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Prevalence of Feeding Intolerance in PICU: A Cross-sectional Study

Alireza Hatami[1], Faezeh Mashhadi[1], Ava Hemmat[1], Hadis Alimoradi[1], Mohammad Safarian[1, 2], Majid Sezavar[3], Gholamreza Khademi[3, 4], Maryam Naseri[3], Fatemeh Roudi[1]*

1. Department of Nutrition, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.
2. Metabolic Syndrome Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.
3. Department of Pediatrics, Faculty of Medicine, Mashhad University of Medical sciences, Mashhad, Iran.
4. Neonatal Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.

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ABSTRACT

Introduction: Malnutrition, as defined by the World Health Organization (WHO), occurs when the body does not receive sufficient nutrients or energy to meet growth, maintenance, and functional needs. Severe malnutrition in children increases the risk of death, disease episodes, complications, and prolonged illnesses. Therefore, early nutritional support is crucial in pediatric critical care settings. In cases where oral feeding is not feasible, enteral feeding (EN) becomes necessary to provide adequate energy. However, despite its advantages, feeding intolerance remains a significant challenge. This study aims to determine the prevalence of feeding intolerance among critically ill children in the Pediatric Intensive Care Unit (PICU).

Method: This cross-sectional study was conducted at the Akbar Pediatric Subspecialty Center's PICU in Mashhad, Iran between March and April 2022. The evaluation focused on nutritional adequacy and feeding intolerance.

Results: A total of 72 patients were included in this study with a majority being girls. Approximately 30 percent of patients exhibited severe malnutrition based on their BMI Z-score (<-3). Boys were more affected than girls in this regard. Most patients received a combination of EN and parenteral nutrition (PN) to fulfill their energy and protein requirements successfully. In most cases, children consumed over 66% of their energy needs through these methods. Feeding intolerance primarily manifested as vomiting and regurgitation (47%), followed by high gastric residual volume (GRV) (36.1%) and abdominal distention (34.7%).

Conclusion: The findings from our study highlight the prevalence of malnutrition within PICU settings along with common complications associated with feeding intolerance such as vomiting and regurgitation. Standardizing a definition for feeding intolerance could prove beneficial for improving research protocols aimed at effectively managing this condition.

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Introduction

Malnutrition is a condition characterized by insufficient nutrient and energy intake to meet the body's growth, maintenance, and functional requirements, as defined by the World Health Organization (WHO) (1). Severe malnutrition in children significantly increases the risk of mortality compared to well-nourished children. Additionally, severe disease episodes are more likely to occur among malnourished children, leading to increased complications and prolonged illness durations for each episode (2). Furthermore, malnutrition can also develop during hospitalization or after discharge, with pediatric intensive care units (PICUs) posing a higher risk setting for such cases (3).

Early nutritional support plays a vital role in pediatric critical care management and should be tailored to individual patient needs (4). Nutritional interventions should be initiated promptly following admission and emphasize early assessment of nutritional status. Preferential oral intake over parenteral feeding is recommended whenever possible, and a

* *Corresponding authors:* Fatemeh Roudi; Assistant Professor, Department of Nutrition, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad 91779-48564, Iran. Tel: + 985138002117, Email: roudif@mums.ac.ir.

preference for enteral feeding over parenteral feeding (3). However, when patients are unconscious or unable to swallow or drink due to sedation or other factors, enteral feeding becomes necessary for adequate nutrition delivery (5).

Enteral nutrition offers several physiological advantages including maintenance of gut integrity through gut-associated lymphoid tissue stimulation that supports motility and prevents intestinal mucosal atrophy. It also helps reduce hyperglycemia levels and decreases hospital stay duration. Nonetheless, enteral nutrition may present complications as well (6). The most common complication associated with enteral feeding is enteral tube feeding intolerance (ETFI), which occurs due to impaired gastroduodenal motility and absorption resulting in inadequate enteral nutrient intake (7). Features indicative of ETFI include large gastric residual volumes (GRVs), abdominal distension or increased girth; vomiting; diarrhea; or subjective discomfort (2, 8). These conditions lead not only to insufficient nutrient intake but also result in extended stays in intensive care units and increased mortality rates (9).

Numerous studies conducted worldwide have explored EN intolerance specifically in PICUs. Some studies have found higher rates of ETFI among critically ill patients receiving EN, as indicated by GRV measurements, particularly within the PICUs of hospitals compared to general wards (6).

Although there are no agreed-upon definitions of EFI, it occurs frequently and can have adverse consequences (10). Nutrition by enteral route (EN), the preferred method of nutrient delivery, may be an integral part of the care provided in the PICU, with the potential to modify the response to critical illness or injury, thus enhancing survival (11). The international PICU community needs to agree on a consistent definition of feeding intolerance so that practice and research are consistent. Further education may help healthcare professionals to better understand the limitations of the markers used to define feeding intolerance (12).

Given the importance of addressing enteral feeding intolerance to prevent malnutrition within the PICU setting, this study aims to determine the prevalence of feeding intolerance among critically ill children in Iran.

Methods

Study design and participants

This cross-sectional study was conducted at the PICU of Akbar Pediatric Subspecialty Center in Mashhad, Iran. Data collection took place from March to April 2022. Patients admitted to the two general PICUs of Akbar Hospital were included using simple sampling based on our inclusion criteria. The study enrolled patients under 18 years old who received ETF and were hospitalized in the PICU for a minimum of 48 hours. Patients who had already been receiving enteral tube feeding prior to hospital admission, those on an oral diet with supplemental ETF, individuals transitioning from PN to an oral diet, or cases where medical records were unavailable were excluded from further analysis.

Patient characteristics, daily nutrition intake (EN or PN), and outcome data were collected during their stay in the ICU. Nutrition data encompassed information such as the type and quantity of prescribed and received nutrition (both calories and protein). These details were recorded daily for a maximum duration of 42 days or until death/discharge from the PICU. The determination of optimal nutrition prescription was not standardized but left to individual provider judgment, which was documented accordingly. Nutrition adequacy was calculated by comparing the percentage of prescribed proteins or calories with the actual amount received.

Data extracted for each patient included demographic characteristics, diagnosis, route of EN delivery, specific enteral formula used, time taken in days following initiation of feeding to achieve nutritional goals, occurrence of feeding intolerance episodes along with associated complications if any occurred during subsequent management.

For children aged 2 to 5 years old standing upright height measurements were recorded while length measurements lying down were taken for those under 2 years old unable to stand independently. Existing digital scales available on-site measured weight in kilograms (kg). Height and weight measurements followed centimeters (cm) units. CDC charts served as references for calculating z-scores.

The criteria defining enteral tube feeding intolerance (ETFI) encompassed the development of symptoms necessitating changes in the feeding protocol and/or specific

treatments, such as antiemetic or prokinetic medication administration. Symptoms could include one or a combination of the following: nausea, vomiting, diarrhea, abdominal pain/distension, and GRV. Nausea, vomiting, or abdominal pain were based on patient-reported symptoms while diarrhea was determined by assessing bowel charts for passing three or more loose bowel movements per day.

Statistical Analysis

Data analysis was performed in Statistical Package for the Social Sciences (SPSS) (Chicago, USA) (version 16) using descriptive statistics to define the baseline characteristics. The obtained results were expressed as mean and standard deviations or median and 25th to 75th interquartile in the case of quantitative data, and the qualitative data were expressed as frequency and percentage.

Result

We studied 72 critically ill patients admitted to PICU (39 males and 33 females) with a mean age of 31 months. According to Table 1, the profile of the patients included in the plan is displayed, which shows that among the seventy-two patients studied, the number of hospitalized male patients is more than female patients. However, their mean age, height, and weight at admission are lower than girls.

Abbreviations

BMI: Body Mass Index
SD: Standard Deviation
WAZ: Weight for Age Z-score
WHZ: Weight-for-length/Height Z-score

Table 1. Characteristics of the Patients admitted to PICU.

Baseline Characteristics			
	Sex		
	Male	**Female**	**Total**
N (percent)	39 (% 54.2)	33 (% 45.8)	72 (100%)
Age (months)	22.6	40.8	31
Mean Weight (range)	8.75kg (2.7-35)	13.5kg (2-88)	10.9kg
Mean Height (range)	74.2cm (5-147)	84.6cm (45-155)	79cm
Mean WAZ	-1.9	-2.18	-2
Mean WHZ	-2.19	-3.16	-2.6
Mean BMI (for Age More than 2) (range)	14.1 (10-17)	16.8 (9-36)	15.6
Mean BMI for age z score	-2.3	-2.1	-2.2

According to Table 2, patients were divided into three groups based on WHZ, WAZ, and BMIZ in terms of low, moderate, and severe malnutrition, and it was observed that most patients have severe malnutrition (Z score <-3).

Table 2. Malnutrition Characteristics

	Total		
	Mild **-1 to -2**	**Moderate** **-2 to -3**	**Severe** **< -3**
WAZ	19%	20%	27%
WHZ	12%	12%	29%
BMI z score (For Age greater than 2)	4%	13%	30%

In Table 3, the state of malnutrition was analyzed separately for girls and boys, and severe malnutrition was observed in boys more than girls.

Table 3. Malnutrition Characteristics

Sex	**Male**			**Female**		
	Mild **-1 to -2**	**Moderate** **-2 to -3**	**Severe** **< -3**	**Mild** **-1 to -2**	**Moderate** **-2 to -3**	**Severe** **< -3**
WAZ	9%	9%	15%	9%	11%	12%
WHZ	6%	4%	18%	5%	8%	11%
BMI z score (For Age greater than 2)	0%	4%	13%	4%	8%	17%

As shown in Table 4, most patients receive EN and PN together to achieve their energy and protein goals. A total of 15 patients receives parenteral nutrition while six patients receive only enteral nutrition.

Table 4. Route of nutritional intervention

Route	N	Percent
Enteral Nutrition (EN)	6	8.3 %
Parenteral nutrition (PN)	15	20.8 %
EN + PN	51	70.8 %
Total	72	100%

Table 5 provides information on receiving nutrition goals or nutritional adequacy. Approximately 86% of children receive more than two third of their energy goals. The ratio for protein adequacy was approximately 70%.

Table 5. Nutritional Characteristics of Energy and Protein

	N (%total)	Mean Percent	Interquartile Range (IQR)
Energy Tolerance (>66.6%)	62 (86.1%)	83.3%	22.75
Energy Intolerance	10 (13.9%)	16.6%	22.75
Protein Adequacy (>66.6%)	51 (70.8%)	73.7%	40
Protein Inadequacy	21 (29.2%)		

According to Table 6, there were several reasons for enteral feeding interruptions. The frequency of vomiting and regurgitation was higher among these patients (47.2%). Following these symptoms, high GRV (36.1%) and abdominal distention (34.7%) occur more often. Children receiving enteral nutrition were less likely to suffer from diarrhea (30.6%) or constipation (13.9%) compared to other symptoms.

Table 6. Prevalence for Each Identified Reason for EN feeding Interruptions.

Reasons for EN feeding interruptions	Case (total=75)	Percent	Episode
Vomiting or Regurgitation	34	47.2 %	63
Excessive GRV	26	36.1 %	53
Abdominal distention	25	34.7 %	46
Diarrhea	22	30.6 %	36
Constipation	10	13.9 %	12

Discussion

In this study, we observed a higher rate of severe malnutrition, particularly among boys compared to girls. Most patients in our study received a combination of enteral nutrition (EN) and parenteral nutrition (PN) to meet their energy and protein goals. Approximately 86% of children obtained more than two-thirds of their energy requirements, while the protein adequacy ratio was around 70%. Feeding intolerance, resulting in vomiting and regurgitation, was found at a frequency of 47.2% among these patients.

A previous study by Kunrong Yu et al. investigated food intolerance during the first seven days of hospitalization and reported the highest level on the second day (1). They defined ETFI as the presence of two or more combinations of symptoms such as GRV with abdominal distension/pain, nausea/vomiting, diarrhea, and subjective discomfort. In contrast, we defined ETFI based on the presence of any single symptom.

Yahyapoor et al., in their research on causes of EFI, found that approximately two-thirds (66%) of critically ill patients experienced EFI. This condition was associated with higher APACHE II scores, SOFA scores, mechanical ventilation duration, large GRV (77.9%), vomiting (33.8%), and abdominal distension in ICU-admitted patients. The most common symptom identified was vomiting (6).

Wang et al.'s study showed that the prevalence of nutritional intolerance among ICU-admitted patients (35.6%) was significantly higher compared to those admitted to general wards within the hospital population (27.4%)(9). Similarly, our study revealed that 16.6% suffered from energy intolerance.

Our study examined the effects of feeding intolerances, such as vomiting, gastrointestinal reflux disease, diarrhea, constipation, and abdominal distention. We found that vomiting accounted for the highest percentage of cases among other symptoms. A review article indicates that vomiting is not an appropriate

marker for evaluating gastrointestinal dysfunction because it is affected by several factors, such as nasogastric aspiration, enteral feeding, and the patient's status. According to some studies evaluating vomiting in critically ill patients, its prevalence ranged from 6-12% (2), while our study found that the prevalence reached 47.2%.

A systematic review of seventy-two studies highlighted that most of them defined feeding intolerance based on a large GRV(1). However, there are challenges in considering GRV as a sole factor for intolerance since each article had its own definition of high GRV. Regular measurement of GRV during enteral feeding is commonly used as an indicator for gastric emptying, feeding success, and aspiration risk according to feeding protocols (2).

While a gastric residual volume below 150 mL is typically considered safe for continued intragastric feeding (2), recent studies suggest that enteral nutrition can still be continued even at residual volumes up to 5 ml/kg or 250ml (13). However, there is conflicting evidence regarding the accuracy and significance of this measurement in assessing gastric emptying. Our study considered multiple factors related to intolerance which provides an advantage over other studies.

In recent research conducted by Liauchonak et al., they aimed to establish an evidence-based definition for enteral nutrition intolerance (14). Their prospective cross-sectional cohort study included patients who received EN during their ICU stay lasting more than 24 hours. The authors modified their nutrition algorithm by incorporating two symptoms of ENI (in contrast to our single symptom criterion) and compared the time required to achieve 60% EN adequacy and the number of interruptions before and after this intervention. In critically ill children, implementing the modified nutrition algorithm did not result in changes in either the time taken or total interruptions required for achieving adequate EN intake.

Solana et al.'s study examined the prevalence of enteral nutrition interruption among critically ill children admitted to PICU along with its associated risk factors. They found that procedures performed outside PICU were the most common cause contributing to ENIs. Caloric and protein intake decreased in the PICU, especially among children with higher Pediatric Risk of Mortality Scores (PRISM), longer PICU stays, and cardiopathy. Their study considered factors such as procedures performed outside the PICU which strengthens their findings. Similarly, our study was influenced by the lack of consistent definition for feeding intolerance and varying interpretations and thresholds for gastric residual volume (15).

Abdominal distension was observed in 13% of patients according to a review article. Studies examining outcomes related to feeding intolerance have shown its association with increased morbidity, mortality, and longer ICU stays. Factors such as large gavage volume received, high rate of gavage infusion, inappropriate gavage temperature or head angle, and medications causing intolerance were taken into account in this study.

Lee et al.'s investigation explored various potential causes of feeding intolerance including respiratory methods such as high positive end-expiratory pressure (PEEP). They found that these methods accounted for most cases of feeding intolerances along with their duration (16).

To reduce food intolerance among patients hospitalized in special care units following certain tips including optimizing gavage administration technique involving considerations like appropriate head angle/temperature/volume infusion rate can be beneficial when combined with training provided to nurses and doctors. However, research in this area has been limited due to the lack of consensus definitions regarding gastrointestinal dysfunction monitoring relying on indirect indicators rather than objective uniform definitions.

It is important to note that none of the GI symptoms alone can predict gastrointestinal function accurately; therefore, further studies are required to develop a simple reproducible scoring system combining clinical symptoms and measurable parameters for evaluating GI tract function.

Conclusion

In conclusion, our study revealed a significant prevalence of EFI among critically ill children admitted to intensive care units. Vomiting and regurgitation were identified as the most common symptoms associated with EFI. Following specific guidelines regarding gavage

administration techniques including considerations like appropriate volumes, infusion rates, temperature, head angle, and medications can help reduce the occurrence of food intolerance in patients hospitalized in special care units. However, further research is needed to establish consensus definitions for gastrointestinal dysfunction and develop effective strategies for managing feeding intolerance.

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