Management of a patient with cardiac arrest, intestinal ischemia necrosis, multiple fractures, hemorrhagic shock, renal failure, disseminated intravascular coagulation, and thrombosis after severe abdominal crush injury: A case report

XIAOKUN YANG[1*], NAN TANG[2*], LE LI[1], GUISEN XU[1], JUAN DAI[1], KAI TAO[1], CHUNYANG HE[3] and CHAOJI HUANGFU[4]

[1]Department of Emergency Medicine, The General Hospital of Western Theater Command, Chengdu, Sichuan 610083; [2]School of Nursing, Lanzhou University, Lanzhou, Gansu 730010; [3]Department of Hyperbaric Oxygenation Medicine, The General Hospital of Western Theater Command, Chengdu, Sichuan 610083; [4]Center for Disease Control and Prevention, Western Theater Command, Lanzhou, Gansu 730020, P.R. China

Received December 28, 2021; Accepted March 28, 2022

DOI: 10.3892/etm.2022.11313

Abstract. Abdominal crush injury has been widely reported. However, abdominal crush injury cases involving most of the organ systems have seldom been reported. In the present case report, a 58-year-old man was hit in the abdomen by a 4-ton machine tool. The case described a rare combination of cardiac arrest, intestinal ischemia necrosis, multiple fractures, hemorrhagic shock, renal failure, disseminated intravascular coagulation and thrombosis after severe abdominal crush injury. During the treatment, crush syndrome, anemia, electrolyte disorder, pleural effusion, pulmonary emphysema, compartment syndrome, respiratory failure, pulmonary hemorrhage, injury of the right common peroneal nerve and tibial nerve, septum abscess and malnutrition were also observed. Systemic and symptomatic treatments were performed for >3 months, after which the patient was discharged from hospital without any further risk of fatality. The related treatments were also described in detail in the present case report. This case represented one of the most complicated cases among abdominal crush injuries that have been reported, and the treatment experiences reported here will hopefully provide suitable reference points for similar cases.

Correspondence to: Dr Chaoji Huangfu, Center for Disease Control and Prevention, Western Theater Command, 509 Donggangdong Road, Lanzhou, Gansu 730020, P.R. China
E-mail: hfcj0370@foxmail.com

Dr Kai Tao, Department of Emergency Medicine, The General Hospital of Western Theater Command, 270 Tianhui Road, Chengdu, Sichuan 610083, P.R. China
E-mail: taokai08@163.com

*Contributed equally

Abbreviations: CS, crush syndrome; CRRT, continuous renal replacement therapy; TCA, traumatic cardiac arrest

Key words: abdominal crush injury, cardiac arrest, intestinal ischemia necrosis, hemorrhagic shock, renal failure, thrombosis

Introduction

Severe abdominal crush injury may affect several organ systems, including the musculoskeletal, urological, cardiovascular, integumentary and digestive (1,2). Every system that is damaged by severe abdominal crush injury could potentially be fatal. A previously published study indicated that only 10.6% of patients with traumatic cardiac arrest, who were transported to UK hospitals in Afghanistan and Iraq, survived (3). It has also been reported that crush syndrome (CS) and acute kidney injury are two major causes of death following earthquakes (1). Furthermore, mesenteric laceration may lead to severe bleeding, resulting in hemorrhagic shock and multiple organ failure (4). The fracture caused by an abdominal crush injury may lead to arterial hemorrhage, which further results in hemorrhagic shock. In the present case report, the case of a 58-year-old man suffering from a severe abdominal crush injury is reported. The total diagnosis of the patient comprised cardiac arrest, intestinal ischemia necrosis, multiple fractures, hemorrhagic shock, disseminated intravascular coagulation (DIC) and thrombosis. His treatment experience is presented in detail.

Case report

A 58-year-old man was hit in the abdomen by a 4-ton machine tool at 10:00 a.m. on July 27, 2020. The patient experienced abdominal pain after injury accompanied by consciousness disturbance. On admission to the Department of Emergency Medicine, The General Hospital of Western Theater Command (Chengdu, China), his blood pressure was 86/48 mmHg, heart

rate was 114 beats/min, breathing was 24 times/min, demeanor was irritable, right lower limb was pale, skin temperature was low and pelvic tenderness was notable. He had a sensitive light reflection, regular heart rhythm and labored breathing. The patient was initially treated with rehydration, hemostasis and acid suppression. A bedside ultrasound revealed intraperitoneal effusion. Ultrasound-guided diagnostic abdominal paracentesis was applied and blood without coagulation was observed. Fractures of the pelvis (Fig. 1A and B) and the 4th and 5th lumbar vertebra transverse process (Fig. 1C and D) were observed via chest and abdomen computed tomography (CT). Blood biochemical parameters were measured and are presented in Table I. The levels of D-dimer and creatine kinase were found to be significantly increased.

At 13:45 p.m. on July 27, 2020, under general anesthesia, suture and ligation of multiple abdominal bleeding vessels, repair of the mesentery of the small intestine, multiple small bowel resection, enterostomy, implantation of a distal small intestinal nutrition tube, ascending colon anastomosis of the small intestine, ileocecal resection, debridement and repair of an abdominal wall defect, and artificial vascular replacement of the abdominal aorta and common iliac artery were performed (Fig. 2A). During the operation, a number of small intestinal mesenteric lacerations with hemorrhage, multiple segments of small intestine ischemia necrosis (Fig. 2B), small intestine rupture, and abdominal aorta, and common iliac artery calcification with thrombosis were observed. The ileocecal region and the adjacent region of the small intestine were shown to be ischemic and necrotic; the proximal small intestine was congested and edematous, and there was no pulsation in the right common iliac artery. The blood loss during the operation was ~3,000 ml, and 1,220 ml plasma, 10 units of red blood cell suspension and 20 units of cryoprecipitate were transfused into the patient.

The patient with tracheal intubation was placed in an emergency intensive care unit after the operation. At 21:10 p.m. on July 27, 2020 (2 h after surgery), the patient presented with ventricular fibrillation and was breathing at a rate of 6 breaths/min. Immediate biphasic wave electric defibrillation (200 J) was performed, although the patient did not recover their sinus rhythm. The electrocardiogram showed that the heart rate of the patient continued to drop to zero at 21:11 p.m., and chest compression was performed. The patient was intravenously injected with epinephrine hydrochloride at regular intervals (1 mg every 5 min). Continuous chest compression and electric defibrillation were maintained. At 21:25 p.m., the heart rate of the patient recovered. Epinephrine (1 mg) was injected every 5 min and repeated 2 times. Subsequently, the patient was treated with a combination of cefoperazone sulbactam sodium and ornidazole, as an anti-infection agent, and low molecular weight heparin (100 IU/kg; administered once every 12 h) as an anticoagulation agent, in addition to receiving treatment for acid suppression, an albumin supplement, and a blood transfusion. Treatment with low molecular weight heparin was discontinued during episodes of hemoptysis and lower gastrointestinal bleeding. When the bleeding was stable in the later stages, the patient received antiplatelet drugs (clopidogrel tablets; 75 mg/day) as anticoagulants on September 2, 2020.

On July 28, 2020 (the 2nd day after the operation), the urine of the patient was brown and the urine volume decreased notably. The level of myoglobin increased to 166,094 μg/l, whereas that of creatine kinase increased to 150,185 IU/l (data not shown). Acute kidney damage caused by CS was also observed. Continuous renal replacement therapy (CRRT) treatment was applied to the patient from July 28, 2020. Anuria was found on July 29, 2020 (i.e., the 3rd day after the operation). CRRT was performed for a total of 273 h during hospitalization of the patient. The urine volume began to increase on September 28, 2020 (63 days after the operation), with >100 ml/24 h produced. Subsequently, the volume of urine continued to increase, such that the urine volume rose to >400 ml/24 h from October 12, 2020 onwards (i.e., 77 days after the operation).

On July 28, 2020 (the 2nd day after the operation), the patient developed osteofascial compartment syndrome in the right leg and underwent open decompression. On August 2, 2020 (the 6th day after the operation), the patient received enteral nutrition solution, although the patient experienced diarrhea. On August 9, 2020 (the 13th day after the operation), lower gastrointestinal bleeding occurred and enteral nutrition was stopped. A colonoscopy revealed the presence of bright red blood (100 ml) and necrotic tissue in the rectal cavity (Fig. 3A), which blocked the lumen such that the endoscope could not pass through. During the laparotomy, the rectal mucosa was necrotic and exfoliated, measuring ~5 cm in length. Gauze packing was used for hemostasis. The intraoperative blood loss was ~200 ml, and the patient was infused with 4 units of red blood cell suspension.

On August 13, 2020 (the 17th day after the operation), the patient experienced sudden pulmonary hemorrhage with hemoptysis (breathing rate, 22 times/min; heart rate, 101 beats/min; blood pressure, 149/79 mmHg and oxygen saturation, 99%). A total of 12 units of posterior pituitary injection was injected intravenously. After 2 h, the patient still had hemoptysis with increased volume, and the oxygen saturation was decreased to 92%. Blood transfusion was immediately conducted, and a pulmonary angiography was performed. A thickening of the bronchial and intercostal arteries was observed (Fig. 2C). with enlarged and disordered bronchial and intercostal arteries. Polyvinyl alcohol embolization granules PVA-500 was used to stop the bleeding. After the operation, the patient still had repeated episodes of hemoptysis and therefore he was treated with diazepam (10 mg), batroxobin (3 IU) for hemostasis, acid inhibition, somatostatin for suppression of intestinal secretion, continuous infusion of posterior pituitary hormone, human prothrombin complex (200 IU), human fibrinogen (0.5 g), and a blood transfusion. Following these therapeutic interventions, hemoptysis was notably reduced and the vital signs of the patient were stable.

At 9:50 a.m. on August 18, 2020 (the 22th day after the operation), the patient discharged a large amount of blood stool, and was found to be in a state of shock. Emergency blood transfusion was performed. At 13:51 p.m., a colonoscopy was performed. Numerous blood clots and blood were found in the intestinal cavity (Fig. 3B). Blood scabs were widely attached to the intestinal wall. The rectal mucosa was observed to be swollen and ulcerated locally. At ~1 cm away from the anus, pulsatile bleeding was found in the rectum. A titanium clip was used to stop the bleeding; however, the patient's anemia was severe, and intermittent blood transfusion was performed.

Table I. Blood biochemical parameters (27/7/2020).

Parameters	Values	Normal values	Changing trend
Glucose, mmol/l	15.6	3.3-6.1	↑
Lactic acid, mmol/l	2.8	0.4-2.2	↑
White blood cell, $x10^9$/l	20.42	4-10	↑
Hemoglobin, g/l	95	120-160	↓
Platelet, $x10^9$	167	100-300	NC
Neutrophil percentage, %	89.5	50-70	↑
Uric acid, μmol/l	619	100-432	↑
Albumin, g/l	28.7	40-55	↓
Creatine kinase, IU/l	5976.5	25-175	↑
Lactate dehydrogenase, IU/l	341.3	95-245	↑
Fibrinogen, g/l	1.87	2-4	NC
D-dimer, mg/l	25.09	0.00-0.55	↑

NC, no change.

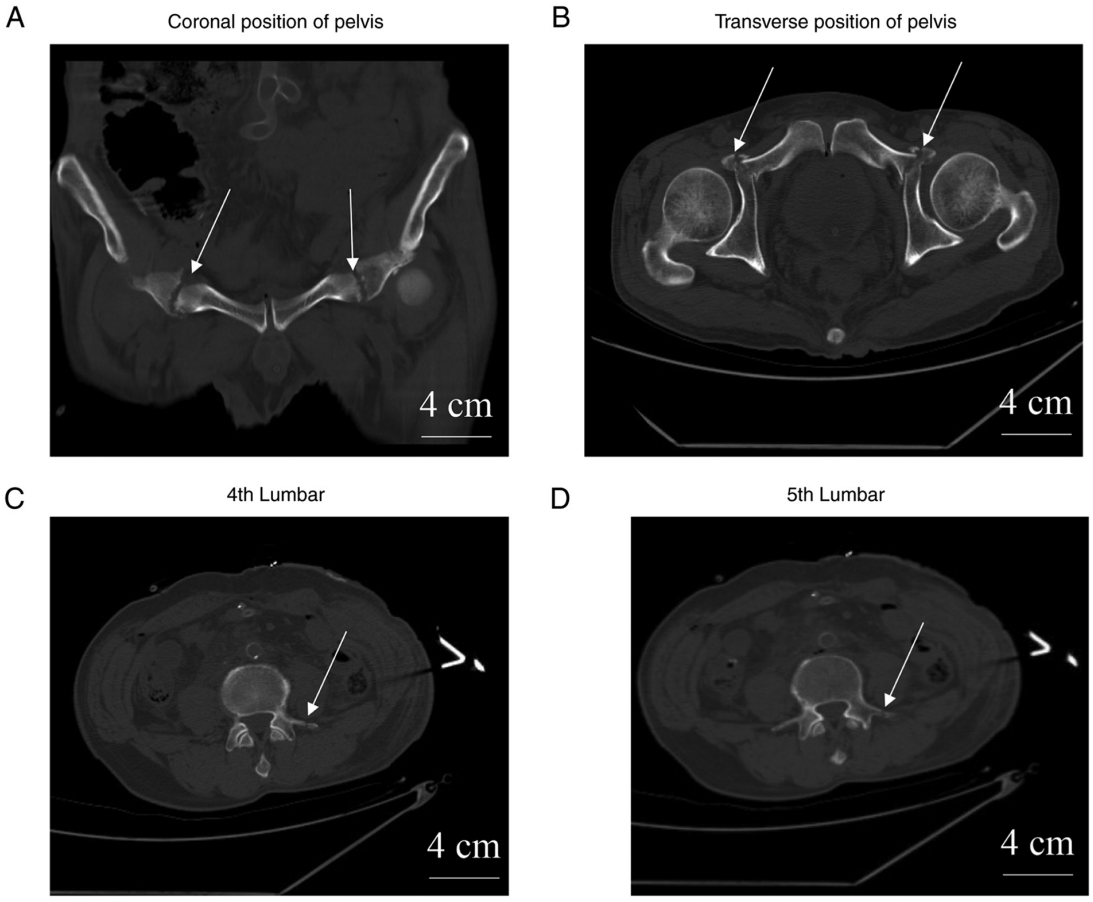

Figure 1. Computed tomography scan shows the fractures of pelvis and the 4th and 5th lumbar. (A) Coronal position of the pelvis fracture. (B) Transverse position of the pelvis fracture. (C) Fracture of the 4th lumbar. (D) Fracture of the 5th lumbar. White arrows indicate the fracture points.

On August 25, 2020 (the 29th day after the operation), a colonoscopy examination was performed. Active bleeding was found in the rectal cavity, and the rectal mucosa was congested and swollen (Fig. 3C). A titanium clip could be seen ~5 cm away from the anus, and another active bleeding point was observed 5 cm from the anus. An attempt was made to use another titanium clip for the hemostasis, although the hemostatic effects were not good. Therefore, a thrombin injection was administered to the patient for hemostasis under endoscopy, and the active bleeding was significantly reduced as a result of this treatment. Thrombus attachments in the deep venous catheter of the left femoral vein and right internal

Table II. Blood biochemical profile (26/10/2020).

Parameters	Values	Normal values	Changing trend
Red blood cell, $x10^{12}$	2.90	4-5.5	↓
Hemoglobin, g/l	93	120-160	↓
Hematocrit, %	27.9	40-50	↓
B-type natriuretic peptide, pg/ml	131.82	0-100	↑
Neutrophil percentage, %	75.8	50-70	↑
Myoglobin, μg/l	117.64	3-110	↑
Fibrinogen, g/l	4.45	2-4	↑
Retinol binding protein, mg/l	142.9	36-72	↑
5'-ribonucleotide hydrolase, U/l	127.2	0-10	↑
Total bile acid, μmol/l	16.8	0-12	↑
Alkaline phosphatase, IU/l	859.8	45-125	↑
γ-glutamyl transferase, IU/l	751.4	10-60	↑
Glutamic oxaloacetic transaminase, IU/l	79.8	15-45	↑
Alanine aminotransferase, IU/l	209.7	9-60	↑
Potassium, mmol/l	3.36	3.5-5.3	↓
Sodium, mmol/l	134.2	137-147	↓
Chlorine, mmol/l	90.8	99-110	↓
Phosphorus, mmol/l	2.02	0.6-1.6	↑
Carbon dioxide binding rate, mmol/l	31.1	21-28	↑
Urea, mmol/l	11.06	2.9-7.2	↑
Creatinine, μmol/l	308	44-133	↑
High sensitivity C-reactive protein, mg/l	7.62	0-3	↑
Procalcitonin, ng/ml	0.4	0.00-0.05	↑

jugular vein were observed using color doppler ultrasound. Anti-platelet aggregation therapy (treatment with clopidogrel, 75 mg) was initiated on September 2, 2020 (the 37th day after operation).

On September 9, 2020 (the 44th day after the operation), the patient was diagnosed with nasal septal abscess and underwent incision and drainage. On September 14, 2020 (the 49th day after the operation), no rectal bleeding was observed, as determined from colonoscopy. During hospitalization, the patient received 60.5 units of red cell suspension, 62.1 units of plasma, 10 units of platelets, 60 units of cryoprecipitate (60 units equate to 1,800 ml cryoprecipitate coagulation factor) and 1,600 ml human albumin (20%).

On November 1, 2020 (the 97th day after the operation), the patient was discharged from hospital. The patient was in good spirits and was sleeping well. No bloody stools, abdominal distension, palpitations, chest tightness or other discomforts were found. The urine volume was 1,300 ml/24 h. The patient was, however, emaciated. The breath sounds of both lungs were thick. No obvious dry or wet rales were heard. The abdomen was in a soft state, without notable tenderness. The small intestine nutrition tube was fixed in its original place. Muscle atrophy of both lower limbs, hypoesthesia of the right lower limbs and a muscle strength of ~3 grades were found. A pelvis CT was performed on October 24, 2020 (the 89th day after the operation). Fractures were observed in the left transverse processes of the 4th and 5th lumbar vertebra, bilateral acetabulum, bilateral pubic superior and inferior branches. The broken ends were slightly dislocated, and a small callus was formed. In addition, multiple calcifications in the abdominal aortic wall and a small amount of effusion in the pelvic cavity were observed. Color Doppler ultrasound revealed the formation of atherosclerotic plaques in the bilateral external iliac arteries and right lower extremity arteries. The results of the routine blood tests are shown in Table II.

In conclusion, the patient was diagnosed with the following conditions: i) hemorrhagic shock; ii) cardiac arrest; iii) ischemia, necrosis and rupture of the ileocecal region and multiple segments of the small intestine; iv) thrombosis of the common iliac artery; v) CS; vi) multiple organ dysfunction; vii) lower gastrointestinal bleeding; viii) pulmonary hemorrhage; ix) fractures of the pelvis, sacrum, the 4th and 5th lumbar vertebrae, and the ribs; x) DIC; xi) bilateral pleural effusion and bilateral pulmonary emphysema and xii) compartment syndrome of the right leg.

Discussion

Cases of blunt abdominal trauma have been reported previously. However, most of these cases have reported no more than three types of diagnoses and the treatments involved were relatively simple. In one such example, a 4-year-old boy was run over by a car, sustaining blunt abdominal trauma. Transrectal small bowel evisceration was performed for this boy, and he was discharged from hospital on the 9th postoperative day with bed rest (4). Patients with traumatic cardiac

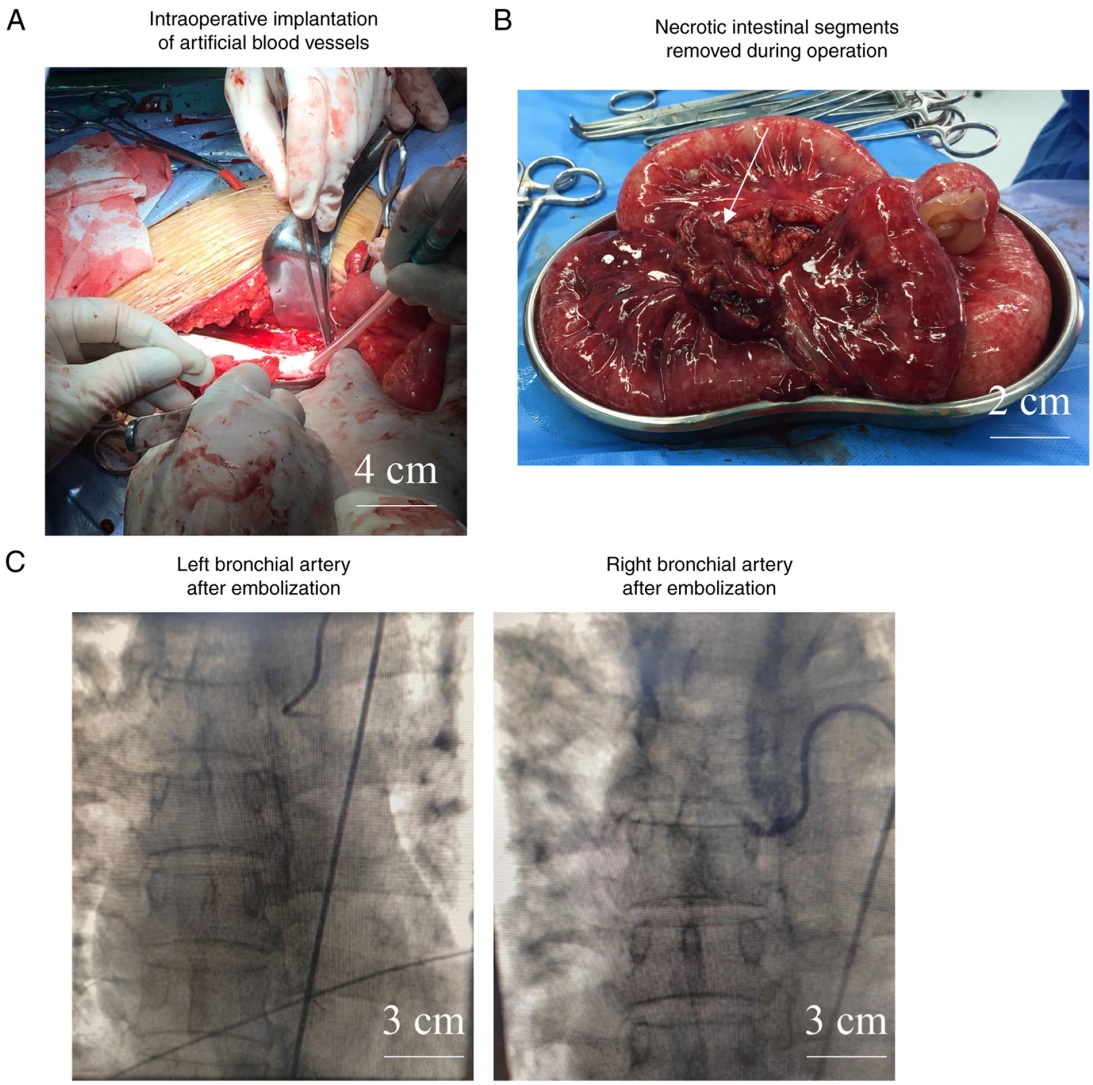

Figure 2. Pulmonary angiography images and intraoperative images. (A) Intraoperative implantation of artificial blood vessels. (B) Necrotic intestinal segments removed during operation. (C) Bronchial artery embolization.

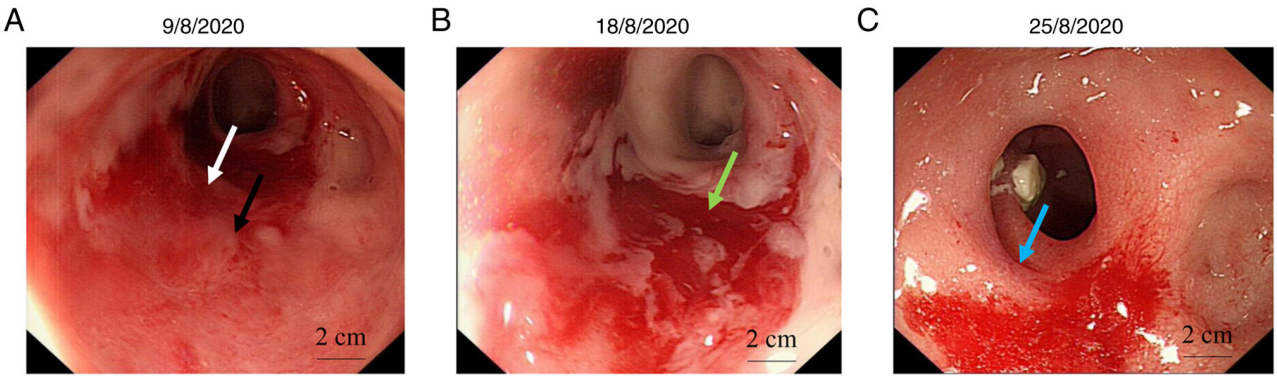

Figure 3. Colonoscopy findings. (A) Bright red blood and necrotic tissue in the rectal cavity were observed on 9/8/2020. (B) Numerous blood clots and blood were found in the intestinal cavity on 18/8/2020. (C) Congested and swollen rectal mucosa were observed on 25/8/2020. The white arrow indicates bright red blood areas, the black arrow indicates necrotic tissues, the green arrow indicates numerous blood clots and blood, and the blue arrow indicates congested and swollen rectal mucosa.

arrest (TCA) have no pulse, and TCA has been viewed as a precursor to traumatic death. Very low survival rates (i.e., 10.6%) following TCA have been reported (3,5). In the present case report, the patient also suffered cardiac arrest, which could have been associated with renal insufficiency after CS and hyperkalemia caused by infusion of excessive blood

products (6.17 mmol/l). Following emergency treatment with continuous chest compression, electric defibrillation and an injection of epinephrine hydrochloride, the patient ultimately recovered. It has been reported that most pelvic injuries may not lead to significant bleeding, since pelvic injuries are mainly associated with damage to small arteries (6,7). No damage sustained to large arteries was found in this case. It is therefore possible to surmise that the hemorrhagic shock of the patient mainly resulted from intestinal rupture, traumatic stress, and bleeding of fracture ends.

The D-dimer levels of the patient were increased on admission. D-dimer is considered to be a marker for fibrinolysis and coagulation activation; however, D-dimer has also been used to predict DIC (8). Furthermore, D-dimer is considered to be a biomarker for thrombosis, and a notable increase in its levels is indicative of a poor outcome (9). The elevated level of D-dimer in the present case report was therefore a predictor for massive thrombosis in the abdominal aorta and bilateral common iliac arteries.

Following the hemostasis and the artificial vessel replacement surgery, upon the suggestion of the vascular surgeons, low molecular weight heparin sodium with good absorption, high selectivity, high bioavailability, less adverse bleeding reactions and no routine blood sampling monitoring was used. Subsequently, the dose of the low molecular weight heparin sodium administered was appropriately reduced over time. In order to cope with the possible risk of bleeding, the coagulation-associated indicators of the patient, including the international normalized ratio during the treatment, were closely monitored.

The patient in the present case report sustained multiple and serious injuries, with a lengthy operation time. The patient had an obvious rupture of the small intestine and a mesenteric injury, and an enterostomy was performed. In addition, the patient had multiple rib fractures and pleural effusion. Therefore, the patient was treated with sulperazon empirically for prophylactic anti-infection purpose, which is indeed worthy of further discussion. A pulmonary angiography was performed after the patient experienced sudden pulmonary hemorrhage and hemoptysis. Because the patient had no history of hypertension, the posterior pituitary injection was administered to reduce circulatory pressure. The use of various hemostatic drugs in the later stages of the operation was due to the persistent bleeding that resulted from hemoptysis in the lower gastrointestinal region. These hemostatic measures were proven to be effective in terms of preventing systemic coagulation dysfunction.

The patient experienced anuria after July 29, 2020 (the 2nd day after the operation). After a total of 273 h of CRRT treatment, the urine volume was increased from September 28, 2020 (the 63th day after the operation), with the patient producing >100 ml urine/24 h. The following factors were considered to be the major reasons leading to acute kidney failure. First, CS resulted in rhabdomyolysis, which induced the further release of a large amount of myoglobin into the blood, leading to acute kidney failure (10). Secondly, hemorrhagic shock may also have accelerated the kidney damage (11). In addition, the application of contrast agent could also have contributed to kidney damage (12). In this case, timely diagnosis and active systemic treatment contributed greatly during the management of the patient's condition, aiding his recovery. The case has demonstrated that a multidisciplinary treatment strategy is crucial for the successful treatment of such patients with multiorgan dysfunction.

Acknowledgements

Not applicable.

Funding

This study was supported by the National Natural Science Foundation of China (grant no. 82101467), by the General Hospital of Western Theater Command (grant no. 2021-XZYG-C20) and by the National Defense Science and Technology and Military Theory Innovation Program (grant no. JJ2021A03-B023).

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Authors' contributions

XY, NT, CHe, KT and CHu took part in the conception and design of the study. XY and CHe participated in the development of methodology. GX, JD, LL, KT and CHe contributed to data acquisition and analysis. NT, KT and CHu wrote and reviewed the manuscript. XY, LL and CHe contributed to technical and material support. CHe and CHu supervised the study. XY and KT confirm the authenticity of all the raw data. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of The General Hospital of Western Theater Command (Chengdu, China).

Patient consent for publication

Informed consent was obtained from the patients included in the study.

Competing interests

The authors declare that they have no competing interests.

References

1. He Q, Wang F, Li G, Chen X, Liao C, Zou Y, Zhang Y, Kang Z, Yang X and Wang L: Crush syndrome and acute kidney injury in the Wenchuan Earthquake. J Trauma 70: 1213-1217; discussion 1217-1218, 2011.
2. Revell MA, Pugh MA and McGhee M: Gastrointestinal traumatic injuries: Gastrointestinal perforation. Crit Care Nurs Clin North Am 30: 157-166, 2018.
3. Barnard EBG, Hunt PAF, Lewis PEH and Smith JE: The outcome of patients in traumatic cardiac arrest presenting to deployed military medical treatment facilities: Data from the UK Joint Theatre Trauma Registry. J R Army Med Corps 164: 150-154, 2018.

4. Gelas T, Combet S, Perinel J, Javouhey E and Mure PY: Transrectal small bowel evisceration after abdominal crush injury. J Pediatr Surg 47: e53-e56, 2012.
5. Rosemurgy AS, Norris PA, Olson SM, Hurst JM and Albrink MH: Prehospital traumatic cardiac arrest: The cost of futility. J Trauma 35: 468-473; discussion 473-464, 1993.
6. Totterman A, Madsen JE and Roise O: Multifocal arterial haemorrhage in a partially stable pelvic fracture after a crush injury: A case report. Arch Orthop Trauma Surg 126: 113-117, 2006.
7. Miller PR, Moore PS, Mansell E, Meredith JW and Chang MC: External fixation or arteriogram in bleeding pelvic fracture: Initial therapy guided by markers of arterial hemorrhage. J Trauma 54: 437-443, 2003.
8. Bates SM: D-dimer assays in diagnosis and management of thrombotic and bleeding disorders. Semin Thromb Hemost 38: 673-682, 2012.
9. Ichkawa Y, Wada H, Ezaki M, Tanaka M, Hiromori S, Shiraki K, Moritani I, Yamamoto A, Tashiro H, Shimpo H and Shimaoka M: Elevated D-Dimer levels predict a poor outcome in critically Ill patients. Clin Appl Thromb Hemost 26: 1076029620973084, 2020.
10. Sever MS and Vanholder R: Crush syndrome: A case report and review of the literature. J Emerg Med 48: 730-731, 2015.
11. Harrois A, Libert N and Duranteau J: Acute kidney injury in trauma patients. Curr Opin Crit Care 23: 447-456, 2017.
12. Gordon E and Kamath S: Fulminant liver failure associated with abdominal crush injury in an eleven-year old: A case report. Case Reports Hepatol 2013: 524371, 2013.