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Original Article

Influence of phased body temperature management for severe abdominal traumatic patients with hemorrhagic shock

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Abstract: Objective: To evaluate the treatment efficacy of phased body temperature management on severe abdominal traumatic patients with hemorrhagic shock. Methods: Ninety severe abdominal traumatic patients with hemorrhagic shock were enrolled in our hospital between March 2015 and December 2016. The patients were randomly divided into a phased management group and a control group (45 cases in each group). In the control group, routine body temperature treatment was used. For the phased management group, the concept of damage control surgery was employed, which indicated the different body temperature management methods in different stages. The temperature recovery time, lactate clearance time, length of hospital stay, prothrombin time (PT), and activated partial thromboplastin time (APTT) were recorded to analyze the differences between two groups. The rates of complication and mortality were also measured. Results: There were significant shorter times of temperature recovery (t=14.877, P=0.000), lactate clearance (t=25.736, P<0.001), PT (t=16.710, P<0.001), and APTT (t=13.696, P=0.000) in the phased management group compared with the control group. No significant different in body temperature between the two groups was observed (t=0.777, P=0.439) at admission. In the surgery and intensive care unit, the body temperature in the phased management group (35.958±0.628°C and 36.973±0.424°C, respectively) was significantly higher (t=7.546, P=0.000; t=10.152, P<0.001) than that in the control group (34.944±0.646°C and 35.842±0.616°C, respectively). There was a significantly shorter length of stay (t=5.499, P<0.001) in the phased management group (21.689±4.166 d) than in the control group (27.733±6.166 d). The rates of complication and mortality in the phased management group (6.667% and 2.222%, respectively) was significantly lower (t=6.480, χ^2=0.011 and t=3.873, χ^2=0.049, respectively) than that in the control group (26.667% and 13.333%, respectively). Conclusion: Phased body temperature management could effectively improve treatment of severe abdominal traumatic patients with hemorrhagic shock, including correction of the risk of hypothermia, metabolic acidosis, and blood coagulation disorder, reducing rates of complications and death, and shortening the length of the hospital stay.

Keywords: Damage control surgery, abdominal trauma, hemorrhagic shock, hypothermia

Introduction

As a serious threat to human life, severe abdominal trauma with hemorrhagic shock fall into categories of hypothermia, metabolic acidosis, and blood coagulation disorders. These can lead to rapid and high rates of disability and death [1, 2]. Damage control surgery is an important treatment for traumatic shock. Throughout the entire treatment process (including hospital emergency treatment and recovery, emergency operation, and monitoring, planned and definitive operation), damage control surgery not only improves the success rate of surgery, but also greatly enhances the patient's survival rate and the quality of life [3, 4]. Based on previous clinical studies, post-traumatic hypothermia is an independent risk factor which affects the prognosis of patients and increases the mortality of traumatic patients [5, 6]. According to incomplete statistics in previous studies, the incidence rate of hypothermia was from 28% to 68% in the emergency room [7, 8]. Temperature management plays a very important role in severe abdominal trauma patients with hemorrhagic shock. In particular,

Table 1. Comparison of participant information in two groups ($\bar{x}\pm sd$)

Item	Phased management group	Control group	t/χ^2	P
Age (years-old)	43.978±13.965	45.622±14.767	0.543	0.589
Gender			0.207	0.649
Male	32	30		
Female	13	15		
Injury mechanism			0.062	0.803
Blunt hepatic injury	35	34		
Penetrating injury	10	11		
Cause of injury			0.818	0.936
Traffic injury	32	30		
High falling injury	6	7		
Stab injury	3	4		
Crush injury	3	2		
Other injuries	1	2		
Injured part			0.258	0.992
Spleen	16	17		
Liver	14	13		
Large and small intestine	11	10		
Pancreas	3	4		
Stomach	1	1		
Associated injury			0.577	0.966
Fracture	16	15		
Hemopneumothorax	12	14		
Cerebral trauma	11	10		
Pulmonary contusion	4	3		
Retroperitoneal hematoma	2	3		
Injury severity score	36.022±7.018	36.533±7.694	0.329	0.743

phased body temperature management significantly improves the success rate of treatment, and reduces mortality [5, 7]. However, there has been no study on phased body temperature management for severe abdominal trauma patients with hemorrhagic shock until now.

In this study, phased body temperature management was employed for severe abdominal trauma patients with hemorrhagic shock in order to provide a clinical basis for its application in clinical settings.

Materials and methods

Participant information

This prospective study was approved by the Ethics Committee of Dongying People's Hospital. Ninety severe abdominal traumatic patients with hemorrhagic shock were recruited at our hospital from March 2015 to December 2016. The inclusion criteria consisted of (A) family members understanding and signing the informed consent, (B) age of 18 years or above, (C) injury or rupture of abdominal parenchyma and cavity, bleeding in the abdomen, (D) blood pressure lower than 90/60 mmHg, (E) body temperature and blood pH lower than 35°C and 7.3 respectively, (F) injury severity score (ISS) equal to 16 or above. The exclusion criteria were (A) patients with fever; (B) abnormal body temperature regulation; (C) thyroid dysfunction; (D) diabetes; (E) unwilling to participate in this study.

According to the order of admission, patients were randomly divided into the phased management group and the control group (45 cases in each group) using a random numbers table. Among them, 62 males and 28 females were enrolled. There were 69 cases of blunt injury and 21 cases of penetrating injury. For reasons of abdominal injury, there were 62 cases of traffic injury, 13 cases of falling injury, 7 cases of stab injury, 5 cases of crush injury, and 3 cases of other injuries. Moreover, for the locations of the lesion, there were 33 cases of spleen, 27 cases of liver, 21 cases of large and small intestines, 7 cases of pancreas, and 2 cases of stomach. For co-existing injuries, there were 31 cases of fracture, 26 cases of hemopneumothorax, 21 cases of cerebral injury, 7 cases of pulmonary contusion, and 5 cases of retroperitoneal hematoma. There was no significant difference between the two groups in age, sex, trauma mechanism, reason of injury, combined injury and ISS (all P>0.05, **Table 1**).

Intervention treatment

Routine nursing care was performed for both groups after admission. Health education,

including surgical treatment of abdominal injuries, and knowledge of postoperative rehabilitation was explained by the responsible nurse to induce active patient cooperation with the treatment. Psychological counseling was also used to relieve patients' emotions such as fear and tension. In order to prevent intestinal contents leaking into the abdominal cavity, preoperative fasting and prohibition of enema were performed. A drainage tube was indwelled in abdominal cavity after operation. Based on the personalized habit of diet and nutrition situation, scientific and effective individualized nutritional support was designed after the gastrointestinal functional recovery. For body temperature management in control group, wet clothes were removed and skin was dried. Clean patient' clothes were put on to keep the body dry. Then the room temperature was maintained between 22 and 24°C. The technologies of damage control surgery in control group were the same as in the phased management group.

Great heat loss easily occurs in the patients with severe abdominal trauma, especially for an open wound. Therefore, the concept of damage control surgery and the management of body temperature were used in the phased body temperature management group to strengthen the management of the patient's temperature. This treatment was employed for the application of severe traumatic shock throughout different stages. The phased body temperature management was listed as follows.

Preoperative preparation and temperature management

After the patients arrived at the Emergency Department, doors and windows were closed quickly. The room temperature was adjusted to 26-28°C. Wet clothes on patients were removed as soon as possible, then cotton wadding was used to cover the patient to keep them warm. The vital signs of patients were monitored strictly. The changes of body temperature were recorded. Three venous channels were prepared to perform limited liquid recovery. The blood plasma was employed as the main recovery solution to restore the blood volume. Systolic blood pressure levels were maintained between 80 and 90 mmHg [9]. Intravenous infusion liquid was warmed to 37-38°C through a heater. In order to avoid blood component damage resulting from high temperature, the blood transfusion temperature was not allowed to be higher than 37-38°C. Emergency fast track was used to collect and detect blood specimen quickly. Bedside electrocardiogram, ultrasonic B, and X-ray examination were performed to evaluate the state of illness rapidly and improve the treatment time. In the meantime, the patients were kept warm to reduce exposure and heat loss. To prevent infections in the abdominal cavity and aggravation of illness, preoperative fasting, prohibition of enema and gastrointestinal decompression were performed.

For the patients with open wound, the lesions were treated carefully, and covered with sterile gauze. Preoperative preparation was performed quickly. The independent air-conditioning surgery room, bed, and blanket (40°C) were prepared by the Emergency Operating Department in advance. The surgery room and bed were preheated to prepare the surgery and body temperature recovery for patients. After the surgery, the patients were also kept warm with cotton wadding when they back to ward from the operation room.

Body temperature management in early surgery stage

Systemic body temperature management approaches were used in the operation. The room temperature was maintained in 26-28°C with 50%-60% humidity to provide warm and comfort environment. Cotton pads or heating blanket (40°C) were employed on non-surgical parts to keep warm, minimize exposure, and reduce heat loss. The intravenous fluid was heated to 37°C. Humidified warm gas (37°C with 44 mg/L humidity) was inhaled in patients with mechanical ventilation using humidifier to decrease the stimulation and damage to the lungs by cold and dry gas [4]. Abdominal cavity flushing fluid was heated to 37°C for the patients who needed cavity flushing [10]. The length of surgery was controlled in 90 min to minimize the operation time. The aim of early stage surgery was to control fatal hemorrhage and pollution [11]. The preparation for the severe abdominal trauma patients with hemorrhagic shock was done by the emergency department, including the preparation of the

preheated bed to 37°C. After the surgery, the patients were kept warm.

Body temperature management in monitoring stage

After emergency surgery in the early stage, patients were transferred to emergency intensive care unit for monitoring and advanced life support. The important objective of this stage was to deal with the fatal triple symptoms effectively [11]. The details of body temperature management are listed as follows. First, the airway management was strengthened. The respiratory secretions were removed in time to keep the airway clear. The ventilator was assisted if necessary to ensure the enough oxygen for patient. The nursing care was improved to prevent the ventilator associated pneumonia. Second, fluid resuscitation was performed. The severe hemodynamic disorder and acidosis were corrected. The speed and amount of transfusion were controlled by infusion pump and recorded. The treatment program was adjusted based on the changes of illness in patient. Third, the coagulation function was maintained. Blood plasma, red blood cells, cold precipitation and platelets were replenished rapidly to recover the prothrombin time (PT) and activated partial thromboplastin time (APTT). Preoperative fasting and depression of gastrointestinal were performed. The nursing care of drainage tube was improved. The different drainage tubes were fixed and marked carefully to avoid distortion and compression. The color, features, and amount of drainage fluid were all recorded.

Next, the changes of body temperature were monitored. The room temperature was maintained between 26 and 28°C. The patients were covered with air convection blanket (40°C). Unnecessary exposure was avoided. The transfusion fluid was heated to 37°C by liquid heater. Then the changes of body temperature were recorded carefully. For the last management part, antibiotics were used properly to block the cascade response of sepsis and restore the physiological function initially. The nutrition support of patients was improved to enhance the tolerance of the deterministic operation. Comprehensive physical examination and auxiliary inspection were performed to avoid missed diagnosis and improve the deterministic operation conditions for patients.

Outcome measures

The changes of body temperature in patients were recorded and analyzed. The temperature recovery time was measured. The concentration of lactic acid in blood was determined by automatic chemical analyzer after admission (normally ranged from 0.1-1 mmol/L). The PT and APTT were determined by the automatic blood coagulation analyzer. The reference values for PT and APTT were 11-14 s and 34-40 s, respectively. The concentration of lactic acid, PT and APTT were determined each 30 min unless recovered to the reference values. The time from admission to recovery of lactic acid, PT and APPT were referred to the lactic acid clearance time, and PT or APTT recovery time. The lengths of those parameters were compared. The complications and mortality in patients were recorded. The length of the hospital stay was measured and analyzed.

Statistical analysis

SPSS 19.0 software was used for data analysis. The data are expressed as mean ± standard deviation ($\bar{x}\pm sd$). Comparison between groups was conducted with independent sample t test. The counting data was tested by χ^2. $P<0.05$ indicated statistically significant difference.

Results

Comparison of lactate level, PT and APTT at admission and correction time of fatal triple symptom after admission in both groups

Severe metabolic acidosis and coagulative dysfunction was observed in patients after admission. The results of lactate level, PT and APTT showed no significant difference between two groups (all $P>0.05$). There were significantly shorter times of body temperature recovery, lactate clearance, PT recovery, and APTT recovery time in phase management group than that in control group (all $P<0.05$). See **Table 2**.

Comparison of body temperature in different stages in both groups

Low body temperature was observed in both groups, which showed no significant difference ($P>0.05$). In both surgery and the intensive care unit, there were significantly higher body temperatures in the phased management group than in the control group (both $P<0.05$, **Table 3**).

Table 2. Comparison of lactate level, prothrombin time, and activated partial thromboplastin time at admission and correction time of fatal triple symptom after admission in two groups ($\bar{x}$±sd)

Item	Phased management group	Control group	t	P
Lactate level (mmol/L)	7.316±1.484	7.491±1.397	0.578	0.565
PT (s)	30.267±6.005	30.556±4.808	0.252	0.802
APTT (s)	66.511±9.054	68.311±6.470	1.085	0.281
Body temperature recovery (h)	4.244±1.401	13.243±3.809	14.877	0.000
Lactate clearance (h)	12.600±2.683	31.267±4.059	25.736	0.000
PT recovery (h)	3.578±1.097	28.844±10.084	16.710	0.000
APTT recovery (h)	5.222±1.491	26.956±10.540	13.696	0.000

Note: PT indicates prothrombin time; APTT indicates activated partial thromboplastin time.

Table 3. Comparison of body temperature in different stages in both groups ($\bar{x}$±sd)

Item	On admission (°C)	Surgery stage (°C)	Monitoring stage (°C)
Phased management group	33.956±0.599	35.958±0.628	36.973±0.424
Control group	34.056±0.622	34.944±0.646	35.842±0.616
t	0.777	7.546	10.152
P	0.439	0.000	0.000

Table 4. Comparison of clinical prognostic indicators in both groups (n (%), $\bar{x}$±sd)

Item	Hospital stay (d)	Rate of complication (cases, %)	Mortality (cases, %)
Phased management group	21.689±4.166	3 (6.667)	1 (2.222)
Control group	27.733±6.166	12 (26.667)	6 (13.333)
t/χ^2	5.449	6.480	3.873
P	0.000	0.011	0.049

Comparison of clinical prognostic indicators in both groups

There was a significantly shorter hospitalization time in the phased management group than in the control group (P<0.05). The complication and mortality rate in the phased management group was significantly lower than in the control group (both P<0.05, **Table 4**).

Discussion

The combination of hypothermia, metabolic acidosis and blood coagulation dysfunction easily occur as a vicious spiral in severe abdominal trauma patients with hemorrhagic shock. With poor prognosis, the difficulty of treatment and mortality are extremely high [1]. In recent years, with rapid development and popularity of damage control surgery technology, treatment of blood coagulation dysfunction and metabolic acidosis have been improved. Moreover, this approach simplified the emergency surgery, and enhanced conditions for subsequent deterministic operation [2, 3]. However, the thermoregulatory function of hypothalamus is partially lost after trauma, and the ability of heat production is decreased. In order to rescue the patient, a large amount of cryogenic fluid and blood are transfused into the body, which is also exposed outside. This operation would induce the hypothermia and increase the oxygen consumption, which leads to a variety of complications, damage, and serious influence on the recovery of the disease [12]. Hence, body temperature management is needed to adopt as early as possible. Comprehensive intervention treatment and phased body temperature management are employed to prevent and improve the hypothermia of patients after trauma [13].

In this study, body temperature recovery time (4.244±1.401 h) in the phased management group was significantly higher than in the control group (13.243±3.809 h). There was also a

significantly higher body temperature in the phased management group than in the control group during the surgery and in the intensive care unit. These results indicate that phased body temperature management can improve the temperature recovery of the patients. Phased body temperature management, damage control surgery, and resuscitation technologies which were employed in this study, may be possible reasons for better recovery of the severe abdominal trauma patients with hemorrhagic shock. The active temperature recovery treatment which combined with body surface and center, would induce the faster body temperature recovery in patients [14]. Zheng et al. reported that phased body temperature induced significant improvement for abdominal trauma patients with hypothermia in the emergency department [15]. Those results were similar to our study. The hemostasis of body temperature is essential for metabolism and life activities of humans. In the previous study, comprehensive heat preservation treatment was employed in hypothermia intervention for hemorrhagic shock patients [16]. The results showed this approach improved the body temperature and shock index recovery.

The PT and APTT in phased body temperature management group showed a significantly shorter recovery time than in the control group. Those results indicate that the phased management improved the illness recovery and eliminated the triple symptom of traumatic death of patients, who suffered severe abdominal trauma with hemorrhagic shock. It also enhanced the conditions of patients for the further treatment. There are many factors inducing the hypothermia in traumatic patients, such as preoperative blood loss, traumatic pain, anesthesia, and normal surface heat dissipation. At the same time, a large amount of fluid was transfused into the patients to maintain the effective blood circulation. The low temperature liquid, especially the large amount of stored blood, was transfused in a short time. It would aggravate the hypothermia in patients. The low temperature in the bloodstream would decrease the amount and function of platelets, also decrease the activity of blood coagulation factor. Moreover, the viscosity of platelets was increased. The activity of thrombin and other enzymes in blood coagulation were also decreased. The coagulation process was delayed and the blood coagulation disorders were increased, as bleeding was prolonged. Therefore, body temperature recovery treatment was needed for the traumatic patients [16]. In a previous study, comprehensive intervention for hypothermia could improve the triple symptom of trauma in traumatic shock surgery, and significantly improve the coagulation function of patients, which showed similar results in this study [17]. Moreover, another study showed the proper nursing and intervention with enhanced body management for traumatic patients could improve lactate clearance time, PT and APTT recovery times [18].

The hospitalization time (21.689±4.166 h) in the phased management group was significantly shorter than in the control group (27.733±6.166 h). Thus, combination damage control surgery technology and phased body temperature management, would decrease the rate of complication, mortality, and hospitalization time. The reason for those results was activity recovery for the abdominal traumatic patients by damage control surgery throughout the whole treatment, and phased body temperature management. Those treatments would decrease the damage of hypothermia for patients, and improve shock and traumatic triple symptoms, then decrease the rate of complication and hospitalization time, also increase the successful rate of rescue. In this study, one patient with severe abdominal trauma died from severe multi-organ failure in the phased management group. Whereas in the control group, six participants died for the same reason. Previous studies showed that the mortality of patients with severe abdominal trauma was from 7.1% to 15.2%, and three patients died from severe multi-organ failure [19, 20]. There was significantly lower mortality (2.2%) in the phased management group in this research. The combination intervention and enhanced temperature monitoring would decrease the rate of complication and death by damage control surgery technology and phased management for the abdominal traumatic patients [18, 21, 22]. Those results were similar to our study.

In conclusion, damage control surgery and resuscitation treatments combined with phased body temperature management and comprehensive temperature recovery approaches (active body surface and center recovery) were

evaluated in this study. Those treatments would improve the temperature recovery, accelerate lactate clearance, and promote clotting index restoration. Also, those treatments could decrease the rate of complication and death, shorten hospitalization time, and provide better support for the patients with abdominal trauma. The low number of samples in this study limited the results. In order to provide more evidence for the scientific treatment, a larger sample size and a multi-center research study will be done in the future. Also, the complications occurred even in the phased body temperature management group in this study. Therefore, this treatment still needs to be optimized to decrease the rate of complication, and improve prognosis.

Disclosure of conflict of interest

None.

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