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ORIGINAL RESEARCH

Effects of the application of Ahmadi continuous nursing model in children with diabetic ketoacidosis

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Abstract

The effects of Ahmadi continuous nursing model in children with diabetic ketoacidosis were investigated in this study. A total of 120 children with diabetic ketoacidosis (DKA) were enrolled by convenience sampling from May 2018 to February 2022. Patients were equally divided into a control group and an observation group by a random number table. The control group received the routine continuous nursing model, while the observation group additionally received the Ahmadi continuous nursing model. The indicators of clinical first aid, level of blood glucose, insulin resistance, blood levels of sodium and potassium, family functioning and nursing satisfaction were compared before and after nursing in the two groups. Children in observation group had significantly shorter correction time of acidosis, blood pH recovery, urinary ketone negative and correction of electrolyte disturbance than those in the control group. The levels of fasting blood glucose (FBG), 2-hour postprandial blood glucose (2 hPG) and glycosylated hemoglobin (HbA1c) of children in the observation group were significantly lower than those in the control group. They also showed higher homeostasis model assessment-β (HOMA-β), less homeostasis model assessment-insulin resistance (HOMA-IR), and higher blood levels of sodium and potassium than those in the control group. The observation group scored higher on family adaptability and cohesion evaluation scales (FACESII-CV) than the control group. Nursing satisfaction in the observation group was 96.7%, higher than that in the control group at 85%. Therefore, the Ahmadi continuous nursing model can effectively reduce the glycemic index, improve insulin resistance, correct the imbalance of blood levels of sodium and potassium, and improve family function and nursing satisfaction in children with DKA.

Keywords

Children; Diabetic ketoacidosis; Blood glucose; Insulin resistance; Family function; Ahmadi continuous nursing model

1. Introduction

Diabetes mellitus (DM) is a chronic disease of the secretory system worldwide that manifested by elevated blood glucose. DM in children, generally referred to in people under 15 years old, is mostly type I, mainly caused by insulin deficiency. Diabetic ketoacidosis (DKA) is one of the common complications of type 1 DM, along with severe metabolic disorders of sugar, fat and protein. The onset of DKA is very rapid, even leading to death, and even after the dangerous period is passed, there are adverse effects on the long-term health of children [1, 2]. Studies have shown the incidence of children's DM has been significantly increasing recently. Besides, long-term uninterrupted drug therapy seriously affects the life quality of children, which in turn caused negative emotions in children and parents [3, 4]. Active cooperation, regular follow-up, and ongoing care interventions for children and their families are prerequisites for ensuring standardization of interventions in treatment and nursing, but traditional nursing model are limited by time and place, and post-discharge care is less effective [5]. The Ahmadi continuous nursing model is a family continuous nursing model proposed by Ahmadi in 2002, which implies the creation of a continuous, effective and complex atmosphere of care through four stages: orientation, sensitivity, control and evaluation [6]. Previously, Ahmadi continuous nursing model has been effective in children with bronchial disease and enterostomy [7, 8], but its efficacy in children with DKA is poorly understood. Therefore, this study aims to explore the impacts of Ahmadi continuous nursing model in children with DKA.

2. Materials and methods

2.1 General data

A total of 120 children with DKA were enrolled by convenience sampling from May 2018 to February 2022. Patients

were equally divided into a control group and an observation group by a random number table. Inclusion criteria: (1) Patients met the diagnostic criteria of the Expert Consensus on the Diagnosis and Treatment of Type I DM in Chinese children (2020 edition) [9]; (2) Patients under 14 years old who met the diagnostic criteria of DKA; (3) Childminder were parents with good communication skills. Exclusion criteria: (1) Children with other types of diabetes; (2) Children combined with cardiovascular and cerebrovascular diseases, Kawasaki disease, sepsis, psychiatric diseases, *etc.*; (3) Children combined with other underlying diseases; (4) Unable to cooperate with examinations and scale surveys related to the present study; (5) Patients with poor compliance and non-cooperation.

2.2 Methods

Children in the control group underwent routine blood glucose monitoring and nursing interventions during hospitalization and after discharge, including blood glucose index recording, medication guidance such as insulin administration, health education such as diet and exercise, psychological intervention, and time points for reexamination, *etc.* Medical staff are followed up by telephone during the first week after discharge, followed up regularly every 2 weeks, with monthly further consultation. The treatment and care plan were adjusted according to the child's condition.

Children in the observation group were additionally given the Ahmadi continuous nursing model on the basis of the control group, and details as follows. (1) Established the Ahmadi continuous nursing model team, including 1 endocrinologist, 1 nursing supervisor and 4 nurses specialized in diabetes. The endocrinologist is responsible for assessing the feasibility of the nursing plan and proposing a treatment plan for the patient's problem. Nursing supervisor are responsible for the training, supervision, implementation of nursing interventions and quality control of the nurses specialized in diabetes. Nurses who specialize in diabetes are responsible for the guidance of blood glucose and the implementation and summarization of nursing protocols. Nurses specialized in diabetes received lectures and trainings from the "nurses specialized in diabetes" organized by the hospital and learned about the latest foreign nursing interventions in diabetes organized by the nursing supervisor. (2) During the orientation stage, the direction of continuous nursing is jointly determined by team members, children and parents throughout hospitalization period. The medial archive recording the basic information of the child's social demography and the WeChat group for the interactive communication and mutual assistance were established on the day of admission. Scientific knowledge related to children's DKA was regularly published in the WeChat group by nurse specialized in diabetes, such as the blood glucose monitoring methods, nutritious diet for children with diabetes, treatment and care for ketoacidosis, as well as pictures, animations, and videos related to improving children's emotions. Two or three articles or videos were published every week, and the reception of these messages was checked in the next morning. During the child's hospitalization, at least twice one-to-one nurse-patient interviews at the bedside to encourage the children and their parents to express their opinions about this disease, the relevant knowledge they want to learn, and the knowledge and skills required for the child's post-discharge care, *etc.* Besides, the mutual expectations and needs were confirmed during the 20-minute interview. (3) In the sensitivity stage, once after the child's condition is stabilized in the hospital, carried out the medical counseling situational game activities for children with DKA, and given drugs and insulin injections with the help of pictures, music, toys, models, *etc*. Nurses explained and demonstrated the knowledge and skills of parent-child interaction, and taught parents how to treat disease episodes and how to seek social support. After the child is discharged from the hospital, nurses who specialize in diabetes regularly send private messages on Wednesdays asking about the results of blood glucose monitoring and medication use. Personalized guidance for daily life are provided to help children with blood glucose record, exercise, diet, *etc.*, such as the blood glucose levels, diet, medication, adverse drug reactions, exercise, and disease progress of this week. The nurses also professionally answered patient's questions, assisted the parents in analyzing the reasons why this week's plan was not completed, finding a solution, and evaluating again next week. (4) During the control stage, the nurses reminded children to take medication and monitor blood glucose regularly every day, follow healthy recipes and exercises, and encourage parents to feedback the implementation of the post-discharge health plan in the form of photos or videos. Questions that the nurses cannot answer can be asked help from the doctor in the group. In addition to monthly telephone follow-ups, online communication activities are organized once a month. Children and parents are informed 1 day in advance of the time and main content of these online activities, mainly including popularization of disease-related knowledge, exchanging and sharing daily management experience, and continuously strengthen and correcting the development of healthy behaviors. (5) In the evaluation stage, the recovery of the child's condition and the emotional state of the children and parents were closely concerned in the process of implementing nursing intervention, the psychological counseling was carried out in time, and the effect of nursing intervention was regularly evaluated by team members. Identify and resolve problems in nursing interventions, and adjust care goals and plans in a timely manner.

2.3 Observational index

Both groups underwent follow-up interventions after discharge. Nursing intervention was conducted for the problems encountered by the children and their parents through telephone follow-up and family follow-up once a month, and the end point was 3 months after the children were discharged. (1) The clinical first aid indicators, including acidosis correction time, blood pH recovery time, urine ketone negative time and electrolyte imbalance correction time were compared between two groups. (2) The levels of blood glucose before and after nursing were compared between two groups. A volume of 2 mL venous blood was collected followed by serum separation. HbAlc levels were measured by latex-enhanced immunoturbidimetry, and FPG and 2 hPG levels were determined using a fully automatic biochemical analyzer. (3) HoMA-β and HOMA-IR were

compared before and after nursing between two groups. HOMA-β = (30 min insulin - fasting insulin)/(30 min blood glucose-FBG) and HOMA-IR = FBG $\times$ fasting insulin/22.5 [10]. (4) The blood levels of sodium and potassium before and after nursing were compared between two groups, which were analyzed by the automatic electrolyte analyzer. (5) The family function before and after nursing was compared using the Chinese version of Family Adaptability and Cohesion Scale Second edition (FACESII-CV) [11] consisting of two sub-tables with a full mark of 100 between the two groups. Cohesion means the emotional connection between family members and adaptability means the resilience of the family system to problems as it evolves. The higher the score, the better the patient's family functioning. The Cronbach's alpha coefficient of the scale is 0.83, indicating good reliability and effectiveness. (6) The nursing satisfaction from the parents was compared using the homemade nursing satisfaction scale of the department between two groups, which was evaluated by nursing supervisor. The scale has passed the validity and reliability test, and 4 items have been established according to the suggestions of nursing experts, including concern and care, environmental management, service technology and overall evaluation, which was assessed using the Likert 5-level scoring method with a full mark of 100. Nursing satisfaction = number of cases with (great satisfaction + satisfaction)/total number of cases $\times$ 100%.

2.4 Statistics

SPSS (22.0, SPSS Inc., Chicago, IL, USA) software was used for data analysis. Quantitative data and enumeration data were respectively represented as mean $\pm$ standard deviation ($\bar{x} \pm s$) and proportion (%), with t-test for quantitative data and Chi-square test for enumeration data. A p value less than 0.05 was considered statistically significant.

3. Results

3.1 Comparisons of the children's general data between the two groups

There was no significant difference regarding the children's general data, including gender, average age, weight, patient's length of stay, the number of days of Ahmadi continuous care, course of disease and severity of disease between the two groups ($p > 0.05$). See Table 1.

3.2 Comparisons of the indicators of clinical first aid between the two groups

Children in observation group displayed significantly shorter time of the indicators of clinical first aid than that in the control group ($p < 0.05$). See Table 2.

3.3 Comparisons of the indicators of blood glucose between the two groups

Before the intervention of nursing, the levels of FBG, 2 hPG and HbA1c were not significantly different between the two groups ($p > 0.05$). However, these indicators were obviously lower in observation group than that in control group after nursing ($p < 0.05$). See Table 3.

3.4 Comparisons of the insulin resistance between the two groups

Before nursing, HOMA-β and HOMA-IR were similar between the two groups ($p > 0.05$). After nursing, HOMA-β was higher while HOMA-IR was lower in the observation group than those in the control group ($p < 0.05$). See Table 4.

3.5 Comparisons of the blood levels of sodium and potassium between the two groups

Before nursing, the blood levels of sodium and potassium were similar between the two groups ($p > 0.05$). After nursing, children in the observation group showed more increased blood levels of sodium and potassium than that in the control group ($p < 0.05$). See Table 5.

3.6 Comparisons of the family function between the two groups

Before nursing, the scores of family function were similar between the two groups ($p > 0.05$). After nursing, children in the observation group showed more increased scores than that in the control group ($p < 0.05$). See Table 6.

3.7 Comparisons of the nursing satisfaction between the two groups

Nursing satisfaction in the observation group was 96.7%, higher than that in the control group at 85% ($p < 0.05$). See Table 7.

4. Discussion

Insulin resistance is the early clinical manifestation of DM. Disorders in glycometabolism and lipid metabolism caused by insulin resistance are common physiological basis for various chronic diseases, such as hypertension, cardiovascular disease and tumors, but the pathogenesis is not clear. As a chronic lifelong disease, DM is undesirable to children and their families, let alone in combination with acute and dangerous ketoacidosis, which seriously burdens families financially and psychologically [12, 13]. Hyperglycemia, ketosis, and acidosis are the basic symptoms of DKA, and children with severe diabetes show metabolic disorders in carbohydrates, fats, and proteins caused by insulin deficiency, which accelerates the breakdown of fats and proteins, thereby accelerating the production of acid metabolites, making DKA a serious metabolic disorder syndrome caused by insufficient insulin secretion [14]. Metabolic acidosis and accelerated proteolysis, in turn, lead to metabolic disorders of calcium and phosphorus and aggravate this disease. Additionally, various infections and nutritional imbalances frequently occur due to the insufficient development of children's immune function and decreased immunity caused by DKA [15, 16]. However, it is difficult to properly monitor blood glucose and daily interventions as parents have a poor understanding of the treatment and care of children's DM and DKA, making effectively continuous

TABLE 1. Comparisons of the children's general data between the two groups ($\bar{x} \pm s$).

Group	N	Gender (N)		Average age (years)	Weight (kg)	Course of disease (Month)	Severity of disease			Patient's length of stay (d)	Ahmadi continuous care (d)
		Male	Female				Mild	Moderate	Severe		
Control group	60	38	22	6.48 ± 1.65	19.11 ± 4.09	1.73 ± 0.82	28	22	10	6.83 ± 1.02	30.06 ± 1.52
Observation group	60	40	20	6.52 ± 1.73	19.16 ± 4.11	1.72 ± 0.68	30	23	7	6.85 ± 1.21	30.03 ± 1.44
χ^2/t value		0.147		0.130	0.067	0.073		0.621		0.098	0.111
p value		0.702		0.897	0.947	0.942		0.733		0.922	0.912

TABLE 2. Comparisons of the indicators of clinical first aid between the two groups ($\bar{x} \pm s$).

Group	N	Time of correction of acidosis (d)	Time of recovery of blood pH (h)	Time of negative of urinary ketone (h)	Time of correction of electrolyte disturbance (d)
Control group	60	5.60 ± 1.09	15.22 ± 1.42	15.83 ± 1.51	7.77 ± 1.11
Observation group	60	3.56 ± 0.78	13.30 ± 2.64	13.90 ± 2.36	6.20 ± 1.27
t value		11.789	4.961	5.336	7.210
p value		<0.001	<0.001	<0.001	<0.001

TABLE 3. Comparisons of the levels of FBG, 2 hPG and HbA1c between the two groups ($\bar{x} \pm s$).

Group	N	Fasting blood glucose (mmoL/L)		Two-hour postprandial blood glucose (mmoL/L)		glycosylated hemoglobin (%)	
		Before nursing	After nursing	Before nursing	After nursing	Before nursing	After nursing
Control group	60	9.80 ± 0.68	6.79 ± 0.87	13.81 ± 1.04	9.93 ± 0.97	7.62 ± 1.12	6.91 ± 1.11
Observation group	60	9.81 ± 0.87	5.59 ± 0.85	13.85 ± 1.16	8.82 ± 0.86	7.66 ± 0.87	6.25 ± 0.95
t value		0.070	7.642	0.199	6.633	0.218	3.499
p value		0.944	<0.001	0.843	<0.001	0.828	0.001

TABLE 4. Comparisons of the insulin resistance between the two groups ($\bar{x} \pm s$).

Group	N	Homeostasis model assessment-β		Homeostasis model assessment-insulin resistance	
		Before nursing	After nursing	Before nursing	After nursing
Control group	60	25.99 ± 3.44	38.46 ± 3.20	3.68 ± 0.38	3.04 ± 0.50
Observation group	60	25.98 ± 3.43	54.81 ± 3.91	3.64 ± 0.43	2.47 ± 0.51
t value		0.016	25.066	0.540	6.182
p value		0.987	<0.001	0.590	<0.001

TABLE 5. Comparisons of the blood levels of sodium and potassium between the two groups (mmoL/L, $\bar{x} \pm s$).

Group	N	Blood levels of sodium		Blood levels of potassium	
		Before nursing	After nursing	Before nursing	After nursing
Control group	60	3.14 ± 0.50	4.43 ± 0.58	121.07 ± 1.99	131.73 ± 3.12
Observation group	60	3.17 ± 0.46	5.42 ± 0.58	121.02 ± 2.08	145.48 ± 4.16
t value		0.342	9.349	0.135	20.482
p value		0.733	<0.001	0.893	<0.001

TABLE 6. Comparisons of the family function between the two groups (score, $\bar{x} \pm s$).

Group	N	Cohesion		Adaptability	
		Before nursing	After nursing	Before nursing	After nursing
Control group	60	79.55 ± 5.84	82.15 ± 5.39	62.82 ± 7.71	71.12 ± 9.40
Observation group	60	79.52 ± 5.45	87.68 ± 4.80	62.87 ± 7.59	80.03 ± 7.57
t value		0.029	5.935	0.036	5.718
p value		0.977	<0.001	0.971	<0.001

TABLE 7. Comparisons of the nursing satisfaction between the two groups (n, %).

Group	N	Great satisfaction	Satisfaction	Qualified satisfaction	dissatisfaction	Nursing satisfaction
Control group	60	27 (45.0)	24 (40.0)	7 (11.7)	2 (3.3)	51 (85.0)
Observation group	60	36 (60.0)	22 (36.7)	2 (3.3)	0.0	58 (96.7)
χ^2 value						4.904
p value						0.027

nursing of great importance, which not only solves the problem of post-discharge nursing, but also ensures professional and effective guidance for children and parents [17].

In the present study, the correction time of acidosis and electrolyte imbalance in observation group were significantly shorter than those in the control group ($p < 0.05$), indicating that Ahmadi continuous nursing model could significantly improve the indicators of clinical first aid. Wang J, *et al.* [18, 19] have shown that continuous nursing can improve the out-of-hospital therapeutic effect of children with T1DM and children with ketoacidosis, which are consistent with the results in this study. Only simple disease-related knowledge was provided to children and parents in routine nursing intervention, thus parents had insufficient awareness of acute attacks of DM combined with DKA and had difficulties in making correct interventions [20, 21]. In Ahmadi's continuous nursing model, nursing staff have established a communication and interaction platform after admission, and regularly published the hospital and scientific popularization of knowledge related to DM combined with DKA in the WeChat group, which helps to strengthen the cognition of this disease, emphasize the pertinence and effectiveness of nursing intervention, and get timely feedback from the actual situation of the children. It helps the children and parents to understand the cause, treatment and rescue plan of the DM combined with DKA, and makes them effectively cooperate with the medical staff to effectively shorten the indicators of clinical first aid during the acute onset of the disease in children [22]. After nursing, children in the observation group showed lower levels of FBG, 2 hPG and HbA1c, higher HOMA-β, and less HOMA-IR than those in the control group ($p < 0.05$), meaning that Ahmadi continuous nursing model significantly decreases the levels of blood glucose and corrects insulin resistance in children with DM and DKA. These investigations were consistent with the previous studies showing that Ahmadi continuous nursing model increases the cognition degree of DM-related knowledge, improves the patient's compliance, and efficiently controls the post-discharge levels of blood glucose [23, 24]. In clinical nursing practice, uneven implementation of health education and ineffective control of blood glucose could be resulted from different understandings of relevant knowledge in DM combined with DKA due to the different educational levels of nursing staff, while in Ahmadi continuous nursing model, emphasis is placed on the knowledge training of nursing staff, and the consistency of health education was ensured through relevant lectures and trainings as well as mastering the latest foreign nursing interventions in diabetes. The Ahmadi continuous nursing model introduces the implementation of phased objectives through four stages: orientation, sensitivity, control and evaluation. The basic needs of children and parents after discharge were clarified in the orientation stage; various, targeted and continuously improved guidance in health was applied after understanding the needs in the sensitivity stage and control stage. In the evaluation stage, the nursing effects were assessed to ensure the continuous improvement of nursing quality, whereby benefiting parents in monitoring and controlling the levels of blood glucose after discharge, and decreasing the insulin resistance. Compared to traditional "cramming" health education, Ahmadi's continuous nursing model shows more personalization and popularization, avoiding incompletely understanding of mass information [25].

In this study, higher blood levels of sodium and potassium were observed in the observation group ($p < 0.05$), demonstrating that Ahmadi continuous nursing model significantly corrected the metabolic disorders of blood sodium and potassium in DM combined with DKA. Liu J, *et al.* [26, 27] have demonstrated that metabolic disorders, improper diet, and poor lifestyle are the high-risk factors for children with ketoacidosis, and the high-risk factors in the beginning stage can be eliminated through comprehensive, multi-angle and in-depth nursing management measures, which were consistent with the results in this study. Glucose and ketone in DM combined

with DKA not only cause lipid metabolism disorders, but also hyponatremia and hypokalemia, and disorders of blood sodium and potassium levels lead to disturbances in insulin secretion, followed by an increase in blood glucose levels, forming a vicious circle [28]. In addition to conventional drug treatment, a reasonable and healthy diet and exercise are also beneficial to stabilize blood glucose levels correct metabolic disorders in children [29]. Ahmadi's continuous nursing model, nurses regularly reminded children to take medication and monitor blood sugar every day, follow healthy recipes and exercises through WeChat platform, and continuously strengthen and modify healthy behaviors and develop healthy habits through scientific popularization of disease-related knowledge, daily management experience exchange and sharing, thereby improving the metabolic disorders.

The family cohesion and adaptability scores were higher in the observation group than those in the control group, and the nursing satisfaction of the observation group was 96.7%, which was higher than that of the control group with 85% ($p < 0.05$), indicating that the Ahmadi continuous nursing model could improve the family function and nursing satisfaction of DM combined with DKA in children. Studies have shown that family functioning is a predominant factor in caring for mental health, which can effectively improve children's psychological state and affect nursing outcomes [30]. As a long-term chronic source of pressure, DM has a negative impact on caregiver's mood, affecting the relationship between family members, which in turn may lead to family conflicts and reduce family functioning. By identifying the child's care problems and giving a targeted intervention plan and continuous post-discharge care, the Ahmadi continuous nursing model helps parents to reduce the pressure regarding the child's care to a certain extent, relieve their bad emotions, and improve psychological conditions, and thus improve family function. Furthermore, it has a positive impact on improving nursing satisfaction.

5. Conclusions

In conclusion, the Ahmadi continuous nursing model effectively reduces the glycemic index, improves the insulin resistance, corrects imbalance of blood levels of sodium and potassium, and improve family function and nursing satisfaction in children with DM and DKA, which has clinical value. However, it also increases the workload of nursing staff and requires corresponding policy support from medical institutions. In addition, this study also has shortcomings, the sample size is small, and there is no corresponding immune function index analysis, the scope of the study thus needs to be expanded in the future.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

HWC—designed the study and carried them out, HWC, JC, YXX and ZZ—supervised the data collection, analyzed the data, interpreted the data, HWC and YJW—prepare the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Affiliated Hospital of Nantong University (2022-K144-01). The children' parents signed an informed consent form for this study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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