

Original Article

Effects of emergency treatment mode of damage-control orthopedics in pelvic fracture complicated with multiple fractures

Haipeng Fan¹, Ruihua Fei², Chunwen Guo¹, Yutang Li¹, Cairong Yan¹, Fengshou Chen¹, Yong Zhang³

Departments of ¹Emergency Intensive Care Unit, ²Oncology Radiotherapy, ³Orthopedics, First Hospital of Quanzhou Affiliated to Fujian Medical University, Quanzhou, Fujian Province, China

Received December 21, 2020; Accepted January 22, 2021; Epub June 15, 2021; Published June 30, 2021

Abstract: Objective: This study aimed to observe the application effect of emergency treatment mode of damage-control orthopedics (DCO) in pelvic fracture complicated with multiple fractures. Methods: Ninety-four patients with pelvic fracture complicated with multiple fractures in our hospital were recruited and divided into two groups according to the random number table method, with 47 cases in each group. Patients in the control group received traditional methods for emergency treatment (early complete treatment), and patients in the research group received DCO for emergency treatment (treatment performed in stages according to patient's physiological tolerance, with simplified initial surgery, followed by ICU resuscitation, and finally definitive surgery). The two groups were compared in terms of mortality, the incidence of acidosis and hypothermia three days after the first surgery, surgery-related indexes (time of the first surgery, blood transfusion volume, intraoperative blood loss, recovery time of temperature, and length of hospital stay), coagulation function indexes (activated partial thromboplastin time (APTT), thrombin time (TT), prothrombin time (PT) and fibrinogen (FIB)), postoperative reduction of fracture, complication rate, and quality of life. Results: The incidences of acidosis, hypothermia, and mortality three days after the first surgery in the research group were lower than those in the control group ($P < 0.05$). Compared with the control group, the research group experienced shorter time of the first surgery, less intraoperative blood transfusion volume, less intraoperative blood loss, shorter recovery time of body temperature, and shorter length of hospital stay ($P < 0.05$). Seven days after surgery, PT, TT and APTT decreased and FIB increased in both groups ($P < 0.05$), PT, TT and APTT in the research group were lower than those in the control group ($P < 0.05$), while FIB was higher ($P < 0.05$). The good rate of reduction in the research group was higher than that in the control group ($P = 0.025$). The incidence of complications in the research group was lower than that in the control group ($P = 0.049$). Six months after surgery, the scores of physiological function (PF), body pain (BP), role physical (RP), emotional function (EF), social function (SF), vitality, and general health (GH) of the research group were higher than those of the control group ($P < 0.05$), but there was no significant difference in mental health (MH) between the two groups ($P > 0.05$). Conclusion: The emergency treatment mode of DCO is effective in pelvic fracture complicated with multiple fractures, which can effectively improve postoperative reduction of patients, improve the coagulation function, reduce complications, and improve the quality of life.

Keywords: Pelvic fracture complicated with multiple fractures, emergency treatment mode of damage-control orthopedics, coagulation function, complications, quality of life

Introduction

Most patients with pelvic fractures are in serious condition, and more than half of them will have multiple fractures, with complicated injuries, many complications, and rapid changes in the condition, resulting in difficulty in treatment [1]. If not treated properly, the mortality rate can be as high as 10.2%, and even if the treat-

ment is successful, there is a 50%-60% disability rate, which seriously affects the quality of life of patients [2]. Due to the non-independence of the human body's functional systems and the non-unitary nature of the discipline, the management of such complex injuries has always been a great challenge for orthopedic surgeons, and accurate timing of interventions will have an important impact on the prognosis

DCO emergency treatment mode in pelvic fracture with multiple fractures

of these patients [3]. In the 20th century, the prevailing view in the medical circles on this kind of compound injury was that patients were in acute stress state and have serious physiological dysfunction in early stage, and were therefore not suitable for major surgery. Subsequent studies have shown that early fracture fixation and early mobility can effectively reduce the complications such as infection and deep vein thrombosis, which is beneficial for prognosis [4, 5]. For patients with high degree of injury, however, early and timely surgery cannot improve their survival rate and prognosis. One study suggests that many patients have symptoms such as acidosis, hypothermia and coagulopathy after early surgery, with extremely poor prognosis [6]. Which again arouses controversy in the orthopedic community regarding the selection of surgical timing and the ability to tolerate a second hit at an early stage in patients with compound injuries.

The concept of damage control is mainly established for the treatment strategy of fatal triad of acidosis, intraoperative hypothermia and coagulopathy [7]. This concept has gradually developed into the field of orthopedics with the aim of giving patients early, quick and simple fracture fixation, followed by definitive fixation when systemic stability allows [8]. The treatment process is divided into three stages. The first stage is the rapid and accurate evaluation of the injury, and related treatments such as hemostasis, debridement and temporary fixation will be done. The second stage is intensive care unit (ICU) resuscitation treatment, to adjust systemic conditions and maintain vital organs. The third stage is the surgical treatment of definite pelvic internal fixation [9]. At present, the biggest difficulty with the concept lies in how to grasp the criteria for implementing orthopedic damage control. In order to explore effective, safe and reasonable emergency treatment measures, this study adopted the emergency treatment model of DCO to treat patients with pelvic fractures complicated with multiple fractures as follows.

Materials and methods

General data

From October 2018 to September 2020, a total of 94 patients with pelvic fractures complicated with multiple fractures admitted to our hospital were recruited and randomly divided into

two groups according to the random number table method, with 47 cases in each group. The control group adopted early complete surgery, while the research group adopted the emergency treatment mode of DCO. There was no significant difference in general data between the two groups, suggesting comparability. This study was approved by the medical Ethics Committee of the hospital.

Inclusion criteria

Inclusion criteria: all patients diagnosed as pelvic fracture complicated with multiple fractures by CT and x-ray; patients with an age of 18-60 years old; patients with unstable hemodynamics; patient whose family had signed the informed consent for the study.

Exclusion criteria: patients with coagulation dysfunction or immune dysfunction before trauma; patients with severe craniocerebral injury; patients without pelvic fracture; patients with major infectious diseases; tumor patients; pelvic fracture patients with rupture or bleeding of large blood vessels such as iliac artery.

Methods

Control group: Traditional method (early complete treatment) was adopted: after admission, patients' vital signs were closely monitored, and medication or liquid resuscitation was given to them. Dual intravenous channels were established, supportive treatments of blood transfusion, respiratory support and anti-shock were given on a case-by-case basis, and the wounds were stuffed or bandaged with pressure to stop bleeding. Then, an imaging examination was performed to determine the fracture type and trauma score. Internal fixation and combined injury management of pelvic fracture were performed according to specific conditions, and the patient was transferred to ICU after surgery.

Research group: The emergency treatment mode of DCO was adopted:

In the first stage, resuscitation with first-aid fluid was applied. Then, CT and X-ray imaging examinations were performed on the traumatized parts of patients to determine whether there was any serious contusion or swelling of the buttocks or groin, whether there was any visible pelvic bone deformity or open wound, etc., so as to provide a preliminary basis for

DCO emergency treatment mode in pelvic fracture with multiple fractures

clinical diagnosis and treatment. After the determination, the vital signs of patients were closely monitored. Intravenous channels were established for fluid replacement. The patient should keep respiratory tract open. Pelvic fixation band and external fixation band were applied for temporary fixation of pelvis, and anti-shock treatment was applied for patients with existing shock manifestations. For patients with combined head injury, the hematoma and foreign body in the area of cranial compression of vital functions were cleared, and intracranial decompression was performed. Flail chest immobilization was performed on patients with combined thoracic rib fractures. And lower extremity bone traction on patients with combined acetabular fractures and hip dislocation after reduction of fracture. For patients with combined lumbar fracture, brace fixation was adopted.

In the second stage, after the simplified treatment in the first stage, the patient was transferred to ICU, where his/her vital signs were closely monitored for "lethal triad". Heating blanket was placed on the bed, and the transfused liquid was heated to avoid low temperature. Patients were injected with blood or blood products to maintain constant blood and improve the coagulation function. The amount of fluid replenishment was controlled at 1000 mL to 2000 mL. At the same time, anti-infection, acidosis correction and other treatments were carried out. Fracture fixators and bone traction nails were taken good care of to avoid infection.

In the third stage, as simple external fixation for long periods of time did not promote disease recovery, a series of supervised treatments in the ICU created the conditions for the most appropriate timing of surgery. When the physiological functions of patients gradually recovered, the simple temporary fixation measures were no longer appropriate, for the unstable fixation of fractures had an important impact on the early and long-term prognosis of patients. When the patient was in good condition, he/she would be transferred to the general ward for definitive internal fixation. The third stage was usually performed 3 days after the injury and lasted less than 21 days. Intramedullary fixation or plate external fixation was conducted for patients with combined extremity fractures and rib fractures, anterior or poste-

rior spinal fracture for spinal fractures. Patients with pelvic fracture underwent definitive ultimate internal pelvic fixation bone to reposition and stabilize the anterior and posterior pelvic rings using reconstructive plate and iliosacral screw. Patients in both groups were followed up by telephone and outpatient service for 6 months.

Outcome measures

Main outcome measures: Mortality and "fatal triad": the mortality, incidence of acidosis and hypothermia in the fatal triad three days after surgery were recorded. Mortality rate = (death cases ÷ total cases) *100%.

Surgery-related indexes: time of the first surgery, intraoperative blood transfusion volume, intraoperative blood loss, recovery time of body temperature and length of hospital stay were recorded.

Coagulation function indexes before the first surgery and three days after the surgery: 4 mL venous blood was taken from each patient to centrifuge to obtain the serum, which was then measured with ACL TOP700 full-automatic blood coagulation analyzer (IL, USA), including prothrombin time (PT), thrombin time (TT), activated partial thromboplastin time (APTT) and fibrinogen (FIB).

Reduction of fracture at six months after surgery: based on Matta standard [10]. X-ray examination showing no displacement of fracture was considered as excellent response, X-ray examination showing a displacement of fracture of less than 10 mm was considered as great response, X-ray examination showing a fracture displacement of 10 mm to 20 mm was considered as acceptable response, and X-ray examination showing a fracture displacement of more than 20 mm was considered as poor response. Good rate of reduction = (excellent response + great response)/n *100%.

Complications: the occurrence of patient complications was recorded, including acute respiratory distress syndrome, multiple organ failure, deep vein thrombosis, subcutaneous soft tissue infection, etc. Incidence of complications = (number of cases of complications ÷ total number of cases) *100%.

Secondary outcome measures: Quality of life six months after surgery: 36-Item Short-Form

DCO emergency treatment mode in pelvic fracture with multiple fractures

Table 1. Comparison of general data of the two groups ($\bar{x} \pm sd$, n)

Items	Control group (n=47)	Research group (n=47)	t/ χ^2	P
Gender (male/female)	27/20	25/22	$\chi^2=0.033$	0.855
Age (years)	35.8±2.7	36.3±3.1	t=0.834	0.407
Severity of trauma (ISS score)	37.05±5.18	36.72±4.86	t=0.319	0.750
Causes of injury				
Traffic accident	21	18	$\chi^2=0.394$	0.530
Fall from height	9	9	$\chi^2=0.000$	1.000
Violence	8	7	$\chi^2=0.079$	0.778
Crush or other	9	13	$\chi^2=0.949$	0.330
Fracture type				
Open fracture	29	26	$\chi^2=0.394$	0.530
Closed fracture	18	21	$\chi^2=0.394$	0.530
Combined fracture				
Right femoral shaft fracture, right ulna and radius fracture	7	9	$\chi^2=0.301$	0.583
Right acetabular fracture, right tibia and fibula fracture	11	10	$\chi^2=0.061$	0.804
T ₁₂ vertebral compression fracture, right femoral intertrochanteric fracture	9	8	$\chi^2=0.072$	0.789
Fractures of left femur, left tibia and fibula	9	10	$\chi^2=0.066$	0.797
Fractures of the right tibia and fibula, bilateral calcaneus and others	11	10	$\chi^2=0.061$	0.804
Preoperative hemoglobin concentration (g/L)				
<110	35	37	$\chi^2=0.237$	0.626
≥110	12	10		
Preoperative platelet count (×10 ⁹ /L)				
<100	33	30	$\chi^2=0.433$	0.510
≥100	14	17		

Health Survey (SF-36) was adopted, which includes 8 dimensions with 36 items: physiological function (PF), body pain (BP), role physical (RF), emotional function (EF), social function (SF), mental health (MH), vitality, and general health (GH) [11]. On a scale of 0 to 100, the score was proportional to the quality of life.

Statistical method

SPSS 21.0 was adopted. The measurement data was expressed as mean \pm standard deviation ($\bar{x} \pm sd$). The independent sample t-test was used for comparison between the two groups, the paired sample t-test for intra-group comparison before and after treatment. The counting data was expressed by percentage, and χ^2 test was adopted. The rank sum test was used for ranked data. P<0.05 was considered statistically significant.

Results

General data

There was no significant difference between the two groups in terms of gender, age, severity

of trauma, causes of injury and other general data (P>0.05), suggesting that the two groups of general data were comparable (**Table 1**).

Mortality and "lethal triad"

The incidence of acidosis, hypothermia and mortality three days after surgery in the research group were lower than those in the control group (P<0.05), indicating that the emergency treatment mode of DCO favors acid-base balance, promotes recovery of body temperature, and reduces mortality (**Table 2**).

Surgery-related indexes

Compared with the control group, patients in the research group experienced shorter time of the first surgery, less blood transfusion volume, less intraoperative blood loss, and shorter recovery time of body temperature (P<0.01). The length of hospital stay of 46 patients in the research group was (23.39±3.56) days, while that of 39 patients in the control group was (26.24±4.63) days, which was shorter in the research group than the control group (t=3.223, P=0.001). The above results indicated that the

DCO emergency treatment mode in pelvic fracture with multiple fractures

Table 2. Comparison of mortality and “lethal triad” of the two groups (n, %)

Items	Acidosis	Hypothermia	Total incidence	Mortality
Control group (n=47)	16 (34.04)	18 (38.30)	34 (72.34)	8 (17.02)
Research group (n=47)	4 (8.51)	6 (12.77)	10 (21.28)	1 (2.13)
χ^2	9.146	8.057	24.611	4.424
P	0.002	0.005	<0.001	0.035

Table 3. Comparison of surgery-related indexes of the two groups ($\bar{x} \pm sd$)

Items	First operation time (min)	Blood transfusion (mL)	Intraoperative blood loss (mL)	Body temperature recovery time (h)
Control group (n=47)	158.68±15.78	615.42±129.12	1650.69±368.51	22.21±3.13
Research group (n=47)	135.34±11.02	548.69±98.98	1248.70±321.04	20.51±1.01
t	8.314	2.812	5.639	3.544
P	<0.001	0.006	<0.001	0.001

emergency treatment mode of DCO is beneficial to shortening surgery time, reducing intraoperative blood loss, promoting the recovery of postoperative body temperature, and shortening the length of hospital stay (**Table 3** and **Figure 1**).

Coagulation function indexes

Before surgery, there was no significant difference between the two groups in terms of coagulation function ($P>0.05$). Seven days after surgery, PT, TT and APTT decreased while FIB increased in both groups. Moreover, PT, TT and APTT in the research group were lower than those in the control group, while FIB was higher than that in the control group ($P<0.001$). The above results suggested that the emergency treatment mode of DCO can help improve the coagulation function of patients (**Table 4** and **Figure 2**).

Reduction of fractures after surgery

The good rate of reduction in the research group was higher than that in the control group ($P=0.025$), indicating that the emergency treatment mode of DCO promotes the reduction of fractures after surgery (**Table 5**).

Incidence of complications

The incidence of complications in the research group was lower than that in the control group ($P=0.049$), indicating that the emergency treatment mode of DCO is helpful in reducing the incidence of complications (**Table 6**).

Quality of life

Six months after surgery, the scores of PF, BP, RP, EF, SF, vitality and GH of the research group were higher than those of the control group ($P<0.001$), but there was no significant difference in MH between the two groups ($P>0.05$), suggesting that the emergency treatment mode of DCO improves the quality of life of patients (**Table 7**).

Discussion

Acidosis, hypothermia and coagulation disorders are three prominent clinical manifestations of pelvic fracture complicated with multiple fractures, namely “lethal triad” [12]. Acute and massive blood loss due to fracture trauma, prolonged exposure of some of the limbs and organs and tissues during surgery, coupled with early resuscitation with large amounts of cold fluids and intraoperative fluid infusion, will easily lead to a rapid decline in body temperature [13]. When the patient suffers from hypothermia, the immune function of the body will be weakened, which in turn inhibits the synthesis of collagen fibers and increases the consumption of protein, reduces the contraction of peripheral blood vessels, and increases the circulation resistance, further aggravating the development of shock [14]. In addition, intraoperative hypothermia can also reduce the number of platelets in the body, activate the fibrinolytic system, reduce the activity of coagulation substances, and aggravate the risk of bleeding [15]. This process is exacerbated by coagulopa-

DCO emergency treatment mode in pelvic fracture with multiple fractures

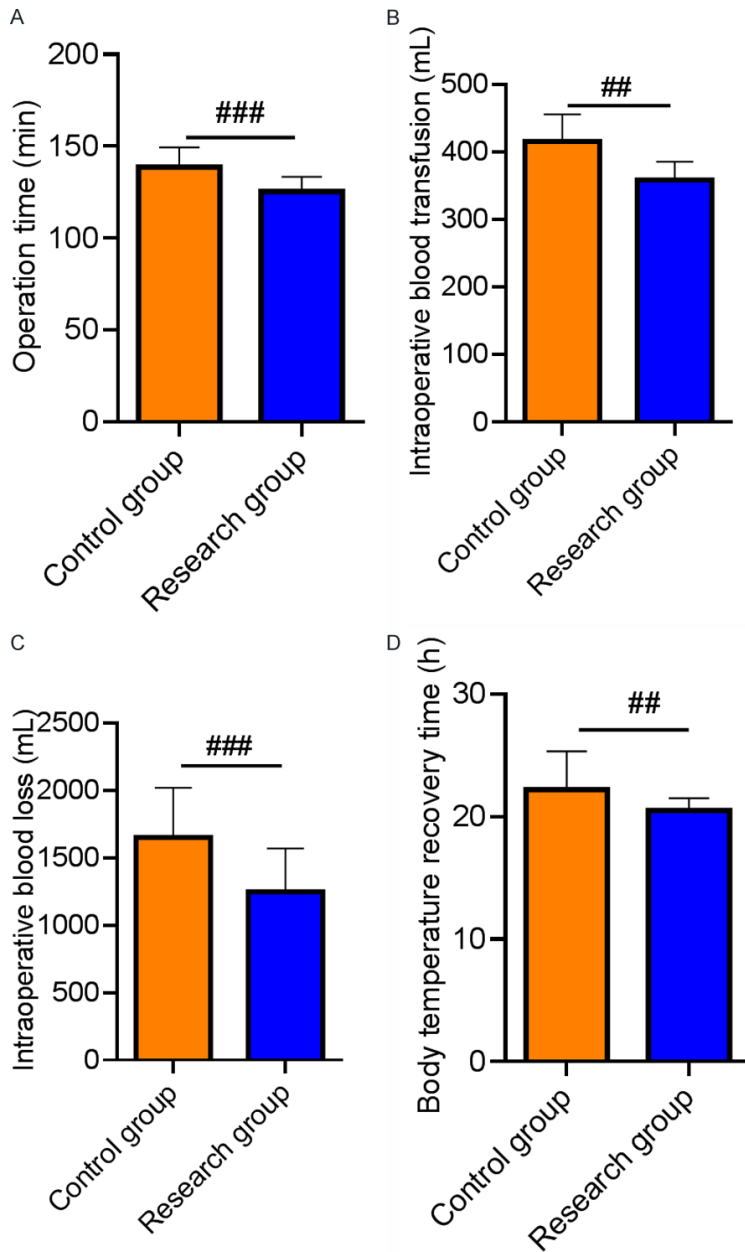


Figure 1. Comparison of related indexes of two groups of surgery. A: Operation time (min); B: Intraoperative blood transfusion (mL); C: Body temperature recovery time (h); D: Hospitalization time (d). Compared with the control group, ## $P < 0.01$, ### $P < 0.001$.

thy and early hemodilution caused by massive blood transfusion, making it more likely to lead to uncontrollable hemorrhage, which is extremely life-threatening [16]. Furthermore, the deviation of oxygen dissociation curve of hemoglobin at low temperature makes it difficult for oxygen carried in blood to be released into the interstitial space, causing the tissue cells to breathe anaerobically without oxygen supply,

and this process will produce a large amount of lactic acid, thus leading to acidosis [17]. In addition, trauma will increase the secretion of inflammatory factors and produce inflammatory reaction, and surgical intervention at inopportune times can exacerbate the systemic inflammatory response and worsen the condition. Therefore, the treatment opportunity and surgery choice for pelvic fracture complicated with multiple fractures are the key to improving the cure rate and prognosis.

Conventional early complete treatment does not take all of these factors above into account and therefore may increase the risk of a life-threatening “fatal triad”. Besides, due to the seriously deteriorated physiological function level of patients with pelvic fractures complicated with multiple fractures, doctors are not allowed to focus too much on the treatment of fractures in this condition, which will lead to the relative indiscretion of conventional early complete treatment in terms of fractures, resulting in delayed reduction and recovery after surgery, and greatly increased risk of complications [18]. On the basis of simplified treatment of early surgery and ICU resuscitation, the concept of DCO can help patients recover their physiological functions, and then definitive surgery can be

performed on fractures, so that patients can keep the best condition for surgery as much as possible, promote the success of reduction of fracture, and reduce related complications. The results of this study showed that compared with the control group, the research group had lower incidence of acidosis and hypothermia three days after surgery, better postoperative reduction of fracture, lower incidence of compli-

DCO emergency treatment mode in pelvic fracture with multiple fractures

Table 4. Comparison of coagulation function of the two groups ($\bar{x} \pm sd$)

Items	Control group (n=39)	Research group (n=46)	t	P
PT (t/s)				
Preoperative	16.25±1.35	16.38±1.32	0.448	0.656
Seven days after surgery	14.12±1.21***	11.21±1.39***	10.200	<0.001
TT (t/s)				
Preoperative	22.06±1.46	22.17±1.49	0.065	0.948
Seven days after surgery	18.14±2.04***	14.54±1.89***	8.438	<0.001
APTT (t/s)				
Preoperative	33.52±2.25	33.38±2.32	0.281	0.779
Seven days after surgery	26.52±2.31***	22.41±2.46***	7.892	<0.001
FIB (p/gL ⁻¹)				
Preoperative	1.85±0.71	1.76±0.83	0.532	0.596
Seven days after surgery	2.33±0.49***	3.07±0.40***	7.666	<0.001

Note: Compared with the same group before surgery, ***P<0.001. PT: prothrombin time; TT: thrombin time; APTT: activated partial thromboplastin time; FIB: fibrinogen.

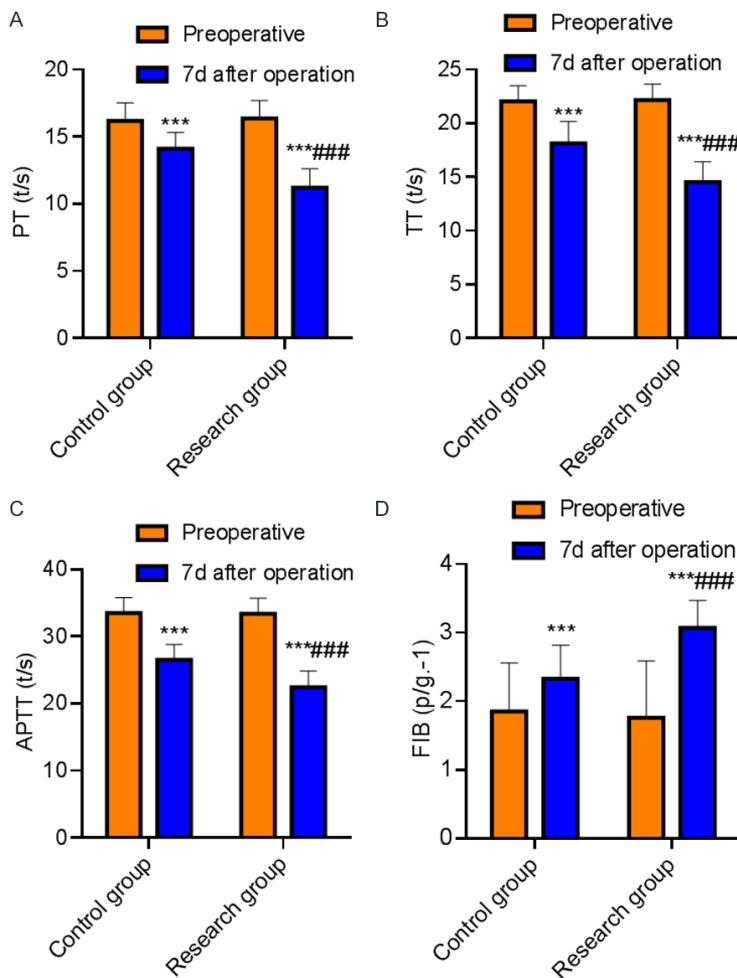


Figure 2. Comparison of coagulation function between the two groups. A: PT (t/s); B: TT (t/s); C: APTT (t/s); D: FIB (p/gL⁻¹). Compared with this group before operation, ***P<0.001; compared with the control group, ####P<0.001. PT: prothrombin time; TT: thrombin time; APTT: activated partial thromboplastin time; FIB: fibrinogen.

cations, and lower mortality, suggesting that the emergency treatment mode of DCO could effectively promote the acid-base balance and body temperature recovery of patients, so as to keep the optimal condition for surgery, thereby reducing the mortality and incidence of complications, and promoting postoperative reduction of fracture. The team of Wang Shan'an supported that the application of DCO concept can improve the good rate of reduction and reduce complications in the treatment of unstable pelvic fractures complicated with multiple fractures of limbs [19]. The team of Luo indicated that damage control can significantly improve the survival rate of patients, improve the good rate of reduction, reduce complications and improve the prognosis of patients, which is also consistent with the results of this study [20]. Since trauma can lead to severe systemic reaction and certain immunosuppression, and this kind of inflammatory reaction often occurs 3-5 days after trauma, if surgery is performed during this period, such secondary

DCO emergency treatment mode in pelvic fracture with multiple fractures

Table 5. Comparison of reduction of fracture after surgery of the two groups (n, %)

Items	Excellent	Great	Acceptable	Poor	Good rate
Control group (n=39)	15 (38.46)	11 (28.21)	8 (20.51)	5 (12.82)	26 (66.67)
Research group (n=46)	22 (47.83)	18 (39.13)	4 (8.70)	2 (4.35)	40 (86.96)
χ^2/Z		Z=3.156			$\chi^2=5.006$
P		0.027			0.025

Table 6. Comparison of incidence of complications of the two groups (n, %)

Items	Acute respiratory distress syndrome	Multiple organ failure	Deep vein thrombosis	Subcutaneous soft tissue infection and others	Total incidence
Control group (n=39)	3 (7.69)	2 (5.13)	1 (2.56)	2 (5.13)	8 (20.51)
Research group (n=46)	1 (2.17)	0 (0.00)	0 (0.00)	1 (2.17)	2 (11.63)
χ^2	0.467	0.699	0.007	0.021	3.870
P	0.495	0.403	0.934	0.884	0.049

Table 7. Comparison of quality of life of the two groups ($\bar{x} \pm sd$, score)

Items	Control group (n=39)	Research group (n=46)	t	P
Physiological function	68.68±7.21	75.51±8.63	3.917	<0.001
Body pain	54.89±7.35	65.41±8.01	6.265	<0.001
Role physical	67.17±7.67	75.87±8.28	4.992	<0.001
Emotional function	60.25±7.85	68.68±8.37	4.760	<0.001
Social function	66.36±7.51	74.65±8.30	4.792	<0.001
Mental health	66.84±7.32	68.37±7.45	0.951	0.344
Vitality	68.41±7.86	76.53±8.56	4.523	<0.001
General health	66.61±7.32	75.12±8.68	4.835	<0.001

trauma is likely to peak the inflammatory response, resulting in acute respiratory distress syndrome or multiple organ failure. At the same time, secondary trauma may prolong the time of bleeding control, which may lead to hemorrhagic shock [21, 22]. In addition to the "fatal triad" mentioned above, the first-aid personnel in DCO actively coordinate with the principle of "saving lives first and treating diseases later" and strengthen the treatment and nursing intervention of all links in the early stage of trauma, taking the patient's life as their primary task of surgery, followed by pelvis and limbs. Compared with the conventional early complete treatment strategy, this concept is more conducive to improving the treatment rate, promoting smooth surgery, and reducing the risk of complications.

Besides, since severe acute hemorrhage is one of the main causes of death, in order to control

hypovolemic shock caused by massive bleeding as quickly as possible, the clinician will often give the patient a large amount of blood or other fluids to rapidly replenish the blood volume, which in turn may cause hypothermia. One study has pointed out that keeping blood pressure at an allowable low level by limiting the amount of fluid intake plays an important role in delaying the deterioration of patients' physiological level and complication control [23]. The American College of

Surgeons also reduced the recommended dose of fluid resuscitation from 2000 ml to 1000 ml, and recommended the use of blood and blood products for early control of coagulopathy [24]. The results of this study showed that the blood transfusion volume in the research group was less than that in the control group, the recovery time of postoperative body temperature was shorter than that in the control group, and the improvement of coagulation function was better than that in the control group, which also confirmed this view. Research by Li YC et al. pointed out that DCO has a positive effect on the improvement of coagulation function in patients with unstable pelvic fractures complicated with multiple fractures of limbs, which is consistent with the results of this study [25]. Besides, the time of the first surgery and length of hospital stay in the research group were shorter than those in the control group, which indicated that the intervention measures in

DCO emergency treatment mode in pelvic fracture with multiple fractures

each link can effectively shorten the surgery time and greatly improve the prognosis of patients. After a 6-month follow-up, it was found that the quality of life of the research group was significantly higher than that of the control group, which indicated that the emergency treatment mode of DCO plays a positive and important role in the long-term prognosis of patients and makes great contributions to social benefits. However, it is worth noting that the patients must be comprehensively evaluated before the implementation of DCO measures to determine whether the patient's condition requires emergency treatment for orthopedic injury control. It is suggested that patients with "fatal triad" or rapid decline in physiological function, such as a combination of vascular or visceral injury, or an ISS score higher than 35, can be considered for DCO emergency treatment.

To sum up, the emergency treatment mode of DCO has a significant effect in treating pelvic fracture complicated with multiple fractures, which can effectively improve the postoperative reduction of patients, improve the coagulation function, reduce complications, and improve the quality of life. However, due to the small sample size of this study, there may be bias in the results. In the future, the clinical research scale can be expanded for in-depth discussion.

Disclosure of conflict of interest

None.

Address correspondence to: Yong Zhang, Department of Orthopedics, First Hospital of Quanzhou Affiliated to Fujian Medical University, No.1028 Anji South Road, Quanzhou 362000, Fujian Province, China. Tel: +86-15805000813; E-mail: zhangyong8t7@163.com

References

- [1] Ghosh S, Aggarwal S, Kumar V, Patel S and Kumar P. Epidemiology of pelvic fractures in adults: our experience at a tertiary hospital. *Chin J Traumatol* 2019; 22: 138-141.
- [2] Bába V, Klimeš J, Tolar V, Zimola P, Balliu I, Vitvarová I, Lásková H, Džupa V, Grivna M and Čelko AM. A 1-year prospective monocentric study of limb, spinal and pelvic fractures: can monitoring fracture epidemiology impact injury prevention programmes? *Cent Eur J Public Health* 2018; 26: 298-304.
- [3] Martínez F, Alegret N, Carol F, Laso MJ, Zancajo J, García E and Ros V. Pelvic fracture in the patient with multiple injuries: factors and lesions associated with mortality. *Emergencias* 2018; 30: 91-97.
- [4] Huang GB, Hu P, Gao JM and Lin X. Analysis of early treatment of multiple injuries combined with severe pelvic fracture. *Chin J Traumatol* 2019; 22: 129-133.
- [5] Höch A, Pieroh P, Gras F, Hohmann T, Märdian S, Holmenschlager F, Keil H, Palm HG, Herath SC, Josten C, Schmal H and Stuby FM. Age and "general health"-beside fracture classification-affect the therapeutic decision for geriatric pelvic ring fractures: a german pelvic injury register study. *Int Orthop* 2019; 43: 2629-2636.
- [6] Yano S, Aoki Y, Watanabe A, Nakajima T, Takazawa M, Hirasawa H, Takahashi K, Nakagawa K, Nakajima A, Takahashi H, Orita S, Eguchi Y, Suzuki T and Ohtori S. Less invasive lumbopelvic fixation technique using a percutaneous pedicle screw system for unstable pelvic ring fracture in a patient with severe multiple traumas. *J Neurosurg Spine* 2017; 26: 203-207.
- [7] Zhou Y, Guo H, Cai Z and Zhang Y. Complex pelvic ring injuries associated with floating knee in a poly-trauma patient: a case report. *Medicine (Baltimore)* 2017; 96: e8783.
- [8] Fu CY, Huang RY, Wang SY, Liao CH, Huang JF, Hsu YP, Lin CY and Kang SC. Concomitant external and internal hemorrhage: challenges to managing patients with open pelvic fracture. *Am J Emerg Med* 2018; 36: 1937-1942.
- [9] Moiroud CH, Coudry V and Denoix JM. Outcome of pelvic fractures identified in 75 horses in a referral centre: a retrospective study. *Vet Comp Orthop Traumatol* 2019; 32: 274-281.
- [10] Yang XS, Wang Y, Li XJ and Chen SN. A evaluation of validity and reliability on chinese version of the SF-36 survey scales. *Prog Anatomical Sci* 2009; 15: 383-385.
- [11] Mulder MB, Maggart MJ, Yang WJ, Perez EA, Namias N, Sola JE, Proctor KG and Thorson CM. Outcomes of pediatric pelvic fractures: a level I trauma center's 20-year experience. *J Surg Res* 2019; 243: 515-523.
- [12] Bott A, Odutola A, Halliday R, Acharya MR, Ward A and Chesser TJS. Long-term patient-reported functional outcome of polytraumatized patients with operatively treated pelvic fractures. *J Orthop Trauma* 2019; 33: 64-70.
- [13] Scott B, Taylor B, Shung JR and Nimityongskul P. Bilateral femoral neck fractures associated with complex pelvic ring injuries in a pediatric patient: a case report. *J Pediatr Orthop B* 2017; 26: 350-357.
- [14] Hermans E, Brouwers L, van Gent T, Biert J, de Jongh MAC, Lansink KWW and Edwards MJR. Quality of life after pelvic ring fractures: long-

DCO emergency treatment mode in pelvic fracture with multiple fractures

- term outcomes. A multicentre study. *Injury* 2019; 50: 1216-1222.
- [15] Cho J, Benjamin E, Inaba K, Lam L and Demetriades D. Severe bleeding in pelvic fractures: considerations in planning damage control. *Am Surg* 2018; 84: 267-272.
- [16] Maertens AS, Martin MP 3rd, Dean CS, Rojas D, Parry JA, Maher M and Mauffrey CP. Occult injuries of the contralateral sacroiliac joint in operatively treated pelvis fractures: incidence, root cause analysis, and proposal of treatment algorithm. *Int Orthop* 2019; 43: 2399-2404.
- [17] Sharpe JP, Magnotti LJ, Gobbell WC, Huang X, Perez EA, Fabian TC and Croce MA. Impact of early operative pelvic fixation on long-term self-reported outcome following severe pelvic fracture. *J Trauma Acute Care Surg* 2017; 82: 444-450.
- [18] Almahmoud K, Pfeifer R, Al-Kofahi K, Hmedat A, Hyderabad W, Hildebrand F, Peitzman AB and Pape HC. Impact of pelvic fractures on the early clinical outcomes of severely injured trauma patients. *Eur J Trauma Emerg Surg* 2018; 44: 155-162.
- [19] Wang SA, Qi SP, Bai Y, Zhang DB and Yang YG. Application of damage control in the treatment of unstable pelvic fracture complicated with multiple fractures of limbs. *Prac J Clin Med* 2019; 16: 149-151.
- [20] Luo CD, Chen SQ and Liang ZM. Analysis of the effect of damage control in emergency treatment of pelvic fractures with multiple fractures. *Chin Prac Med* 2020; 15: 29-31.
- [21] Esmer E, Esmer E, Derst P, Schulz M, Siekmann H and Delank KS. Influence of external pelvic stabilization on hemodynamically unstable pelvic fractures. *Unfallchirurg* 2017; 120: 312-319.
- [22] Hsu JM, Yadev S and Faraj S. Controlling hemorrhage in exsanguinating pelvic fractures: utility of extraperitoneal pelvic packing as a damage control procedure. *Int J Crit Illn Inj Sci* 2016; 6: 148-152.
- [23] Kalinterakis G, Koutras A, Syllaios A, Michalakeas N, Lytras D and Tsilikis I. The evolution and impact of the "Damage Control Orthopedics" paradigm in combat surgery: a review. *Eur J Orthop Surg Traumatol* 2019; 29: 501-508.
- [24] Gilbert F, Schneemann C, Scholz CJ, Kickuth R, Meffert RH, Wildenauer R, Lorenz U, Kellersmann R and Busch A. Clinical implications of fracture-associated vascular damage in extremity and pelvic trauma. *BMC Musculoskeletal Disord* 2018; 19: 404.
- [25] Li YC, Liu Y and Huang B. Influence on coagulation function and the therapy effect of damage control orthopaedics for unstable pelvic fractures and multiple fractures of extremities. *Zhongguo Gu Shang* 2017; 30: 198-201.