Blood Glucose Regulation and Clinical Improvement in Diabetic Ketoacidosis: Role of Comprehensive Emergency Care

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Abstract: This study aimed to evaluate the effect of comprehensive emergency care on blood glucose control and clinical outcomes in patients with diabetic ketoacidosis (DKA). A total of 90 DKA patients admitted to the Seventh Affiliated Hospital of Sun Yat-sen University from May 2021 to May 2024 were randomly divided into two groups using the envelope method: the control group (n=45) received routine emergency care, and the study group (n=45) received comprehensive emergency care. Main outcome measures included symptom improvement time, blood glucose/ketone normalization time, insulin dosage, fasting plasma glucose (FPG), 2-hour postprandial glucose (2hPG), psychological status (SAS/SDS scores), and complication rate. Results showed the study group had shorter symptom correction time, faster blood glucose/ketone normalization, lower insulin dosage, better blood glucose control (lower FPG and 2hPG), reduced anxiety/depression scores, and lower complication rate than the control group (all $P<0.05$). Conclusion: Comprehensive emergency care effectively improves DKA patients' clinical outcomes and is worthy of clinical promotion.

***Keywords*:** diabetic ketoacidosis, comprehensive emergency care, blood glucose control, clinical outcomes, psychological status

1. Introduction

Diabetic ketoacidosis (DKA) is a life-threatening acute complication of diabetes, characterized by hyperglycemia, ketonemia, and metabolic acidosis [1]. Epidemiological data from the Centers for Disease Control and Prevention (CDC, 2023) show the annual incidence of DKA among diabetic patients ranges from 4.6 to 8.0 per 1000 person-years, with higher rates in type 1 diabetes (T1DM) patients (up to 14.9 per 1000 person-years) [2]. The onset of DKA is often triggered by acute infection, improper insulin use, or psychological stress, leading to severe dehydration, nausea, vomiting, and even shock if not treated promptly [3].

Although modern emergency treatments (e.g., fluid resuscitation, insulin infusion) have reduced DKA mortality to less than 1% in developed countries [3], routine emergency care still has limitations. Routine care mainly focuses on vital sign monitoring and medication administration, with insufficient attention to individualized needs such as psychological support and health education [4]. This one-size-fits-all approach often results in prolonged symptom resolution, increased insulin usage, and higher complication rates [5].

In recent years, comprehensive emergency care has emerged as a patient-centered nursing model that integrates holistic assessment, precise physiological management, and psychological intervention [6]. Previous studies have shown this model can improve blood glucose control in DKA patients, but few have systematically analyzed its impact on insulin dosage, psychological status, and long-term complication prevention [7]. Given this gap, this study explores the effect of comprehensive emergency care on DKA patients' outcomes to provide evidence for nursing protocol optimization.

Based on previous literature and clinical observations, this study proposes three research hypotheses: (1) Compared with routine emergency care, comprehensive emergency care can significantly shorten the symptom correction time (including DKA symptom correction time and urine ketone clearance time) and normalization time of blood glucose and blood ketone in DKA patients. (2) Comprehensive emergency care can reduce the total insulin dosage and the incidence of complications (such as hypokalemia and infection) in DKA patients compared with routine emergency care. (3) Comprehensive emergency care can alleviate negative emotions (anxiety and depression) in DKA patients, as reflected by lower scores of Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS) compared with routine emergency care.

2. Research design

2.1 Study type and setting

This was a prospective randomized controlled trial in the Seventh Affiliated Hospital of Sun Yat-sen University from May 2021 to May 2024. The study protocol was approved by the hospital's Institutional Review Board. All participants or their legal representatives provided written informed consent.

2.2 Participant selection

Inclusion criteria were: (1) meeting DKA diagnostic criteria [3]: blood glucose >13.9 mmol/L, arterial pH <7.35, serum bicarbonate <18 mmol/L, positive urine/serum ketones; (2) aged 18-70 years; (3) complete clinical and laboratory data; (4) no allergy to insulin; (5) able to cooperate with follow-up. Exclusion criteria were: (1) severe organ dysfunction (e.g., acute myocardial infarction, end-stage renal disease); (2) malignant tumors or mental disorders; (3) pregnancy/lactation; (4) participation in other clinical trials within 3 months; (5) DKA caused by trauma or surgery.

A total of 102 DKA patients were initially screened, and 12 were excluded (3 with severe renal failure, 2 with mental disorders, 4 with incomplete data, 3 lost to follow-up). The remaining 90 patients were randomly assigned to two groups using the envelope method: 45 in the control group and 45 in the study group. The random sequence was generated by a statistician not involved in patient recruitment, and envelopes were opened by nursing staff after enrollment.

2.3 Intervention measures

The control group received routine emergency care, including: (1) initial resuscitation (quiet environment, supine position with head turned aside, peripheral venous access within 10 minutes); (2) vital sign monitoring (blood pressure, heart rate every 30 minutes; continuous ECG for unconscious patients); (3) medication administration (insulin infusion at 0.1 U/kg/h, oxygen therapy at 2-4 L/min); (4) nutritional support (liquid diet after regaining consciousness, high-fiber diet after blood glucose stabilization); (5) basic education (dietary taboos, reporting discomfort promptly).

The study group received comprehensive emergency care based on routine care, implemented by a specialized team (1 head nurse with >10 years of DKA experience, 3 senior nurses with >5 years of experience, 2 junior nurses). The team underwent 2 weeks of training (DKA pathophysiology, insulin infusion, psychological intervention) and passed an assessment before participation. Specific measures included: (1) holistic assessment (mental status, hydration, laboratory indicators within 5 minutes of admission); (2) precise physiological management (weight-based insulin protocol, individualized fluid/electrolyte correction, personalized nutrition); (3) psychological intervention (SAS/SDS assessment, counseling, family involvement); (4) systematic health education (individualized plans, practical training, follow-up education); (5) complication prevention (infection control, hypokalemia monitoring, foot care).

2.4 Outcome measures

Outcomes were assessed at baseline (admission) and 12 days after intervention: (1) symptom improvement indicators (urine ketone clearance time, DKA symptom correction time); (2) recovery indicators (blood glucose normalization time, blood ketone normalization time, total insulin dosage); (3) blood glucose indices (FPG, 2hPG, measured via Beckman Coulter AU5800 analyzer); (4) psychological status (SAS: 20-item scale, cut-off 50 points; SDS: 20-item scale, cut-off 53 points) [8,9]; (5) complication rate (hypokalemia: serum potassium <3.5 mmol/L; infection; hepatorenal impairment); (6) secondary outcomes (length of hospital stay, nursing satisfaction via a self-designed questionnaire with Cronbach's α=0.89).

2.5 Statistical analysis

Data were analyzed using SPSS 25.0. Continuous variables with normal distribution were presented as mean ± standard deviation ($\bar{x}\pm s$) and compared via independent samples t-test (between groups) or paired samples t-test (within groups). Categorical variables were presented as n (%) and compared via chi-square test. $P<0.05$ was considered statistically significant.

3. Empirical analysis

3.1 Descriptive statistics

Table 1 presents the descriptive statistics of baseline characteristics for all participants. The sample included 49 male (54.44%) and 41 female (45.56%) patients, with an average age of (52.75±3.55) years. The average diabetes duration was (6.85±1.45) years, with 22 patients (24.44%) having T1DM and 68 (75.56%) having T2DM. Baseline FPG was (9.68±2.62) mmol/L, baseline 2hPG was (12.42±3.01) mmol/L, baseline SAS score was (58.93±12.85) points, and baseline SDS score was (59.21±13.27) points. The main triggering factors of DKA were infection (34 cases, 37.78%), insulin non-compliance

(32 cases, 35.56%), dietary irregularity (15 cases, 16.67%), and others (9 cases, 10.00%).

Table 1. Baseline characteristics of the two groups (x̄±s or n, %)

Characteristic	Control Group (n=45)	Study Group (n=45)	t/χ^2 Value	P Value
Gender (male/female, n)	24/21	25/20	0.045	0.831
Age (years)	52.8±3.6	52.7±3.5	0.137	0.891
Diabetes type (T1DM/T2DM, n)	12/33	10/35	0.338	0.561
Diabetes duration (years)	6.8±1.5	6.9±1.4	0.314	0.754
Baseline FPG (mmol/L)	9.85±2.81	9.52±2.43	0.596	0.553
Baseline 2hPG (mmol/L)	12.49±3.13	12.35±2.88	0.221	0.826
Baseline SAS score (points)	58.83±13.60	59.02±12.09	0.070	0.944
Baseline SDS score (points)	59.18±12.73	59.24±13.81	0.021	0.983
Triggering factor (n, %)			1.236	0.746
- Infection	18 (40.00)	16 (35.56)		
- Insulin non-compliance	15 (33.33)	17 (37.78)		
- Dietary irregularity	7 (15.56)	8 (17.78)		
- Others	5 (11.11)	4 (8.89)		
Baseline arterial pH	7.21±0.12	7.23±0.10	0.825	0.412
Baseline serum ketones (mmol/L)	4.85±1.23	4.72±1.18	0.487	0.627

Note: T1DM = type 1 diabetes mellitus; T2DM = type 2 diabetes mellitus; FPG = fasting plasma glucose; 2hPG = 2-hour postprandial glucose; SAS = Self-Rating Anxiety Scale; SDS = Self-Rating Depression Scale.

3.2 Baseline characteristics comparison

To ensure group comparability, baseline characteristics were compared between the two groups (Table 1). No significant differences were found in gender (χ^2=0.045, P=0.831), age (t=0.137, P=0.891), diabetes type (χ^2=0.338, P=0.561), diabetes duration (t=0.314, P=0.754), baseline FPG (t=0.596, P=0.553), baseline 2hPG (t=0.221, P=0.826), baseline SAS (t=0.070, P=0.944), baseline SDS (t=0.021, P=0.983), triggering factors (χ^2=1.236, P=0.746), baseline arterial pH (t=0.825, P=0.412), or baseline serum ketones (t=0.487, P=0.627). These results confirmed the two groups were comparable at baseline, ensuring the validity of subsequent outcome comparisons.

3.3 Analysis of main outcomes

3.3.1 Symptom improvement and recovery indicators

Table 2 shows the comparison of symptom improvement and recovery indicators between the two groups. The study group had a significantly shorter urine ketone clearance time [(12.26±1.43) h vs. (20.25±1.22) h, t=28.5143, P<0.001] and DKA symptom correction time [(5.26±1.47) h vs. (8.66±1.32) h, t=11.5443, P<0.001] than the control group. In terms of recovery indicators, the study group also had faster blood ketone normalization [(22.63±2.54) h vs. (33.47±2.77) h, t=19.3486, P<0.001] and blood glucose normalization [(4.24±0.59) h vs. (6.56±0.50) h, t=20.1237, P<0.001]. Additionally, the total insulin dosage in the study group was significantly lower than that in the control group [(60.56±3.11) U vs. (72.46±3.44) U, t=17.2138, P<0.001]. These findings fully supported Hypothesis H1 and H2, confirming that comprehensive emergency care accelerates symptom improvement and reduces insulin usage.

Table 2. Comparison of symptom improvement and recovery indicators between the two groups (x̄±s)

Outcome Indicator	Control Group (n=45)	Study Group (n=45)	t Value	P Value
Urine ketone clearance time (h)	20.25±1.22	12.26±1.43	28.5143	<0.001
Correction time of DKA symptoms (h)	8.66±1.32	5.26±1.47	11.5443	<0.001
Blood ketone normalization time (h)	33.47±2.77	22.63±2.54	19.3486	<0.001
Blood glucose normalization time (h)	6.56±0.50	4.24±0.59	20.1237	<0.001
Total insulin dosage (U)	72.46±3.44	60.56±3.11	17.2138	<0.001

Note: DKA = diabetic ketoacidosis.

3.3.2 Blood glucose control

Table 3 presents the comparison of blood glucose control between the two groups. After 12 days of intervention, both

groups showed a significant decrease in FPG and 2hPG compared with baseline (all P<0.001). However, the study group had a more significant reduction: the FPG in the study group was (6.57±1.34) mmol/L, which was significantly lower than (7.83±1.26) mmol/L in the control group (t=4.5953, P<0.001); the 2hPG in the study group was (8.67±0.80) mmol/L, significantly lower than (10.62±1.54) mmol/L in the control group (t=7.5378, P<0.001). This result further verified the positive effect of comprehensive emergency care on blood glucose control, which is consistent with the findings of Wang et al. (2022) that comprehensive care improves glucose metabolism in DKA patients.

Table 3. Comparison of blood glucose control between the two groups ($\bar{x}$±s, mmol/L)

Blood Glucose Index	Group	Baseline	After 12 Day	Within-Group t Value	Within-Group P Value	Between-Group t Value (After 12 Days)	Between-Group P Value (After 12 Days)
FPG	Control	9.85±2.8	7.83±1.26	4.2156	<0.001	4.5953	<0.001
	Study	9.52±2.43	6.57±1.34	7.632	<0.001		
2hPG	Control	12.49±3.13	10.62±1.54	3.8762	<0.001	7.5378	<0.001
	Study	12.35±2.88	8.67±0.80	8.945	<0.001		

Note: FPG = fasting plasma glucose; 2hPG = 2-hour postprandial glucose.

3.4 Analysis of psychological status and complications

3.4.1 Psychological status

Table 4 shows the comparison of psychological status between the two groups. After 12 days of intervention, both groups had lower SAS and SDS scores than baseline (all P<0.001), but the study group showed a more obvious decrease. The SAS score of the study group was (33.55±9.86) points, significantly lower than (42.48±9.93) points in the control group (t=4.2808, P<0.001); the SDS score of the study group was (35.05±9.53) points, which was significantly lower than (48.56±9.82) points in the control group (t=6.6229, P<0.001). This result supported Hypothesis H3, indicating that comprehensive emergency care effectively alleviates negative emotions in DKA patients. The reason may be that the psychological intervention component (counseling, family involvement, success story sharing) reduces patients' anxiety about disease prognosis and enhances their treatment confidence (Li et al., 2022).

Table 4. Comparison of psychological status between the two groups ($\bar{x}$±s, points)

Psychological Scale	Group	Baseline	After 12 Days	Within-Group t Value	Within-Group P Value	Between-Group t Value (After 12 Days)	Between-Group P Value (After 12 Days)
SAS	Control	58.83±13.6	42.48±9.93	6.1237	<0.001	4.2808	<0.001
	Study	59.02±12.09	33.55±9.86	9.876	<0.001		
SDS	Control	59.18±12.73	48.56±9.82	4.7892	<0.001	6.6229	<0.001
	Study	59.24±13.81	35.05±9.53	10.2341	<0.001		

Note: SAS = Self-Rating Anxiety Scale; SDS = Self-Rating Depression Scale.

3.4.2 Complication rate

Table 5 presents the comparison of complication rates between the two groups. The total complication rate in the study group was 4.44% (2/45), which was significantly lower than 24.44% (11/45) in the control group (χ^2=7.2827, P=0.0069). Specifically, the study group had 1 case of hypokalemia (2.22%) and 1 case of infection (2.22%), while the control group had 4 cases of hypokalemia (8.89%), 5 cases of infection (11.11%), and 2 cases of hepatorenal impairment (4.44%). Although the differences in individual complications did not reach statistical significance (all P>0.05), the significant reduction in total complication rate further supported Hypothesis H2. This result is consistent with Chen et al. (2023), who reported that multi-component complication prevention measures reduce DKA-related adverse events.

Table 5. Comparison of complication rate between the two groups [n (%)]

Complication Type	Control Group (n=45)	Study Group (n=45)	χ^2 Value	P Value
Hypokalemia	4 (8.89)	1 (2.22)	2.031	0.154
Infection	5 (11.11)	1 (2.22)	3.047	0.081
Hepatorenal impairment	2 (4.44)	0 (0.00)	2.022	0.155
Total complications	11 (24.44)	2 (4.44)	7.2827	0.0069

Note: Some patients had multiple complications, so the sum of individual complications may exceed the total number of patients with complications.

3.5 Analysis of secondary outcomes

Table 6 shows the comparison of secondary outcomes between the two groups. The study group had a significantly shorter length of hospital stay [(5.82±1.03) days vs. (8.35±1.21) days, t=10.8762, P<0.001] than the control group. Additionally, the nursing satisfaction rate in the study group was 97.78% (44/45), which was significantly higher than 82.22% (37/45) in the control group (χ^2=6.0494, P=0.0139). These results indicated that comprehensive emergency care not only improves clinical outcomes but also enhances patient satisfaction, which is of great significance for improving the quality of emergency care services.

Table 6. Comparison of secondary outcomes between the two groups ($\bar{x}$±s or n, %)

Secondary Outcome	Control Group (n=45)	Study Group (n=45)	t/χ^2 Value	P Value
Length of hospital stay (days)	8.35±1.21	5.82±1.03	10.8762	<0.001
Nursing satisfaction (n, %)	37 (82.22)	44 (97.78)	6.0494	0.0139

4. Discussion

4.1 Mechanisms of comprehensive emergency care

The study found that comprehensive emergency care significantly improved DKA patients' outcomes, and the underlying mechanisms can be summarized as follows. First, the specialized nursing team with standardized training ensured evidence-based and consistent interventions. The 2-week training enhanced the team's ability to identify high-risk patients (e.g., those with severe acidosis) and adjust treatment plans promptly [6]. Second, precise physiological management (weight-based insulin protocol, individualized fluid correction) avoided over-insulinization and fluid overload, thus accelerating blood glucose/ketone normalization and reducing insulin usage [3]. Third, psychological intervention and family involvement alleviated negative emotions, improved treatment adherence, and further promoted recovery [4]. Fourth, targeted complication prevention measures (infection control, hypokalemia monitoring) reduced adverse events, which is consistent with the findings of Chen et al. [7].

4.2 Comparison with previous studies

Most previous studies on DKA nursing focused on a single aspect, such as insulin therapy or health education [5]. This study integrated multiple components (specialized team, precise management, psychological support, education, complication prevention) into a comprehensive model, providing more systematic evidence. For example, Wang et al. [6] found that comprehensive care reduced hospital stay by 2.1 days, while this study showed a reduction of 2.53 days, which may be due to the addition of systematic health education and family involvement. Additionally, this study is the first to report that comprehensive care reduces insulin dosage, which has important implications for reducing treatment costs and hypoglycemia risk.

4.3 Clinical implications

The findings have three main clinical implications. First, hospitals should optimize DKA nursing protocols by establishing specialized teams and standardized training programs to improve care quality. Second, the patient-centered concept should be emphasized, integrating physiological and psychological care to enhance patient satisfaction and adherence. Third, comprehensive care can reduce hospital stay and complication rates, which helps lower healthcare costs and improve resource utilization.

4.4 Limitations and future directions

This study has four limitations. First, it was a single-center trial, so the results may not be generalizable to community hospitals. Second, the sample size (90 patients) was small, which may limit the detection of small differences in rare complications. Third, the follow-up period was only 12 days, so the long-term effect (e.g., DKA recurrence rate) remains unknown. Fourth, blinding was not possible due to the nature of the intervention, which may have introduced bias.

Future studies should address these limitations by: (1) conducting multi-center trials with larger sample sizes; (2) extending follow-up to 6-12 months to assess long-term outcomes; (3) using third-party assessors for outcome measurement to reduce bias; (4) evaluating the cost-effectiveness of comprehensive care via economic analysis.

5. Conclusion

Comprehensive emergency care is a safe and effective nursing model for DKA patients. It significantly accelerates symptom resolution, improves blood glucose control, reduces insulin dosage and complication rates, shortens hospital stay, and enhances nursing satisfaction. Theoretically, this study enriches the evidence on DKA nursing and provides a new framework for patient-centered care. Practically, it provides a scientific basis for clinical protocol optimization. Compared with previous studies, this model integrates more components and has more comprehensive benefits. Although there are limitations, the model is still worthy of clinical promotion. Future studies should validate the results in larger populations and explore long-term effects to further improve DKA management.

6. Ethical Statement

The study was approved by the Institutional Review Boards of the Seventh Affiliated Hospital of Sun Yat-sen University (IRB No. KY-2025-420-02). All procedures were conducted in accordance with the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants, including explicit permission for the publication of deidentified clinical data and results. Participants were informed that their data would be presented in aggregate form, with no individual identifiers (e.g., names, medical record numbers) included in any publication or presentation.

7. Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional restrictions on patient data privacy but are available from the corresponding author upon reasonable request. Requests must include a detailed research proposal and approval from the requesting institution's ethics committee to ensure compliance with data protection regulations.

8. Competing Interests

The authors declare no competing financial or non-financial interests. No author received financial support from pharmaceutical companies or other commercial entities for the conduct of this study or the preparation of the manuscript.

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