendations were recorded and reviewed in this study. Oral communication with ICU physicians during

Table 5. Types and examples of accepted pharmacist interventions in PN prescription and delivery

Intervention type†	Accepted interventions, n	Examples
Adjustment for PN compatibility/stability	36	- Limit the amounts of positively charged divalent cations calcium and magnesium - Adjust dosing of amino acid to maintain its final concentrations ≥4% in TNA
Adjustment according to co-morbidities/complications	26	- Adjust dextrose dose or rate of administration for better glycemic control - Prevent or treat IFALD by adjusting dose and/or type of IVFE formulation
Change venous accesses (routes)	11	Recommend the preferred vascular access for administering TNA
Adjustment for volume balance	6	Choose formulations based on different nutrient concentrations to control the total volume of TNA
Total	79	

PN: parenteral nutrition; TNA: total nutrient admixture; IFALD: intestinal failure–associated liver disease; IVFE: intravenous fat emulsion.
†Guaranteed stability and compatibility of PN admixtures was a precondition of all interventions.

daily medical rounds was the most common communication method for pharmacy recommendations (201, 81.4%). Other methods employed were written consultation papers (24, 9.7%), short messages (15, 5.3%), and telephone consultation (9, 3.6%).

DISCUSSION

To the best of our knowledge, this was the first prospective study to investigate pharmacy interventions for patients receiving NST in critical care settings in China. NST-related problems were common in this patient population, with an average of 2.06 per patient. The most common intervention category was related to PN. The MDT acceptance rate for pharmacy recommendations was high, with 85.0%; this result was similar to those of two previous studies that yielded corresponding acceptance rates of 84% and 83.77%.[14,15]

Pharmacist interventions and MDT acceptance of recommendations

ICU patients are typically associated with high risk of adverse events and medication errors, especially when multiple intravenous medications are administered simultaneously.[3,16] The safe compounding of TNAs is a longstanding problem because of its complexity, and related errors occur frequently.[17] Per the standards of practice for NSPs,[6] pharmacists are to participate in developing, implementing, and adhering to procedures for detecting and preventing compatibility or stability problems associated with PN admixtures. Our study indicated that pharmacy interventions under the category of PN prescription and delivery were the most frequent and most accepted type of intervention. The rationale behind this category was to assure compatibility between ordered nutrients and medications and the expected stability of the TNA formulation in question. Specific examples in this category included selecting an alternative admixed formulation owing to brand product unavailability and the NSP needing to adjust the dosage of electrolytes or amino acids based on considerable differences in ion content and/or nutrient concentration in a new formulation product.

PN support, especially long-term use of TPN, is reportedly associated with adverse metabolic effects, including hyperglycemia, serum electrolyte alterations, and hepatic dysfunction such as IFALD. However, as shown in Table 2, clinical comorbidities such as abnormal liver function, hypertriglyceridemia, electrolyte disturbance, and diabetes were fairly common among the critically ill patients analyzed in this study; these findings indicated that this population may have been more susceptible to metabolic complications when receiving PN that when not receiving PN. Previous studies have demonstrated that adding a pharmacist to an MDT to conduct direct interventions as part of a nutrition care plan can reduce the incidence of metabolic and electrolyte complications associated with PN therapy.[4,10,11] These findings indicate a great opportunity for pharmacists to participate in and provide recommendations for practical nutrition support. Our study indicated that adjustment of PN regimens based on patients' changing clinical conditions, namely comorbidities and metabolic complications related to nutrition support, obtained the highest MDT acceptance rate for pharmacy recommendations. Interventions under the category of other MRPs were also highly accepted by the MDT. Pharmacist knowledge and expertise regarding medications contributed to the detection of MRPs, including drug–drug, drug–nutrient, and drug–laboratory interaction and incompatibility.

Pharmacists in the MDT were able to perform interventions by monitoring a patient's laboratory test results such as those related to electrolytes. Our study indicated that the acceptance rate for this category of intervention was high, WITH 85.2%. As an example, one patient in this study developed acute encephalopathy and cardiac arrhythmias after substantial intravenous glucose infusion. With body weight loss of 10 kg in the three months following subtotal gastrectomy, this severely malnourished patient had a serum potassium level of <3 mmol/L, which raised suspicion of refeeding syndrome (RFS; a severe complication related to the recommencement of nutrition) in the pharmacist. After the communication between the pharmacist and other members of the MDT, a laboratory evaluation for RFS was ordered, and RFS was confirmed alongside concurrent hypophosphatemia and hypomagnesemia. This outcome contributed to the provision of appropriate nutrition treatment for this patient.

Methods of communication of pharmacy interventions to the MDT

More than half (57.9%) of the pharmacy interventions in this study were conducted during daily monitoring and follow-up for patient-specific nutrition care plans. The most common method of communication (81.4%) for these interventions was oral communication during daily medical rounds. After reviewing medical records and laboratory findings in advance, the pharmacy team typically communicated with physicians and other health care professionals during daily and/or MDT rounds, when the team members were able to discuss and share their views about patient-specific nutrition care plans, with each member contributing his or her expertise for treatment optimization. This communication method enabled more rapid responses from physicians and allowed the MDT to more frequently accept pharmacist interventions; a similar finding was observed in a study by Sevilla Sánchez.[15]

Our study had the following limitations: 1) Although Cerulli et al reported that 85% of pharmacist interventions for NST yielded positive clinical outcomes among patients, and Mousavi et al reported markedly improved nutritional status and clinical outcomes in a pharmacy intervention group,[13,18] we were unable to evaluate the clinical outcomes of our pharmacy interventions because of the complexity and heterogeneity of patients' disease states in the critical care setting. 2) The impact of pharmacy interventions on costs or other value-based aspects of care were not assessed; this may be investigated in our future studies.

Conclusions

The interventions performed by pharmacists on patients for NST in this study demonstrated the value of pharmaceutical care provided by pharmacists. As members of nutrition MDTs, NSPs can offer unique and valuable perspectives to direct patient care and contribute to safe and efficacious nutrition care for those in need of specialized NST.

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AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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