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Original Article

Aclinical study on damage control orthopedics in the treatment of patients with fractures and severe multiple trauma

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Abstract: Objective: The goal of this study was to determine the clinical effect of damage control orthopedics (DCO) in the treatment of fractures in severe multiple trauma. Methods: A total of 120 patients of fractures with severe multiple trauma who were treated in Dezhou People's Hospital and our cooperating hospitals from August 2015 to September 2017 were selected and randomly divided into control group (n=60) and study group (n=60). Patients in the control group were treated with one-stage operation through incision and internal fixation, and those in the study group received the therapy of DCO. The operative time, intraoperative blood loss, recovery time of body temperature, time for bone callus formation, good rate, incidence rates of complications, and mortality rate were compared between the two groups. Additionally, functional recovery, treatment satisfaction rate and laboratory-related indicators were evaluated. Results: The good rate in the study group at 6 months after operation (76.67%) was overtly higher than that in the control group (60.00%) (P<0.05). There were statistically significant differences in intraoperative blood loss ((210.34±23.29) vs. (378.67±48.54) mL), operative time ((45.44±7.21) vs. (74.32±9.18) min), recovery time of body temperature ((5.73±0.81) vs. (9.23±1.45) h) and time for bone callus formation ((30.26±4.79) vs. (38.56±4.31) d) between study group and control group (all P<0.05). The incidence rates of various complications and mortality rate in study group were lower than those in control group, and the differences were statistically significant (all P<0.05). The Majeed score was (86.72±4.94) points in the study group and (75.83±3.55) points in the control group, showing a statistically significant difference between two groups (P<0.05). The study group had a clearly increased treatment satisfaction rate compared with that in control group, and the difference was of statistical significance (P<0.05). The physiological indicators including pH, prothrombin time, activated partial thromboplastin time, fibrinogen, thrombin time, and interleukin-6 in study group were superior to those in the control group, and there were statistically significant differences (all P<0.05). Conclusion: Application of DCO in patients with fractures with severe multiple trauma is not only able to effectively improve treatment effect on patients, but also to facilitate reduction of the incidence of complications. Furthermore, DCO is safer and thus worthy of popularization and application in clinical practice.

Keywords: Damage control orthopedics, fractures in severe multiple trauma, clinical effect

Introduction

Multiple trauma complicated with fractures is a common acute and severe disease in clinical practice, which is a damage caused by the external environment to the body. According to the statistics of World Health Organization, trauma is the fourth leading cause of human death [1]. Patients are in danger when they are admitted to hospitals and often die in the early stage because of massive blood loss and organ failure [2]. For the treatment of patients with fractures in multiple trauma, emergency surgery is often used. However, emergency surgery for trauma takes a long time, together with aggravated internal environment disturbance and continually accumulated inflammatory substances in the body, easily causing lung injury, respiratory failure and other organ failure, thus it seriously threatens the life and health of patients [3].

In recent years, damage control orthopedics (DCO) is gradually introduced into clinical prac-

tice. DCO is a rapid, temporary and effective treatment method that can be conducted in the early stage of traumas, which can reduce the risks of excessive blood loss and soft tissue damage. After the condition of patients is stabilized and improved, the second-stage definitive treatment is carried out. DCO focuses on the correction of physiological disorders of patients, reduction of the release of inflammatory factors, and prevention of hypothermia in patients due to excessive blood loss, thereby preventing irreversible physiological damages [4]. Simultaneously, reducing intraoperative blood loss and damage to the body caused by "second hit" due to stress response is conducive to lowering the mortality rate of patients [5]. Many studies at home and abroad have reported that this technique can reduce the mortality and incidence rates of postoperative complications, but there are few comprehensive studies on relevant clinical indicators and laboratory examinations of patients [6, 7].

This study aims to evaluate the role of DCO in treating patients with fractures in severe multiple trauma by relatively detailed observation indicators. In this study, 120 patients with fractures in severe multiple trauma in Dezhou People's Hospital were selected as objects of study. Clinical efficacy of DCO was observed, and the improvement in patients' outcomes after DOC was explored.

Materials and methods

Selected objects and grouping

A total of 120 patients with fractures in severe multiple trauma treated in the Emergency Surgery Department in Dezhou People's Hospital from August 2015 to September 2017 were enrolled and randomly divided into two groups (study group and control group, with 60 patients in each group) using a random number table. All patients had smooth breathing and were given conventional treatments including oxygen inhalation, rehydration, hemostasis, nutritional support and symptomatic treatment.

Inclusion criteria: (1) Patients who and whose family members were aware of and agreed with study content, and signed the informed consents approved by the Ethics Committee of the Dezhou People's Hospital; (2) Patients who had two or more severe concurrent or successive damages in tissues or organs after the same hit, of which one damage alone might also endanger the life of the patient; (3) Patients who aged 18-65 years old; (4) Patients were with the trauma and injury severity score (TRISS) of 14-48 points [8]; (5) Patients were with one or more fractures.

Exclusion criteria: (1) Patients who did not stay in the intensive care unit (ICU) and died within 24 h after injury; (2) Patients with TRISS >50 points; (3) Patients with severe multi-organ failure; (4) Patients with severe mental illness and not cooperating with treatment; (5) Patients with incomplete medical records; (6) Patients whose guardian requested midway withdraw from the study automatically.

This study was approved by the Ethic Committee of Dezhou People's Hospital, and all patients signed the informed consent.

Study methods

One-stage operation through incision and internal fixation was applied in control group [9]. Patients were given general anesthesia, and treatment plan was selected according to the different types of fractures. The skin, subcutaneous tissue, muscle and layer of deep fascia were separated one by one to fully expose the trauma site. Then, the local bone fragments were removed, and the appropriate method of hemostasis was carried out. Then, the reduction was conducted using a pair of reduction forceps, followed by internal fixation with a reconstruction plate. During the operation, X-ray was adopted to check whether the internal fixation was in place. After that, the incision was closed, and patients were followed up for 9 months. Damage control was strictly followed for treatment in study group [10]. First, bleeding at trauma site was controlled and the trauma was thoroughly cleaned. Patients were prevented from shock and provided with treatment like fluid or blood volume replacement according to their condition. At the same time, temporary fixation for fractures was performed, with external fixation as the preferred method. Second, patients were timely transferred to the ICU for observation after operation, and correction of internal environment disturbance, control of infection and provision of assisted respiratory therapy were carried out. Third, the definitive reduction and internal fixation for fractures

Table 1. Comparisons of general data in two groups of patients

Group	Study group (n=60)	Control group (n=60)	t/χ^2	P
Age	35.73±9.62	36.31±9.84	-0.339	0.735
Gender			0.164	0.685
Male	44	42		
Female	16	18		
Cause of trauma			1.325	0.516
Violent trauma	23	26		
High falling injury	10	13		
Traffic injury	27	21		
TRISS	23.83±10.42	24.16±10.13	-0.160	0.873

Note: TRISS, trauma and injury severity score.

were conducted after patients had stable condition and no surgical contraindications.

Observation indicators

Main observation indicators: (1) Operative time, intraoperative blood loss, recovery time of body temperature and time for bone callus formation; (2) Good rate, incidence rates of complications (including acute respiratory distress syndrome (ARDS)), pulmonary infection, thrombosis and subphrenic abscess) and mortality rate at 6 months after operation; (3) Functional recovery and treatment satisfaction rate.

Secondary observation indicators: Laboratory-related indicators (pH, prothrombin time (PT), activated partial thromboplastin time (APTT), fibrinogen (Fib), thrombin time (TT) and interleukin-6 (IL-6)) in blood samples collected before operation and at 7 d after operation.

Criteria and methods for evaluation

(1) Evaluation using TRISS scale was carried out in sites such as brain, chest, abdominal cavity and pelvis. The total score was 75 points (TRISS <16 points, mild; 16 points ≤ TRISS ≤25 points, moderate; TRISS >25 points, severe), and the score was positively related to the severity of the trauma. (2) The efficacy of patients was evaluated using the Matta criteria. Excellent, the maximum separation displacement distance was less than 4 mm on the postoperative X-ray film; good, the maximum separation displacement distance was 4-10 mm on the postoperative X-ray film; fair, the maximum separation displacement distance was 10-20 mm on the postoperative X-ray film; bad, the maximum separation displacement distance was over 20 mm on the postoperative X-ray film. (3) The evaluation of functional recovery was performed using criteria for Majeed scoring. Majeed scoring covered pain, working, sitting, sexual life, and the ability to stand. The total score was 100 points, with >85 points for excellent, 70-85 points for good, 55-69 points for fair and <55 points for bad [11]. (4) Treatment satisfaction rate: The satisfaction degree of the patient's family members with the overall treatment was evaluated by questionnaires according to the own situation of Dezhou People's Hospital. The questionnaire consisted of 20 items with 100 points in total. Criteria for scoring: satisfactory, total score ≥85 points; basically satisfactory, 60 points ≤ total score <85 points; unsatisfactory, total score <60 points. Satisfaction rate = Number of cases (satisfactory + basically satisfactory)/total number of cases * 100%.

Statistical analyses

Data were sorted and analyzed using SPSS17.0 software. Measurement data are expressed as mean ± standard deviation ($\bar{x}$ ± sd). For measurement data meeting normal distribution, two independent samples t test was applied to calculate differences between groups. Quantitative data were expressed as ratio (%), and χ^2 test and Fisher's exact test were used for differences between groups. P<0.05 suggests that the difference is statistically significant.

Results

General data

There were no statistically significant differences in general data including gender, age, cause of trauma and TRISS between two groups (all P>0.05) as shown in **Table 1**.

Comparisons of operation-related indicators

The operative time, recovery time of body temperature and time for bone callus formation of patients in study group were shorter than those in control group (all P<0.001). The intraoperative blood loss in study group was decreased compared with that in control group (P<0.001) as shown in **Table 2**.

Table 2. Comparisons of operation-related indicators in two groups of patients

Group	Study group (n=60)	Control group (n=60)	t/χ^2	P
Operative time (min)	45.44±7.21	74.32±9.18	-19.178	<0.001
Intraoperative blood loss (mL)	210.34±23.29	378.67±48.54	-24.214	<0.001
Recovery time of body temperature (hour)	5.73±0.81	9.23±1.45	-16.463	<0.001
Time for bone callus formation (day)	30.26±4.79	38.56±4.31	-9.905	<0.001

Table 3. Comparisons of treatment efficacy in two groups of patients (n, %)

Group	Study group (n=60)	Control group (n=60)	χ^2	P
Excellent	32 (53.33)	23 (38.33)		
Good	14 (23.33)	13 (21.67)		
Fair	10 (16.67)	14 (23.33)		
Bad	4 (6.67)	10 (16.67)		
Good rate	46 (76.67)	36 (60.00)	3.851	0.049

Table 4. Comparisons of incidence rates of various complications and mortality rate in two groups of patients (n, %)

Group	Study group (n=60)	Control group (n=60)	χ^2	P
Complications				
ARDS	0	4 (6.67)	4.138	0.042
Pulmonary infection	9 (15.00)	20 (33.33)	5.502	0.019
Thrombosis	1 (1.67)	7 (11.67)	4.821	0.028
Subphrenic abscess	2 (3.33)	8 (13.33)	3.927	0.048
Mortality rate	3 (5.00)	9 (15.00)	4.227	0.039

Note: ARDS, including acute respiratory distress syndrome.

Table 5. Majeed score and treatment satisfaction rate in two groups of patients

Group	Study group (n=60)	Control group (n=60)	t/χ^2	P
Majeed score (point)	86.72±4.94	75.83±3.55	14.021	<0.001
Satisfaction degree				
Satisfactory	39	29		
Basically satisfactory	15	16		
Unsatisfactory	6	15		
Satisfaction rate (n, %)	54 (90.00%)	45 (75.00%)	4.675	0.031

Comparisons of treatment efficacy

In the study group, there were 32 cases of excellent response and 14 cases of good response, and the good rate was 76.67%. In the control group, 23 patients had excellent response, and 13 patients had good response, with an good rate of 60.00%. The difference in good rate was statistically significant between the two groups (P=0.049) as shown in **Table 3**.

Comparisons of incidence rates of various complications and mortality rate

The incidence rates of ARDS, pulmonary infection, thrombosis and subphrenic abscess were 0, 15.00%, 1.67% and 3.33%, respectively, in study group, and 6.67%, 33.33%, 11.67% and 13.33%, respectively, in the control group; and there were statistically significant differences in incidence rates of adverse reactions between the two groups (P=0.042, P=0.019, P=0.028, P=0.048). The mortality rate in the study group (5.00%) was clearly lower than that in the control group (15.00%), showing a statistically significant difference (P=0.039) as shown in **Table 4**.

Majeed score and treatment satisfaction rate

The Majeed score was (86.72±4.94) points in the study group and (75.83±3.55) points in control group; the former was evidently higher than the later, and the difference was statistically significant (P<0.001). The care satisfaction rate in the study group (90.00%) was remarkably higher than that in the control group (75.00%), displaying a statistically significant difference (P=0.031) as shown in **Table 5**.

Comparisons of laboratory-related indicators before and after operation

Before operation, the differences in pH, PT, APTT, Fib, TT and IL-6 were not statistically sig-

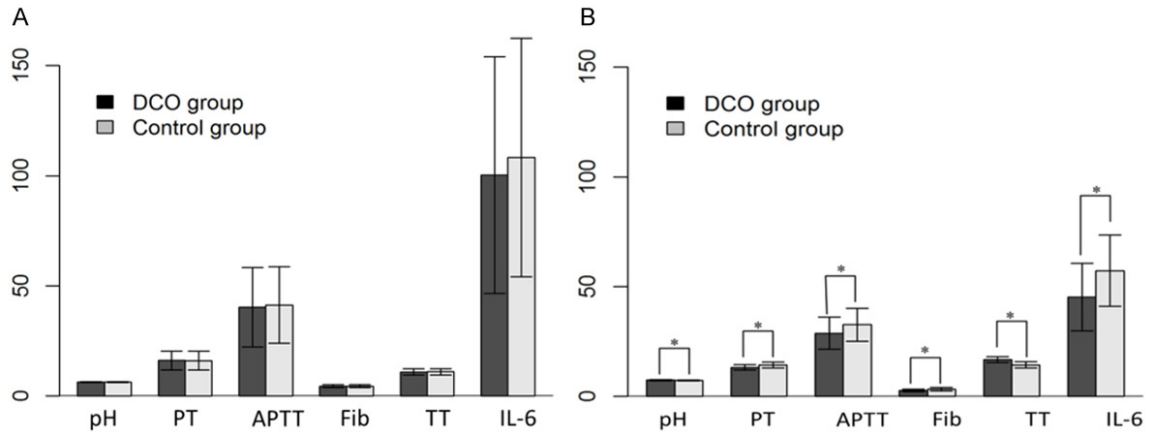

Figure 1. Comparisons of laboratory-related indicators before and after operation in two groups of patients. A: Before operation, there was no significant difference in laboratory-related indicators between the study group and the control group. B: After operation, there were significant differences in laboratory-related indicators between the study group and the control group. *P<0.05. PT, prothrombin time; APTT, activated partial thromboplastin time; Fib, fibrinogen; TT, thrombin time; IL-6, interleukin-6.

nificant between two groups (all P>0.05). After operation, the blood coagulation function, pH and IL-6 were overtly improved in two groups. The pH in the study group was higher than that in the control group, and the difference was of statistical significance (P<0.05), indicating that patients in study group had improved internal environmental disturbances. The study group had clearly elevated PT, APTT, TT, and significantly lowered Fib, in comparison with the control group (all P<0.05). The IL-6 in the study group was clearly lower than that in the control group, with a statistically significant difference (P<0.05) as shown in **Figure 1**.

Discussion

Patients with fractures in severe multiple trauma easily have symptoms such as hemorrhagic shock, coma, and metabolic dysfunction, so the disease has the characteristics of rapid progression and high mortality rate [12]. For treatment of the above-mentioned patients, the "gold standard" of complete treatment for bone fractures in the early stage was adopted previously [13]. However, with the continuous development of research, a study of Cannon et al. proved that thoracic fracture patients receiving complete treatment in the early stage had obviously increased incidence rates of postoperative complications; DCO is applied to patients of fractures in multiple trauma through three aspects, i.e., temporary fixation in the early stage of fractures, close monitoring of the stability of vital signs in the ICU and conduction of second-stage operation after the condition of patients is stable [14].

In this study, the good rate of patients receiving DOC after treatment (76.67%) was higher than that in the control group (60.00%). At the same time, the Majeed score was adopted to evaluate the postoperative functional recovery of patients, and the results indicated that the study group had significantly better postoperative functional recovery than that in the control group, proving that damage control can evidently improve the prognosis of patients with fractures in multiple trauma. Compared with those in the control group, the operative time, recovery time of body temperature, and intraoperative blood loss were overtly decreased in the study group. This was because the condition of patients with multiple trauma was severe, and the vital signs of patients were unstable during immediate surgery, and there were various complications. Additionally, endogenous and exogenous inflammatory factors could be secondarily activated after severe trauma, and the body suffered from metabolic acidosis, ischemia-reperfusion and increased blood loss in the multiple organ dysfunction syndrome (MODS) phase. The application of damage control stabilized the vital signs of patients and reduced the release of multiple inflammatory factors after "second hit', which is consistent with the findings of previous studies [15]. Moreover, the time required for post-

operative bone callus formation of patients in study group was shorter than that in the control group, which was due to the fact that patients who underwent debridement and external fixation and were promptly transferred to the ICU for close monitoring, had timely corrected acidosis and reduced accumulation of lactic acid in the body, thereby promoting bone callus formation [16].

It was discovered in this study that the study group had significantly higher PT, APTT, and TT and clearly lower Fib after operation in comparison with the control group. After the occurrence of multiple trauma, massive blood loss, hypothermia, the inhibition of blood coagulation, and the gradually elevated coagulation-related products were observed, and the coagulation dysfunction was further aggravated after transfusion of a great amount of stored blood [17, 18]. Therefore, pretreatment of patients to reduce the impact of the second hit on patients can further restore blood coagulation, which is similar to the results of Bayin's study [19].

It was also discovered that study group had a significantly lower IL-6 concentration than that in control group, indicating that damage control is able to reduce the occurrence of second hit, avoid the failure of immune defense system and decrease the incidence rate of MODS [20]. Additionally, the incidence rates of complications and mortality rate in the study group were lower than those in the control group. This can be interpreted that the incidence rates of related complications were reduced with the recovery of the immune system, the occurrence of systemic inflammatory response syndrome was avoided, and the mortality rate was further reduced [21]. Because this study has a relatively short follow-up period and a smaller sample size, result bias might exist. In the future, a prospective study with a larger sample size and a longer follow-up period will be carried out for verification, so that the treatment model of DCO can be widely popularized in clinical practice.

In summary, this study used DCO in treating patients with fractures in severe multiple trauma to evaluate the laboratory-related indicators and patients' satisfaction rates through detailed observation indicators. These indicators included: more attention paid to the psychological changes during the development of the disease and damage control treatment contribution to the improvement in efficacy of patients. Furthermore, reduction of the occurrence of complications, decreases in the mortality rate, and the incidence rate of complication were all improved.

Disclosure of conflict of interest

None.

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