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DAMAGE CONTROL SURGERY IN PATIENTS WITH CRUSH INJURY

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Background: Damage Control Surgery is a quick termination of surgical procedure aims to reduce the mortality rate. In the past damage control surgery only perform in abdominal procedure, now the concept has developed, so can be applied to other procedure. Damage control surgery have 3 phases, abbreviate surgery, intensive care unit resuscitation and definitive surgery.

Case: A 19-years-old man patient, weighing 45 kg was presented as a case. The patient had work accident at his workplace, his hand trapped in wood machine, and his chest hit a machine. The condition when arrived at hospital show the sign of hypovolemic shock and have a transient respond to resuscitation, so it's decided to perform damage control surgery.

Results: In the case that described in the manuscript, the patient showed improvement after the surgery. The bleedings stop and the hemodynamic is stable. Post operative patient admitted to intensive observation room and planned to the next surgery.

Conclusion: The goal of this study is to emphasize the importance of damage control surgery in the management of critical trauma patients. This explains the stages that involved, including the initial surgery to control bleeding and contamination, the ICU phase focused on stabilizing the patient's condition and the planning for definitive surgery. Additionally, this study also emphasizes the importance of a multidisciplinary approach in optimizing patient outcomes and preventing further harm.

Keywords: Crush Injury, Damage control, Resuscitation

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BACKGROUND

Damage control surgery is defined as a quick termination of surgical procedure after controlled life-threatening bleeding and contamination, followed by correcting abnormal physiology in the ICU and definitive management (Schreiber, 2004). Damage control aims to avoid "operating the patient to death," one of a strategy to limited prolonged surgical procedures that might lead to increased blood loss, potentially causing hypothermia, coagulopathy, and acidosis (Schreiber, 2004).

In the new millennium, the concept of damage control surgery has developed. Now, there is awareness that prolonged surgery may harm the patients even in the absence of hypoperfusion or coagulopathy. This awareness has expand the knowledge of damage control surgery, so now can be applied to orthopedic procedures (for example : external fixation vs. intramedullary nailing of femur fractures), intrathoracic surgery (delaying repair of stable aortic injuries), and even neurosurgery (craniotomy without bone flap replacement, even in the absence of massive edema) (Dutton, 2005).

CASE PRESENTATION

The patient was a 19-year-old man. On January 6th, 2023, at 04.30 PM, he had work accident at his workplace, his hand trapped in wood machine, and his chest hit a machine. At 05:00 PM on the same day, the patient was taken to Kediri General Hospital. On arrival, glasgow coma scale (GCS) was 334, blood pressure of 90/64 mmHg, heart rate 114 beats per minute, respiratory rate of 22 breaths per minute, with bruise in right hemithorax, asymmetric chest movement, and crepitasi. The right hand looks pale, with oxygen saturation (SpO2) only at 84% with room air. Laboratory test results included hemoglobin of 16.2 g/dl, hematocrit of 46.3%, white blood cell count of 11.2 x 10^3/µl, platelet count of 119 x 10^3/µl, sodium of 141 mmol/L, potassium of 5.7mmol/L, SGOT of 101U/L, SGPT of 69 U/L, blood urea nitrogen (BUN) of 12 U/L, and serum creatinine (SCr) of 1.02 U/L. The patient received therapy pressure bandage on the right antebrachial region and the placement of a 32Fr chest tube in the right hemithorax, along with resuscitation fluids.

On January 7th, 2023, at 11:30 AM, as the patient's condition worsened, he was referred to Dr. Soetomo Surabaya Hospital for multidisciplinary treatment. The patient arrived at Dr. Soetomo Surabaya Hospital at 13:30 PM, with a condition requiring special attention. Primary survey at Dr. Soetomo Surabaya Hospital, obtained a patent airway, spontaneous breathing with a respiratory rate of 28-34 breaths per minute, Spo2 of 97% with Jackson Reese support at 15 liter per minute, a 32 Fr chest tube in the right hemithorax with hemorrhagic drainage, decreased breath sounds on the right side, in circulationnwe found a warm acral, dry and pale skin, CRT <2 seconds, a heart rate of 123 beats per minute, blood pressure of 82/53 mmHg (MAP 66), a GCS of 335, and swelling in the right hand, with cold sianotic acral and bleeding tendencies. Based on the examination, intubation was performed, along with loading 1L Ringer's lactate as a resuscitation fluid and 1-unit whole blood, keep the pressure bandage on the wound, and warming the patient. From observations and monitoring, the patient shows the transient hemodynamic responses to resuscitation.

In Dr Soetomo Surabaya Hospital, the patient laboratory showed changes in several parameters. Hemoglobin (Hb) and hematocrit (Hct) decreased to 6.6 g/dl and 29.8%, respectively, while the white blood cell count (WBC) increased to 15,5 x 10^3/µl, and platelet count (PLT) increased to 87 x 10^3/µl. Sodium (Na) was 143 mmol/L, potassium (K) was 6.2 mmol/L, and chloride (Cl) was 117 mmol/L. Blood glucose level was 85 mg/dl. Blood urea nitrogen (BUN) increased to 39.2 U/L, while creatinine (SCr) was 2.7 U/L. APTT and PPT were 30.3 and 11.2, respectively. Blood gas analysis show metabolic acidosis with the base excess of -10,2 mmol/L. On chest X-ray examination, there was a complete fracture of the right clavicle, complete fracture of the right acromion, and incomplete fractures of ribs II, III, IV, V, VI, and VII lateral.

At that point, the patient was diagnosed with hypovolemic shock with transient response, right shoulder crush injury, right-sided pneumothorax with a water-seal drainage (WSD) system, incomplete fractures of ribs 1-6 on the right, and right-sided flail chest.

Due to continuous bleeding from the wound and transient hemodynamic response so it's decided to perform damage control surgery. Operation time was 120 minutes, during the operation, the surgeon found severe tissue damage and vascular damage in the upper right extremity and performed vessel ligation and debridement, followed by temporary wound closure. The patient remained hemodynamically stable during the operation. The intraoperative blood loss was 1500 ml, and the intraoperative transfusion included 2 units of whole blood and 5 units of platelets. After the surgery, the patient was transferred to the Intensive Observation Room (ROI). Postoperative conditions were stable, and postoperative laboratory results become better. The next step, patient would be planned definitive surgery, which would involve disarticulation of the right humerus.

The aim of this study is to describe the case of a patient who suffered a severe injury due to a workplace accident and need a damage control surgery. This case will provide an understanding of how the damage control surgery approach can be applied in the management of patients with severe injuries and how this intervention can impact the patient's clinical outcomes. Additionally, this research aims to highlight the crucial role of intensive care and multidisciplinary team collaboration in the management of patients. Therefore, this study will offer valuable insights into the application of the concept of damage control surgery in clinical practice and its implications for the care of critically injured patients.

DISCUSSION

Damage control resuscitation represents a fundamental shift from surgical techniques that initially focused on anatomy to a focus on physiology. A proper understanding of the patient's pathophysiology is the basic of discovery damage control principle. In 1982, Kashuk et al created the term "bloody vicious cycle," consisting of hypothermia, coagulopathy, and metabolic acidosis, which refers to the fluctuation of the patient's physiological condition (Schreiber, 2004).

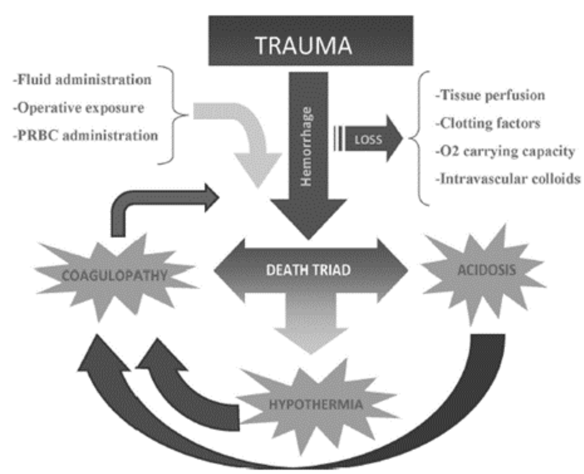

Figure (1) Components that involved in the development of coagulopathy in trauma (Duchesne, 2010)

Hypothermia

Hypothermia causes cardiac dysrhythmia, reduces cardiac output, shifts the oxygen-hemoglobin saturation curve to the left, thereby preventing oxygen exchange to cells, and affects the clotting cascade. Hypothermia is believed to affect the clotting cascade by limiting temperature-sensitive, enzyme-activated serine esterase, leading to platelet dysfunction, endothelial abnormalities, and alterations in the fibrinolytic system (Polderman, 2012).

Coagulopathy

Every aspect of coagulation is affected by hypothermia. With every increase in temperature, both prothrombin time (PTT) and activated partial thromboplastin time (aPTT) increase significantly. Platelet dysfunction, as evidenced by increased bleeding time, is caused by decreased levels of plasma thromboxane. This is expected due to changes in the GIIIb-Ila receptor function. Furthermore, the dilution effect on platelet factors V and VIII, combined with the effects of hypothermia, leads to clotting cascade dysfunction (Van Poucke et al., 2014).

Metabolic Acidosis

Acidosis due to tissue hypoperfusion and oxygen debt leads to a shift from aerobic metabolism to anaerobic metabolism at the cellular level, subsequently causing lactic acidosis. Trauma patients who can eliminate their lactate within 24 hours, have a 100% survival rate (Oliveros-Rodríguez et al., 2017). Similarly, if lactate is not eliminated within 24 hours, only 14% can survive. Several studies have shown the prognostic value of blood lactate as an index of oxygen delivery, morbidity, and mortality in hemorrhagic shock (Schuster, 1984; Soller et al., 2015; Vandromme et al., 2010). Previous studies have demonstrated the value of blood lactate as a prognostic index in over 600 trauma patients (Raux et al., 2017; Régnier et al., 2012; Sagraves et al., 2006).

Identification Of Damage Control Surgery Patients

The damage control approach is only suitable for specific patient groups. Rotondo et al. declare that only patients with major vascular injuries and two or more visceral injuries have shown the benefits of the damage control approach.

Table (1) Preoperative Indications for Damage Control Surgery

Revised Trauma Score ≤ 5
pH ≤ 7.2
Temperature ≤ 34°C
Emergency room resuscitation ≥ 2000 mL crystalloid or ≥ 2 units PRC
Multiple mass casualties
Multisystem trauma with large abdominal trauma
Open pelvic fracture with major abdominal trauma
Major abdominal trauma requiring immediate evaluation of possible extraabdominal trauma
Traumatic limb amputation with major abdominal trauma
Requires emergent thoracotomy
Requires additional use of angioembolization

Damage Control Surgery Stages

Damage control consists of three stages: abbreviated surgery, resuscitation in the ICU, and subsequent reopening for definitive therapy (Browne, 2011; Duchesne, McSwain, et al., 2010; Dutton, 2005; Frauenfelder et al., 2011; Ortega-Gonzalez, 2012; Sagraves et al., 2006). There is no ideal anesthesia drug for patients with hemorrhagic shock (Duchesne, Kimonis, et al., 2010). The key to safe anesthesia management is to administer small incremental doses of the drug. Propofol and thiopental have the potential to cause hypotension. Ketamine is highly popular for induction in trauma patients.

Maintenance of anesthesia can be achieved through intermittent dosing, with small doses of ketamine (25 mg every 15 minutes) usually well-tolerated, low-concentration volatile agents (<0.5 MAC), relaxants (usually rocuronium or vecuronium), and titrated fentanyl doses (1-3 mg/kg). Small doses of midazolam can be used to reduce patient awareness. Once bleeding has been controlled, the attention shifts to contamination control. No reconstruction is performed during damage control part one. Before definitive hemostasis, aggressive fluid administration increases bleeding from injured blood vessels. Increased blood pressure leads to increased bleeding due to coagulation disruption and the reversal of vasoconstriction ("pop the clot" phenomenon) (Duchesne,2010)

Permissive hypotension, also known as hypotensive resuscitation, involves restricting fluid administration until bleeding can be controlled. The goal of permissive hypotension is to maintain systolic blood pressure in the range of 80-100 mmHg (clinically indicated by radial pulse disappearance), achieve a MAP of 65 mmHg, delay or limit fluid administration until bleeding is controlled. Permissive hypotension is contraindicated in patients with severe head injuries where the priority is to maintain cerebral perfusion pressure (Sagraves et al., 2006)

Fluid selection is crucial, crystalloids is recommended by the National Institute of Clinical Excellence in the UK, while Hartman's solution is recommended by the Royal Centre for Defence Medicine University of Birmingham, because not causing hyperchloremic metabolic acidosis in patients who already have tendencies to acidosis. Blood products should be given as early as possible, preferably with uncross matched type-O RBCs when the patient arrives in an unstable condition. Plasma and platelets should follow promptly when available from the blood bank (Duchesne,2010).

After the first stage is completed, the second stage of damage control begins (Hsu & Pham, 2011; Parr & Alabdi, 2004). The focus of the team shifts to secondary resuscitation to rewarm the patient, correct acidosis, and coagulopathy. This resuscitation often requires comprehensive assessment from medical resources.

Table (2) Resuscitation Targets During Damage Control

Systolic blood pressure 90 mmHg
Pulse < 120 x per minute
Pulse oximeter functioning, $SaO_2 > 95\%$
Urine production present
$PaCO_2 < 50$
pH > 7.25
Hematocrit > 25%
Lactate levels are stable or decreasing
Ionized calcium > 1.0
International Normalized Ratio < 1.6
Platelets > 50,000
Normothermia
Deep anesthesia

Ventilation Technique
The goal of ventilation strategy is to maintain oxygenation and ventilation but also preventing volutrauma. Damage-controlled patients are at risk of developing Acute Lung Injury (ALI) and Acute Respiratory Distress Syndrome (ARDS). Factors that may contribute to the development of ALI and ARDS, in addition to direct lung parenchymal injury and shock, include the massive resuscitation received by patients during the first day of resuscitation (Sklar et al., 2019).

Rewarming
Rewarming significantly contribute to the resuscitation process by allowing co-factors in the clotting process to function, so that it can control over bleeding and eliminate lactic acidosis. The rewarming process should continue in the ICU. The ICU room is warmed to 30°C. Wet linen should be promptly replaced and dried as soon as the patient arrives in the ICU. The patient's head is covered with an aluminum foil cap. The ventilator circuit must be heated. A convection air blanket should cover the patient, with the temperature set at 40°C. All transfusion lines must have a fluid warmer. The patient should be warmed to 37°C within 4 hours of arriving in the ICU (Parr, 2004).

Coagulopathy Correction
Damage control part II requires 24 - 48 hours to restore normal physiological function. The 10- unit rule (10 units each of PRC, FFP, and platelets) can be used as a transfusion guideline during the first 24 hours (Parr, 2004).

Acidosis Correction
All damage control patients experience lactic acidosis, reflecting anaerobic metabolism due to inadequate oxygen transport. The acidosis typically resolves on its own after adequate resuscitation and adequate rewarming, correction of oxygen debt, and a shift from anaerobic to aerobic metabolism. Inotropic/vasopressor support should be considered if the patient does not respond adequately to volume and blood product administration, and myocardial depression may appear at pH < 7.2. After hemodynamic stability has been achieved, the patient is warm and coagulopathic resolved, definitive surgery can be performed. This typically occurs within 12-48 hours after damage control. The intensivist plays a crucial role in preparing the patient to return to the operating room (Parr, 2004).

The goal of this third phase is to explore the injured area, reassessment of injuries, and perform a definitive surgery. If the physiological disturbances occur during this procedure (usually within 2-4 hours), the surgeon should consider returning to damage control, phase 1, where the surgical procedure is abbreviated, and patient transferred back to the ICU.

Table (3) Resuscitation Targets After Damage Control

Systolic blood pressure > 100 mmHg
Pulse < 90x per minute
Pulse oximetry functioning, SaO2 > 97%
Urine output > 0.5 cc/kgBW/hour
PaCO2 < 40 torr
pH > 7.35
Hematocrit > 20%
Lactate normal
Ionized calcium > 1.0
International Normalized Ratio < 2
Platelets > 50,000
Normothermia
Normal cardiac output
Mild sedation (comfortable, spontaneous ventilation can be initiated)
Normal lactate is the best marker for adequate resuscitation. A low hematocrit can be tolerated in patients who are not actively bleeding.

CONCLUSION

The principles of damage control surgery in patients have been outlined. Damage control surgery represents a significant development in the management of trauma patients. The sequence of damage control consists of a stepwise approach, including abbreviated surgery, resuscitation in the ICU, and planning for definitive surgery. In damage control resuscitation, time plays an important role, time saving is lifesaving. Goal of damage control surgery is to prevent patients falling into a condition such as hypothermia, coagulopathy, and metabolic acidosis. Intensivists have a important role to be involved during the initial stages of managing damage control patients in the ICU. A multidisciplinary approach is necessary to achieve optimal outcomes.

AUTHORS' CONTRIBUTION

MSS : Concept and design, data acquisition, interpretation, drafting, and agree to beaccountable for all aspects of the work. CSW : Data acquisition, interpretation, final approval and agree to be accountable forall aspects of the work.

Conflict of interest: Authors declared no conflict of interest.

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