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Case Report

Summary of the diagnosis and treatment of diabetic ketoacidosis complicated by multiple organ dysfunction syndrome in 21 patients

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Abstract: Objective: To summarize the data on the clinical features, treatments, and prognosis in 21 patients with diabetic ketoacidosis (DKA) complicated by multiple organ dysfunction syndrome (MODS). Methods: The clinical data on 21 patients with DKA complicated by MODS treated in Shanghai Jiao Tong University Affiliated Sixth People's Hospital South Campus from February 2015 to February 2017 were collected, and the pathogenesis, manifestations, treatment principles and method, and prognosis and so forth of DKA complicated by MODS were investigated. Results: Infection was the main inducement in these 21 patients with DKA complicated by MODS. Based on the routine medical treatments, quickly dripping insulin could effectively relieve the clinical manifestations of ketoacidosis and improve the prognosis of DKA complicated by MODS. The cure rate and death rate of the combined modality therapy were 85.71% and 14.29%, respectively. There was no significant difference between the cure rate and mortality of DKA with MODS ($P>0.05$). Conclusion: DKA complicated by MODS has complicated causative factors, critical conditions, and ominous prognosis. Combined modality therapy (quickly dripping insulin combined with routine medical treatments) should be given in time according to different conditions, and directed treatments be given based on the clinical features and causative factors.

Keywords: Diabetic ketoacidosis, multiple organ dysfunction syndrome, clinical analysis

Introduction

Diabetes is a disease due to the pancreas producing insufficient or no insulin or the cells of the body not responding properly to the insulin produced [1]. Poor control of blood sugar may cause various complications, among which, ketoacidosis is common. Diabetic ketoacidosis (DKA) is mainly clinically manifested by aggravated diabetes, nausea, dehydration, unconsciousness, or even shock, and severely affects the safety of life.

DKA is mainly caused by decreased insulin level which lead to too high blood sugar concentration, and destroyed acid-base balance in the bodies of diabetes patients. After the onset of DKA in diabetes patients, multiple organ dysfunctions is triggered, which severely threatens the safety of life. Multiple organ dysfunction syndrome (MODS) is a phenomenon of non-function of two or more organs or the whole body system, after severe trauma or infection [2]. DKA complicated by MODS is a critically severe disease with an extremely high fatality rate clinically, both prompt diagnosis and early active prevention are required [3, 4]. Quickly dripping insulin in addition to routine medical treatments in clinical practice can effectively relieve the patient's conditions and result in a very low death rate [5, 6]. But the relative reports are still few, therefore, this article summarized the clinical data of the 21 patients with DKA complicated by MODS treated in Shanghai Jiao Tong University Affiliated Sixth People's Hospital South Campus from February 2015 to February 2017, who were given quickly dripping insulin in addition to routine medical treatments, with good clinical efficacy. The details were reported below.

Materials and methods

General clinical data

The study had been approved by the Ethics Committee. The clinical data of the 21 patients

with DKA complicated by MODS treated in Shanghai Jiao Tong University Affiliated Sixth People's Hospital South Campus from February 2015 to February 2017 were retrospectively analyzed. All the patients were diagnosed with DKA based on metabolic acidosis, hyperketonemia, and hyperglycosemia.

Diagnosis of DKA: Blood sugar level was significantly increased over 300 mg/dL or 16.6 mmol/L, urine acetone bodies were positive, and acidemia (pH=7.2) and the clinical manifestations of ketoacidosis were present such as rotten apple flavor when breathing, hypnody, drowsiness, nausea, coma, and decreased food appetite, etc.; when the clinical signs and symptoms were insignificant, it was diagnosed mainly based on laboratory examination results and medical history and so on. All the patients with DKA were definitely diagnosed according to the criteria for MODS [7].

Information collection

The following data on the 21 patients were collected and summarized: 1) the basic information of the patients, including age, sex, underlying diseases, and past diagnosis and treatments of diabetes and so on; 2) clinical manifestations, including symptoms, physical signs, and related laboratory examination results; 3) clinical courses, including treatment principles and specific treatment protocols; 4) treatment outcomes and prognosis.

Treatment methods

The treatment measures for DKA complicated by MODS included early fluid recovery, monitoring renal function, controlling blood sugar, preventing and controlling infection, and controlling hemorrhage.

Early active fluid recovery: In clinical practice, there were two ways for fluid recovery, intravenous fluid infusion and fluid infusion via a gastric tube. Intravenous fluid infusion: After definite diagnosis, the patients should be given early, prompt, and rapid fluid recovery to ensure sufficient tissue perfusion, which was the key measure to rescue DKA patients. Fluid infusion via a gastric tube: Warm boiled water was infused via a gastric tube to supplement lost water and avoid increasing the cardiac burden caused by large dose intravenous fluid infusion [8]. Generally, the volume of fluid infusion via a gastric tube was 1/3-1/2 of the total volume and the infusing speed was 100-200 mL/L, of which the efficacy was good.

Monitoring renal function: Renal failure was one of the most common complications of DKA, and the main reasons were related with organ hypofunction of underlying diseases. In the early days, the renal function should be closely monitored, 24 h volumes of input and output correctly recorded, the volume and color of urine in each hour closely observed, and renal function judged according to the urine volume.

Controlling blood sugar: In clinical practice, predominately, stable, safe, and effective measures were taken to control the blood sugar, which could bring the maximum benefits and decrease the incidence of hypoglycemia events [9-11]. It was carried out mainly by rapidly dripping insulin. In the dripping period, the changes in blood sugar should be closely monitored, and hypoglycemia symptoms observed, such as hand tremor, sweating, and paleness. According to *Guidelines for the treatment of diabetes* issued by American Diabetes Association in 2012, it was recommended to strictly control the blood sugar below 7.8 mmol/L in severe patients.

Controlling bleeding: Diabetes patients usually were accompanied by hypercoagulability, hypoxemia, infection, and acidosis and so forth, which was also one of the main reasons for disseminated intravascular coagulation [12, 13]. Once disseminated intravascular coagulation occurred, the fatality rate would be greatly increased. After admission, in patients with DKA complicated by MODS, the primary disease should be actively controlled, inducements eliminated, and bleeding symptoms closely observed, including ecchymosis in skin and bleeding in respiratory tract, alimentary tract, brain, and other sites.

Preventing and controlling infection: In diabetes patients, the systemic resistance and skin defensive ability were significantly decreased, and consequently septicemia occurred easier. All the patients with DKA complicated by MODS were given antibiotics after admission. Before medication, bacterial culture and drug sensitive test were performed; and after medication, adverse reactions and side effects were observed.

Table 1. Inducements of DKA (n, %)

Inducement	Case	Cases of stealth infection
Infection	14 (66.67)	7 (33.33)
Respiratory tract infection	7 (50.00)	3 (42.86)
Urinary tract infection	4 (28.57)	3 (42.86)
Biliary tract infection	3 (21.43)	1 (14.28)
Improper treatment	3 (14.29)	0
Excessive drinking	2 (9.52)	0
Other incentives	2 (9.52)	0

Note: DKA, diabetic ketoacidosis.

Table 2. Distributions and outcomes of organ failure (n, %)

Number of organ failure	Case	Cure or improve	Death	P
≥2	21	18 (85.71)	3 (14.29)	0.064
≥3	13	11 (52.38)	2 (9.52)	
≥4	4	3 (14.29)	1 (4.76)	

Monitoring respiratory function: For patients with DKA complicated by MODS who were sober, effective cough was encouraged. For coma patients, endotracheal intubation or tracheotomy, and adjunctive mechanical ventilation when necessary were performed; each parameter and index on the breathing machine were closely monitored and adjusted; the consciousness, frequency, rhythm, and depth of breathing, saturation of blood oxygen, heart rate, and the colors of the lips and the ends of four limbs were observed; the blood gas analysis results of arterial blood were collected, and the parameters of the breathing machine were adjusted based on the analysis results and the patient's conditions.

Statistical analysis

The data were analyzed by SPSS17.0 software. Quantitative data and qualitative data were expressed in ($\bar{x}$ ± sd) and (n, %), respectively.

Results

Basic data on the 21 patients

All the 21 patients had DKA complicated by MODS. Among them, 10 patients were male and 11 female; and the age range and mean were 24-76 years old and 46.7±2.9 years old, respectively. Moreover, totally 5 patients had respiratory failure, 4 had hepatic failure, 6 had renal failure, 4 had coagulation disorders, and 2 had cerebral edema and hernia.

Summary of the inducements and clinical manifestations in the 21 patients

In all the 21 patients, their blood sugar level was significantly increased (>16.6 mmol/L), urine acetone bodies were positive, and acidemia (pH=7.2) and the clinical manifestations of ketoacidosis were present, and all the patients were definitely diagnosed with DKA; according to the diagnostic criteria for MODS, totally 5 patients had respiratory failure, 4 had hepatic failure, 6 had renal failure, 4 had coagulation disorders, and 2 had cerebral edema and hernia. It was discovered after analysis of various inducements of DKA that infection caused the most DKA cases. The details are shown in **Table 1**.

Analysis of clinical efficacy

Among the 21 patients, 18 patients achieved improvement, with an improvement rate of 85.71%; 3 patients died, with a death rate of 14.29%. And the mean length of stay was 17.3±3.4 days. It was discovered by this case summary that among the 21 patients with DKA complicated by failure of 2 or more organs, 18 patients achieved cure and 3 died; among the 13 patients with DKA complicated by failure of 3 or more organs, 11 patients achieved cure and 2 died; and among the 4 patients with DKA complicated by failure of 4 or more organs, 3 patients achieved cure and 1 died. The overall cure rate and death rate in the 21 patients with DKA complicated by multiple organ failure were 85.71% and 14.29%, respectively. There was no significant difference between the cure rate and mortality of DKA complicated by MODS (P>0.05). The details are shown in **Table 2**.

Discussion

DKA is a critically severe disease with a high incidence in clinical practice, of which causative factors are mainly fatigue, trauma, unreasonable medication, and infection and so forth. It is usually complicated by various diseases, such as hyperchloraemia, hypoglycemia, hypokalemia, and cerebral edema [14-16]. Due to the accelerated increase in blood sugar, MODS

occurs, then both the systemic resistance and skin defensive ability are significantly decreased, thereby severe infections including septicemia occur easier. In the absence of prompt and effective treatment for DKA in clinical practice, the safety of life is severely threatened.

DKA complicated by MODS is a critically severe disease with a high fatality rate clinically; therefore, medical personnel should be familiar with the rescue skills for critical and severe diseases, judge the monitoring parameters promptly, and consequently elevate the achievement ratio of rescue. It can be seen that combined modality therapy in treatment of DKA complicated by MODS can effectively decrease the fatality rate and promote the recovery as soon as possible.

As revealed by the clinical data summary, DKA is predominately caused by infections in the urinary system and respiratory tract; and clinically, it is mainly treated with rapid fluid infusion, adjusting the acid-base balance, and keeping the internal environment homeostasis [17]. In addition to the routine medical treatments, dripping a small dose of insulin can control diabetes, relieve the symptoms, and prevent from the risks caused by rapidly decreased blood levels of sugar and potassium in DKA patients [18]. As reported by Eledrisi et al., using insulin in addition to routine medical treatments could relieve the symptoms as soon as possible; meanwhile, the levels of blood sugar and electrolytes were closely monitored to prevent from accidents caused by rapidly decreased blood levels of sugar and potassium [19]. After 11±4 h, 49 patients had their blood sugar level decreased to 5.8-11.9 mmol/L; and after 21±9 h, all the indexes were recovered; there was a patient with coma; and the efficacy was ideal. The report results are similar to those of this study.

Seen from the summary of the clinical data on the 21 patients with DKA complicated by MODS treated in Shanghai Jiao Tong University Affiliated Sixth People's Hospital South Campus from February 2015 to February 2017, the clinical efficacy of early fluid recovery, monitoring renal function, controlling blood sugar, preventing and controlling infection, and controlling hemorrhage was evaluated, and the data showed that infection was the main inducement of DKA complicated by MODS. Based on the routine medical treatments, quickly dripping insulin could effectively relieve the clinical manifestations of ketoacidosis and improve the prognosis of DKA complicated by MODS [20]. The cure rate and death rate of the combined modality therapy were 85.71% and 14.29%, respectively. There was no significant difference between the cure rate and mortality of DKA complicated by MODS ($P>0.05$).

To sum up, DKA complicated by MODS has complicated causative factors, critical conditions, and ominous prognosis. Quickly dripping insulin based on routine medical treatments should be given in time according to different conditions, and directed treatments be given based on the clinical features and causative factors. This summary has investigated the clinical efficacy of these combined modality therapy in treatment of DKA complicated by MODS and provided new evidence-based medicine foundations. Furthermore, the sample size should be enlarged, and the patients should be grouped for comparative analysis.

Disclosure of conflict of interest

None.

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