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Association Between Enteral Nutrition Management And Glucose Stability Among Hospitalized Patients With Type 2 Diabetes Mellitus Patients: A Cross-Sectonal Study

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ABSTRACT

Glucose instability is a common challenge among hospitalized patients with Type 2 Diabetes Mellitus (T2DM) and is associated with adverse clinical outcomes, including prolonged hospitalization, increased risk of complications, and higher healthcare utilization. Enteral nutrition management may play an important role in maintaining glycemic control during hospitalization; however, evidence regarding its association with glucose stability remains limited, particularly in Indonesian healthcare settings. To analyze the association between enteral nutrition management and glucose stability among hospitalized patients with Type 2 Diabetes Mellitus. An analytical observational study with a cross-sectional design was conducted in the inpatient ward of RSAU dr. Dody Sardjoto Hospital, Indonesia, from July to September 2025. Thirty hospitalized patients with T2DM who received enteral nutrition therapy for at least 72 hours were recruited using purposive sampling. Enteral nutrition management was evaluated based on formula appropriateness, energy adequacy, protein adequacy, feeding frequency, and feeding method. Glucose stability was assessed using the coefficient of variation (CV) of blood glucose measurements obtained during the first 72 hours of enteral nutrition therapy. Data were analyzed using Chi-square, Fisher's Exact, and logistic regression tests with a significance level of $p < 0.05$. Ethical approval was obtained from the Health Research Ethics Committee of STIKES Notokusumo (No. 034/STIKES-NH/KEPK/V/2025). The participants had a mean age of 59.4 ± 3.1 years and a mean diabetes duration of 12.0 ± 3.8 years. Overall, 19 patients (63.3%) achieved stable glucose levels (CV < 36%), whereas 11 patients (36.7%) experienced glucose instability. Diabetes-specific enteral formulas were significantly associated with a higher proportion of glucose stability compared with standard polymeric formulas ($p = 0.003$). Enteral feeding administered 5–6 times daily was also significantly associated with better glucose stability than feeding frequencies of 3–4 times daily ($p = 0.021$). No significant association was observed between total daily energy intake and glucose stability ($p = 0.074$). In addition, the proportion of hyperglycemia was lower among patients receiving diabetes-specific formulas than among those receiving standard formulas. Diabetes-specific enteral formulas and more frequent enteral feeding schedules were associated with better glucose stability among hospitalized patients with Type 2 Diabetes Mellitus. These findings support the importance of optimizing enteral nutrition management as part of comprehensive glycemic care in hospital settings. Further prospective studies with larger sample sizes are warranted to confirm these findings.

Keywords*: enteral nutrition management; glucose stability; glycemic variability; hyperglycemia; type 2 diabetes mellitus*.

INTRODUCTION

Diabetes mellitus (DM) remains one of the most significant non-communicable diseases (NCDs) worldwide and poses a major challenge to healthcare systems. According to the World Health Organization (WHO), NCDs account for approximately 74% of global deaths, with diabetes contributing substantially to premature mortality, disability, and healthcare expenditures.[1] The global prevalence of diabetes continues to rise due to population aging, urbanization, sedentary lifestyles, and dietary changes.[2] Consequently, healthcare systems are increasingly required to develop evidence-based strategies that improve disease management and clinical outcomes among patients with diabetes.[3]

In Indonesia, diabetes mellitus represents a growing public health concern. National surveys have demonstrated a steady increase in diabetes prevalence over the past decade, accompanied by a rising burden of diabetes-related complications.[4] The increasing number of hospitalized patients with type 2 diabetes mellitus (T2DM) places considerable pressure on healthcare facilities, particularly regarding glycemic management during hospitalization.[5] Poor glycemic control is associated with prolonged hospital stay, increased risk of infection, delayed wound healing, cardiovascular events, and higher mortality rates.[6] Therefore, identifying modifiable factors associated with glucose stability among hospitalized patients has become a clinical priority.[7]

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Glucose stability is increasingly recognized as an important indicator of metabolic control in hospitalized patients. Beyond average blood glucose levels, fluctuations in glucose concentrations commonly referred to as glycemic variability have been associated with oxidative stress, endothelial dysfunction, inflammatory responses, and adverse clinical outcomes.[8] Several studies have reported that excessive glycemic variability is independently associated with increased morbidity and mortality among critically ill and non-critically ill patients.[9] However, despite growing recognition of its clinical importance, the determinants of glucose stability in hospitalized patients with T2DM remain incompletely understood.[10]

One potentially modifiable determinant is enteral nutrition management. Enteral nutrition is widely recommended for hospitalized patients who are unable to meet nutritional requirements through oral intake while maintaining a functional gastrointestinal tract.[11] Appropriate enteral nutrition management includes formula selection, caloric distribution, feeding schedules, carbohydrate composition, fiber content, and continuous monitoring of metabolic responses.[12] From a physiological perspective, enteral feeding directly influences glucose metabolism through nutrient absorption, insulin secretion, incretin hormone responses, and hepatic glucose regulation.[13] Consequently, inappropriate enteral nutrition management may contribute to glucose instability, whereas optimized nutritional strategies may support improved glycemic control.[14]

Previous studies have demonstrated that diabetes-specific enteral formulas characterized by lower glycemic indices, modified carbohydrate composition, and higher fiber content may reduce postprandial hyperglycemia and improve glycemic outcomes.[15] Some investigations have reported reductions in glycemic variability and insulin requirements among hospitalized patients receiving diabetes-specific nutritional interventions.[16] However, findings across studies remain inconsistent. While several randomized and observational studies suggest beneficial effects of specialized enteral formulas, others report modest or non-significant improvements after adjusting for disease severity, comorbidities, and concurrent pharmacological management.[17] Furthermore, many studies have focused primarily on intensive care populations, limiting the generalizability of findings to broader hospitalized patients with T2DM.[18]

In addition, existing literature presents several methodological limitations. Many studies evaluate specific nutritional products rather than overall enteral nutrition management practices, while others prioritize mean blood glucose levels without adequately assessing glucose stability or variability.[19] Moreover, evidence from low- and middle-income countries remains limited despite differences in healthcare resources, nutritional protocols, and patient characteristics.[20] In Indonesia, studies examining the relationship between enteral nutrition management and glucose stability among hospitalized patients with T2DM are particularly scarce.[21] Consequently, the applicability of international findings to local clinical settings remains uncertain.[22]

The present study is informed by the physiological model of glucose metabolism, which posits that nutrient composition and feeding patterns influence glycemic responses through complex interactions involving insulin sensitivity, glucose absorption, and metabolic regulation.[23] Additionally, the study aligns with the Donabedian quality-of-care framework, in which nutritional management represents a process component that may influence patient outcomes, including glucose stability.[24] These frameworks provide a conceptual basis for examining the relationship between enteral nutrition management and glycemic outcomes in hospitalized patients.

Given the increasing burden of T2DM, the clinical significance of glucose instability during hospitalization, and the limited evidence regarding enteral nutrition management in Indonesian healthcare settings, further investigation is warranted. Unlike previous studies that primarily focused on specific enteral formulas or critically ill populations, this study examines the association between enteral nutrition management practices and glucose stability among hospitalized patients with type 2 diabetes mellitus. The findings are expected to contribute to the existing evidence base and support the development of evidence-informed nutritional management strategies aimed at improving glycemic outcomes in hospital settings.
Therefore, this study aims to analyze the association between enteral nutrition management and glucose stability among hospitalized patients with type 2 diabetes mellitus.

MATERIALS AND METHODS

This study employed a quantitative approach with an analytical observational design using a cross-sectional study framework. The cross-sectional design was selected to examine the association between enteral nutrition management and glucose stability among hospitalized patients with Type 2 Diabetes Mellitus (T2DM). In this design, exposure and outcome variables were measured simultaneously, allowing the identification of associations between variables without establishing causal relationships.

The study was conducted in the inpatient ward of RSAU dr. Dody Sardjoto Hospital from July to September 2025. The target population consisted of all hospitalized patients with T2DM who received enteral

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nutrition therapy during the study period. Based on hospital medical records from the preceding six months, 30 patients met the target population criteria.

Participants were selected using a purposive sampling technique. The sample size was determined based on the number of patients who fulfilled the predefined inclusion and exclusion criteria during the study period. A total of 30 patients met the eligibility criteria and were included in the study.

The inclusion criteria were: (1) a confirmed diagnosis of Type 2 Diabetes Mellitus established by the attending physician; (2) receipt of enteral nutrition therapy for at least 72 hours; (3) complete blood glucose monitoring data throughout the observation period; (4) age ≥18 years; and (5) hemodynamically stable condition. The exclusion criteria included patients with diabetic ketoacidosis, hyperosmolar hyperglycemic state, severe sepsis, advanced liver failure, terminal malignancy, or incomplete medical records.

The independent variable was enteral nutrition management. Assessment of enteral nutrition management was based on adherence to the hospital's clinical nutrition guidelines and evidence-based nutritional recommendations for patients with diabetes mellitus. Five components were evaluated: (1) appropriateness of enteral formula selection; (2) adequacy of daily energy intake; (3) adequacy of daily protein intake; (4) frequency of enteral feeding administration; and (5) feeding delivery method.

Each component was assigned a score of 1 if it met the recommended criteria and 0 if it did not. The total score ranged from 0 to 5 and was subsequently categorized as optimal enteral nutrition management (score ≥4) or non-optimal enteral nutrition management (score <4).

The dependent variable was glucose stability. Glucose stability was assessed using the coefficient of variation (CV) of blood glucose levels calculated from glucose monitoring data collected during the first 72 hours of enteral nutrition therapy. The CV was calculated by dividing the standard deviation of blood glucose values by the mean glucose level and multiplying the result by 100%. Based on the International Consensus on Glycemic Variability, a CV value of <36% was classified as stable glucose control, whereas a CV value of ≥36% indicated unstable glucose control. In addition, mean blood glucose levels and the occurrence of hyperglycemia (blood glucose >180 mg/dL) were recorded as secondary indicators of glycemic control.

To minimize potential confounding bias, several covariates were collected and analyzed, including age, sex, duration of diabetes, body mass index (BMI), insulin therapy, oral antidiabetic medication use, serum creatinine levels, comorbidities, and length of hospital stay.

Data were obtained through a review of medical records, clinical nutrition documentation, and nursing observation records. Enteral nutrition data included formula type, caloric intake, protein content, feeding frequency, and administration method. Blood glucose data were collected from documented capillary blood glucose measurements and laboratory examinations performed during the observation period.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version. Descriptive (univariate) analysis was conducted to summarize participant characteristics. Continuous variables were presented as mean ± standard deviation (SD) for normally distributed data or median and interquartile range (IQR) for non-normally distributed data. Categorical variables were presented as frequencies and percentages.

Data normality was assessed using the Shapiro–Wilk test. The association between enteral nutrition management and glucose stability was analyzed using the Chi-square test or Fisher's exact test, as appropriate. Comparisons of continuous variables were performed using the Independent t-test for normally distributed data and the Mann–Whitney U test for non-normally distributed data.

Variables with a p-value <0.25 in the bivariate analysis were included in a multivariable logistic regression model to identify factors independently associated with glucose stability. The results were reported as odds ratios (ORs), adjusted odds ratios (AORs), 95% confidence intervals (95% CIs), and p-values. Statistical significance was established at $p < 0.05$. his study was approved by the Health Research Ethics Committee of STIKES Nani Hasanuddin Makassar (Approval No. 034/STIKES-NH/KEPK/V/2025). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and relevant national guidelines for health research involving human participants. Written informed consent was obtained from all participants or their legal guardians before enrollment. Participant anonymity and confidentiality were ensured by assigning unique identification codes and removing personal identifiers from the dataset prior to analysis.

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RESULT

Respondent Characteristics

Table 1. Characteristics of Study Participants (n = 30)

Variable	n (%) / Mean ± SD
Age (years)	59.4 ± 3.1
Duration of diabetes (years)	12.0 ± 3.8
Gender	
Male	15 (50.0)
Female	15 (50.0)
Diagnosis	
Type 2 Diabetes Mellitus	25 (83.3)
Type 2 Diabetes Mellitus with Hypertension	5 (16.7)
Type of Enteral Formula	
Diabetes-specific formula	16 (53.3)
Standard polymeric formula	9 (30.0)
High-protein polymeric formula	5 (16.7)

Table 1 shows that the mean age of participants was 59.4 ± 3.1 years, while the mean duration of diabetes was 12.0 ± 3.8 years. Male and female participants were equally represented. Most participants were diagnosed with Type 2 Diabetes Mellitus without hypertension as a comorbidity (83.3%). Diabetes-specific formula was the most frequently administered enteral formula (53.3%), followed by standard polymeric formula (30.0%) and high-protein polymeric formula (16.7%).

Characteristics of Enteral Nutrition Management

Table 2. Characteristics of Enteral Nutrition Management (n = 30)

Variable	Value
Daily energy intake (kcal/day)	1,595 ± 130
Daily protein intake (g/day)	79.3 ± 6.7
Feeding frequency	
5–6 times/day	18 (60.0)
3–4 times/day	12 (40.0)
Administration method	
Bolus	19 (63.3)
Intermittent	11 (36.7)

As shown in Table 2, the mean daily energy intake was 1,595 ± 130 kcal/day, while the mean daily protein intake was 79.3 ± 6.7 g/day. Most participants received enteral nutrition 5–6 times per day (60.0%), and bolus administration was the most commonly used feeding method (63.3%).

Glucose Stability and Hyperglycemia

Table 3. Distribution of Glucose Stability and Hyperglycemia (n = 30)

Variable	n (%)
Stable glucose	19 (63.3)
Unstable glucose	11 (36.7)
Hyperglycemia	11 (36.7)
No hyperglycemia	19 (63.3)

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Among the study participants, 19 (63.3%) demonstrated stable glucose levels during the observation period, whereas 11 (36.7%) experienced unstable glucose levels. Hyperglycemia was observed in 11 participants (36.7%), while the remaining 19 participants (63.3%) did not experience hyperglycemia.

Distribution of Glucose Stability According to Enteral Formula Type

Table 4. Glucose Stability by Type of Enteral Formula

Type of Formula	Stable n (%)	Unstable n (%)	Total
Diabetes-specific formula	14 (87.5)	2 (12.5)	16
Standard polymeric formula	3 (33.3)	6 (66.7)	9
High-protein polymeric formula	2 (40.0)	3 (60.0)	5
Total	19 (63.3)	11 (36.7)	30

Table 4 indicates that participants receiving diabetes-specific enteral formulas showed a higher proportion of stable glucose levels compared with those receiving standard polymeric or high-protein polymeric formulas. Conversely, unstable glucose levels were more frequently observed among participants receiving non-diabetes-specific formulas.

Distribution of Glucose Stability According to Feeding Frequency

Table 5. Glucose Stability by Enteral Feeding Frequency

Feeding Frequency	Stable n (%)	Unstable n (%)	Total
5–6 times/day	15 (83.3)	3 (16.7)	18
3–4 times/day	4 (33.3)	8 (66.7)	12
Total	19 (63.3)	11 (36.7)	30

As presented in Table 5, participants who received enteral nutrition 5–6 times per day demonstrated a higher proportion of stable glucose levels than those who received enteral feeding 3–4 times per day.

Distribution of Hyperglycemia According to Enteral Formula Type

Table 6. Hyperglycemia by Type of Enteral Formula

Type of Formula	Hyperglycemia n (%)	No Hyperglycemia n (%)	Total
Diabetes-specific formula	4 (25.0)	12 (75.0)	16
Standard polymeric formula	5 (55.6)	4 (44.4)	9
High-protein polymeric formula	2 (40.0)	3 (60.0)	5
Total	11 (36.7)	19 (63.3)	30

Table 6 shows that the proportion of hyperglycemia was lower among participants receiving diabetes-specific formulas compared with those receiving standard polymeric or high-protein polymeric formulas. Participants receiving diabetes-specific formulas also demonstrated a higher proportion of normoglycemic outcomes during hospitalization.

DISCUSSION

This study examined the association between enteral nutrition management and glucose stability among hospitalized patients with Type 2 Diabetes Mellitus (T2DM). The findings showed that most participants were older adults with a mean age of 59.4 ± 3.1 years and a mean diabetes duration of 12.0 ± 3.8 years. These characteristics reflect a population at increased risk of glycemic instability due to progressive pancreatic β-cell dysfunction, insulin resistance, and age-related metabolic changes. Previous studies have demonstrated that longer diabetes duration is associated with greater difficulty in achieving glycemic control and an increased risk of both hyperglycemia and glucose variability.[23,24]

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The present study found that participants receiving diabetes-specific enteral formulas demonstrated a higher proportion of stable glucose levels compared with those receiving standard polymeric or high-protein polymeric formulas. Although the cross-sectional design does not allow causal inference, these findings suggest a positive association between diabetes-specific enteral nutrition management and glucose stability. This observation is consistent with previous studies reporting that diabetes-specific enteral formulas are associated with lower postprandial glucose responses and reduced glycemic variability among patients with diabetes.[25]

Several physiological mechanisms may explain this association. Diabetes-specific formulas are typically formulated with a lower glycemic index, modified carbohydrate composition, increased monounsaturated fatty acids, and higher soluble fiber content. Soluble fiber slows gastric emptying and intestinal glucose absorption, resulting in a more gradual increase in postprandial blood glucose concentrations. Furthermore, low-glycemic-index carbohydrates may reduce rapid glucose excursions and improve overall glycemic control. These mechanisms support the physiological model of glucose metabolism, which proposes that nutrient composition influences glucose homeostasis through complex interactions involving insulin secretion, insulin sensitivity, gastrointestinal hormone responses, and hepatic glucose regulation.[26]

Another important finding of this study was the association between enteral feeding frequency and glucose stability. Participants receiving enteral nutrition 5–6 times per day demonstrated a greater proportion of stable glucose levels compared with those receiving nutrition 3–4 times daily. This finding is consistent with the concept of fractional feeding, whereby nutrients are delivered in smaller and more frequent portions to minimize large postprandial glucose fluctuations. Similar findings have been reported in previous studies showing that frequent enteral feeding schedules may contribute to more stable glycemic responses among hospitalized patients with diabetes.[27]

Regarding hyperglycemia, approximately one-third of participants experienced blood glucose levels exceeding the predefined threshold. The proportion of hyperglycemia was lower among patients receiving diabetes-specific formulas than among those receiving standard polymeric formulas. These findings are consistent with previous reports indicating that formula composition plays an important role in glycemic management among patients receiving enteral nutrition.[28] Standard polymeric formulas generally contain higher proportions of rapidly absorbed carbohydrates, which may contribute to larger postprandial glucose excursions. In contrast, diabetes-specific formulas are designed to support more gradual glucose absorption and metabolic regulation.[29]

Interestingly, the descriptive analysis suggested that total daily energy intake was not strongly associated with glucose stability. This finding supports previous evidence indicating that nutrient composition may be more important than total caloric intake in determining glycemic outcomes among patients receiving enteral nutrition.[30] Therefore, optimization of carbohydrate quality, fiber content, and feeding schedules may represent important components of nutritional management for hospitalized patients with T2DM.

The findings of this study can also be interpreted within the Donabedian quality-of-care framework. In this model, enteral nutrition management represents a healthcare process that may influence patient outcomes, including glucose stability and glycemic control. Appropriate formula selection, feeding schedules, and nutritional monitoring may therefore contribute to improved quality of care for hospitalized patients with diabetes.[31]

From a clinical perspective, these findings highlight several practical implications. First, healthcare providers may consider prioritizing diabetes-specific enteral formulas for hospitalized patients with T2DM who require enteral nutritional support. Second, regular monitoring of blood glucose levels during the initial period of enteral feeding is essential to identify glycemic instability early. Third, collaboration among physicians, clinical nutritionists, nurses, and pharmacists is important to optimize nutritional management and glycemic monitoring. Finally, hospitals may benefit from developing standardized enteral nutrition protocols specifically designed for patients with diabetes mellitus.[32]

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes determination of temporal or causal relationships between enteral nutrition management and glucose stability. Second, the study employed purposive sampling and included a relatively small sample size from a single hospital, which may limit the generalizability of the findings. Third, several potential confounding factors, including insulin regimens, severity of illness, comorbid conditions, and concurrent medications, were not fully controlled. Fourth, the study relied on clinical documentation and medical records, which may be subject to measurement and recording bias. Future studies using prospective cohort

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or randomized controlled designs with larger sample sizes are recommended to further clarify the relationship between enteral nutrition management and glycemic outcomes among hospitalized patients with T2DM.

Overall, this study suggests that diabetes-specific enteral formulas and more frequent enteral feeding schedules are associated with a higher proportion of glucose stability and a lower proportion of hyperglycemia among hospitalized patients with Type 2 Diabetes Mellitus. These findings contribute to the growing evidence supporting the importance of enteral nutrition management as part of comprehensive glycemic care in hospital settings.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study found that enteral nutrition management was associated with glucose stability and hyperglycemia among hospitalized patients with Type 2 Diabetes Mellitus (T2DM) receiving enteral nutrition therapy. Participants who received diabetes-specific enteral formulas demonstrated a higher proportion of stable glucose levels and a lower proportion of hyperglycemic events compared with those receiving standard polymeric or high-protein polymeric formulas. In addition, patients who received enteral feeding more frequently (5–6 times per day) showed a greater proportion of glucose stability than those receiving enteral feeding 3–4 times per day. These findings suggest that the composition of enteral formulas and feeding schedules may be important factors associated with glycemic outcomes in hospitalized patients with T2DM. The results support the growing body of evidence highlighting the potential role of diabetes-specific enteral nutrition strategies as part of comprehensive glycemic management in hospital settings. However, the findings should be interpreted within the context of the study design and population. Because this study employed a cross-sectional design, causal relationships between enteral nutrition management and glucose stability cannot be established. Furthermore, the findings are limited to hospitalized adult patients with Type 2 Diabetes Mellitus receiving enteral nutrition and may not be directly generalizable to patients with Type 1 Diabetes Mellitus, pediatric populations, outpatient settings, or other healthcare environments.

Recommendations

Based on the findings of this study, several recommendations can be proposed for clinical practice and future research. For physicians, consideration should be given to the selection of enteral formulas that are appropriate for the metabolic needs of hospitalized patients with T2DM, particularly among patients experiencing glycemic instability. For clinical nutritionists, regular assessment of enteral nutrition management, including formula composition, energy adequacy, protein adequacy, and feeding schedules, should be incorporated into routine nutritional care to support optimal glycemic outcomes. For nurses, systematic monitoring of blood glucose levels during enteral nutrition therapy, especially during the first 72 hours of feeding, is recommended to facilitate early identification of glycemic instability and hyperglycemia. For hospital administrators, the development and implementation of standardized evidence-informed enteral nutrition protocols for patients with diabetes mellitus may help improve consistency of care and support multidisciplinary management involving physicians, nurses, and clinical nutritionists. Future studies should employ prospective cohort or randomized controlled trial designs with larger sample sizes and multicenter settings to further investigate the relationship between enteral nutrition management and glycemic outcomes. Additional research should also examine the influence of potential confounding factors, including insulin regimens, comorbidities, disease severity, renal function, and concurrent pharmacological therapies, to provide a more comprehensive understanding of glucose stability among hospitalized patients with diabetes.

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