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The effective risk factors on mortality in patients undergoing damage control surgery

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Abstract. – BACKGROUND: Damage control surgery is a life-saving procedure used in fatal injuries. Morbidity and mortality rate are high in these patients due to massive trauma. The aim of this study was to analyze the risk factors associated with mortality in abdominal traumas that underwent damage control surgery.

PATIENTS AND METHODS: The retrospective study included 24 patients that underwent damage control surgery between January 2004 and September 2010. Age, gender, type of injury, period of time before admission, hemodynamic parameters, associated organ injury, injury severity score, surgical procedures performed, length of hospital stay, and complication and mortality rates were recorded.

RESULTS: The study included 16 (66.7%) men and 8 (33.3%) women, with a mean age of 32.3 years. Median period of time before admission was 30.83 minutes. All the patients were present with hypothermia and acidosis at admission, while only 5 of them were hemodynamically stable. Mean 6.75 units of blood were transfused in all of them. Common etiological factors included gunshot (50%) and motor vehicle accident (25%). Hepatic injury (83.3%) was the most common organ injury. Mean injury severity score (ISS) was 28.88. Damage control surgery was performed in all the patients. Skin-only closure was applied in 17 (70.8%), while 7 (29.2%) patients received Bogota bag application. Definitive surgery was achieved through de-packing over 36-48 hours in average. Total mortality occurred in 11 (45.8%) patients. Period of time before admission, core temperature at admission, pH levels and amount of blood transfusion were statistically different in the mortality group. A total of 16 complications occurred in 10 patients. Among these, intraabdominal abscess (46.2%) was the most common.

CONCLUSION: Hypothermia (< 35°C), acidosis (pH < 7.2), instability related to systolic blood pressure, massive blood transfusion, and delayed admission are predictive factors for mortality.

Key Words:
Damage control surgery, Mortality, Risk factors.

Introduction

Damage control surgery (DCS) is a life-saving procedure employed in fatal and critical injuries. In 1983, Stone et al[1] defined the terms "short-term laparotomy" and "packing" for the first time, reporting that acidosis and coagulopathy may develop in severe traumas, causing deterioration in the clinic condition of the patients. DCS became popular and more common when Rotondo et al defined its details and steps in 1993[2]. The DCS procedure includes several steps: the initial laparotomy for bleeding control, resuscitation and rewarming in intensive care unit (ICU) and definitive surgery for all injuries after the correction of metabolic imbalances is achieved[3,4]. DCS is reported as an effective procedure in cases of severe injuries, which are complicated by the presence of metabolic acidosis, hypothermia, and coagulopathy–commonly known as "the lethal triad"[5]. The cases in DCS are inflicted by massive trauma, with an average mortality of 50%[5,6]. The aim of this study was to analyze the risk factors for mortality in cases that underwent DCS due to abdominal trauma.

Patients and Methods

Study Population

The retrospective study included 24 patients that underwent DCS due to abdominal trauma at Dicle University School of Medicine, Department of General Surgery between January 2004 and September 2010. Age, gender, type of injury, period of time before admission (PTBA), core temperature at admission, pH levels, systolic blood pressure (SBP), international normalized ratio (INR) results, associated organ injury, in-

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jury severity score (ISS), surgical procedures performed, post-DCS closure procedure, pre- and post-operative amounts of blood and plasma transfusions, the date of the second operation performed, length of hospital stay, and complication and mortality rates were reviewed.

All the patients were divided into two groups as non-exitus (n=13, 54.2%) and exitus (n=11, 45.8%). The patients whose preoperative cardiopulmonary resuscitation (CPR) took more than 5 mins and the ones who died intraoperatively were excluded in the study.

Damage Control Surgery

The patients were promptly taken into resuscitation unit in the ICU. Following a prompt evaluation for respiratory functions, intravenous cannulas for bolus-type crystalloid infusion and urinary catheter were inserted to all of the patients. They were resuscitated according to Advanced Trauma Life Support (ATLS) recommendations[7]. Following 2,000 cc Ringer lactate infusion, hemodynamic stability was considered (I) as *stable* for patients with systolic blood pressure over 90 mmHg, (II) as *temporarily stable* for patients progressing with over 90 mmHg but lowering to below 90 mmHg as a result of the cessation of infusion and, thus, requiring blood and blood products, and (III) as *unstable* for the ones below 90 mmHg[8]. While taking operative decisions, hemodynamic instability, penetrating injuries, acute peritonitic findings and amounts of blood transfusions were considered[9,10]. All the patients received preoperative antibiotic therapy. Jugular catheters and pulmonary artery catheters were inserted for the treatment and follow-up of fluid resuscitation with electrolyte replacement. Heated blankets were used to minimize intraoperative temperature loss. Fluids heated to body temperature were given[11]. Laparotomy was performed via median incision. The initial step in the procedure included the hemostatic control via abdominal packing in all four quadrants. Selective ligation of arterial and biliary leakages was achieved through finger fracture technique following the Pringle maneuver for hepatic injuries. The Pringle maneuver was performed in 20 mins' periods. In the initial step of packing, the liver was pulled down and packs were inserted between the diaphragms and the liver. The packing procedure was completed upon the insertion of 5 to 8 packs in lower liver along with the front side of right and left lobes[10]. For splenic hemorrhages, organ resection was performed to avoid prolonged surgery. Vascular injuries were treated with vascular clamp or suture ligation. Cases with intestinal injuries received primary closure. For major intestinal injuries, intestinal staplers or 1/0 silk suture were used. Also, no resection and anastomosis procedure, no ostomy or feeding tube was used in intestinal injuries. In order to avoid acute compartment syndrome, the abdomen was simply closed by skin-only closure or a sterile plastic bag (with a silo of plastic constructed out of empty crystalloid fluid bags, sewn to the skin with large, nonabsorbable suture–Bogota bag) without using any drainage. In the light of explorative laparotomy findings, organ injuries were graded according to the scale by the American Association for the Surgery of Trauma[12], and injurity severity score (ISS) was calculated for each patient. Following the first laparotomy in DCS, the patients were transferred to ICU, where they continued fluid resuscitation by means of intravenous fluid, blood, plasma, and volume expanders. Once the physiological and biochemical abnormalities were corrected, the patients were re-operated in 36 to 48 hours after the initial operation[2,13]. The packs were swiftly and neatly removed via soakage, beginning from the one with the least possibility of hemorrhage. Vascular repair and intestinal sustainability were achieved by standard anastomotic techniques. In cases with successful fascial closure, 1/0 polydioxanone was used. For the unsuccessful ones, skin-only closure was performed.

Statistical Analysis

Data analysis was performed with SPSS 11.5 (SPSS Inc., Chicago, IL, USA). Quantitative values were represented as mean ± standard deviation. In group comparisons, Mann Whitney-U test was used for nonparametric data, while independent categories were evaluated by Chi-Square test. The risk factors for mortality were evaluated by logistic regression test. A p value of <0.05 was considered to be statistically significant.

Results

The patients included 16 (66.7%) men and 8 (33.3%) women, with a mean age of 32.3 years. Median period of time before admission was 30.83 minutes. In all the patients, hypothermia and acidosis were present at admission, while on-

ly 5 of them were hemodynamically stable. Mean 6.75 units of blood and 5.54 units of plasma were transfused in all the patients. Mean preoperative INR was 1.83 (Table I).

Common etiological reasons included gunshot (50%) and motor vehicle accident (25%). Hepatic injury (83.3%) was the most common organ injury: 5 of them were in grade 3, 9 in grade 4, and 6 in grade 5. Hepatic injury was followed by diaphragmatic injury. The patients had a mean ISS of 28.88 (Table II). DCS was performed in all the patients. Skin-only closure was applied in 17 (70.8%), while 7 (29.2%) received Bogota bag. Four patients died after the initial laparotomy, and one patient received re-packing following the second laparotomy for hemostasis. For the remaining 19 patients, definitive surgery was achieved through de-packing over 36-48 hours in average. Total mortality occurred in 11 (45.8%) patients.

The patients were divided into two groups as non-exitus (n=13, 54.2%) and exitus (n=11, 45.8%). The groups were statistically different in terms of PTBA (p = 0.001), amount of blood transfusion (p = 0.009), and presence of acidosis (p = 0.001) and hypothermia (p = 0.035). In multivariate analysis, PTBA, core temperature, arterial blood, pH levels, hemodynamic stability, and amount of blood transfusion were confirmed as predictive factors for mortality (Table III).

A total of 16 complications developed in 10 (76.9%) of the non-exitus group. Common complications included intraabdominal abscess, acute compartment syndrome, and perennial renal failure (Table IV). The group had a mean hospital stay of 20.77 days, with a median of 13.31 days in ICU.

Discussion

DCS is a three-step procedure used in salvaging the critical patients with massive hemorrhage caused by critical trauma; also it is a technical situation regarding the patient's physiological condition and surgical procedures[3,4,6,14]. The decision to apply DCS should be made in the first 15 mins. The initial and the most important step of the three steps includes prompt prevention of hemorrhage and contamination[3]. In addition to well-known hemostatic procedures that are performed in this step, abdominal packing and temporary closure of abdomen are also used. In the second step, the patient is transferred to ICU so as to achieve physiological restoration (core rewarming, correction of coagulopathy, completion of acute resuscitation). Once physiologic normalization is achieved, relevant relaparotomy and definitive surgery are performed, and also abdominal closure is completed as the third step[15]. Patients between the ages of 47 and 56 and males with a rate of 73-87% constitute the largest groups for DSC implementation[8,10,16]. Etiological factors vary depending on geographical regions: In Japan, blunt trauma[8] and in the

Table I. The findings of the patients (n=24).

Gender (male/female)	16/8
Age (years)	32.3 ± 13.01 (14-66)
Period of time before admission (minutes)	30.83 ± 9.29 (15-60)
Core temperature (ºC)	35.1 ± 0.36
Blood pressure (n)	
Stable	5 (20.8%)
Temporary stable	16 (66.7%)
Unstable	3 (12.5%)
pH	7.24 ± 0.11
INR	1.83 ± 0.36
Blood transfusion (unit)	6.75 ± 3.01
Plasma transfusion (unit)	5.54 ± 1.41
Mortality	11 (45.8%)
The average time of death (days)	3.18 ± 2.92 (1-11)
The median time of ICU stay (days), for surviving patients	13.31 ± 3.63 (7-20)
The median time of hospital stay (days), for surviving patients	20.77 ± 5.45 (15-35)

INR, international normalized ratio; ICU, intensive care unit.

Table II. The form of injuries and injured organs.

The form of injury (n, %)	
Gunshot	12 (50%)
Traffic accident	6 (25%)
Falls from height	4 (16.7%)
Latrogenic	1(4.2%)
Stab wounds	1(4.2%)
Injured Organs (n, %)	
Isolated liver injury	9 (37.5%)
Liver and additional organ injuries	11(45.8%)
Diaphragm	4 (36.4%)
Major vascular	2 (18.2%)
Spleen	2 (18.2%)
Small intestine	2 (18.2%)
Kidney	1 (9.1%)
Stomach	1 (9.1%)
Colon	1 (9.1%)
Thoracic	1 (9.1%)
Iliac bone	1 (9.1%)
Intracranial	1 (9.1%)
Non-liver injuries	4 (16.7%)
Diaphragm	1 (25%)
Major vascular	1 (25%)
Spleen	1 (25%)
Small intestine	1 (25%) (9.1%)
Kidney	1 (25%)
Colon	1 (25%)
ISS	28.88 ± 8.63 (16-50)

ISS, injury severity score.

Table III. Potential predictors for mortality in patients with damage control surgery.

Parameters	Group 1 n (%)	Group 2 n (%)	Significance (*p*)
Gender			NS
Female	3 (23.1%)	5 (45.5%)	
Male	10 (76.9%)	6 (54.5%)	
Age(years)	32.69 ± 12.45 (14-52)	31.82 ± 14.26 (18-66)	NS
PTBA (minute)	25.77 ± 5.72 (15-35)	36.82 ± 9.29 (25-60)	0.003
Core temperature (°C)	35.51 ± 0.55 (34.5-36.5)	34.64 ± 1.00 (33-36)	0.014
pH	7.30 ± 0.07 (7.13-7.40)	7.17 ± 0.10 (7.01-7.30)	0.002
Blood pressure			0.036
Stable	4 (30.8%)	1 (9.1%)	
Temporary Stable	9 (69.2%)	7 (63.6%)	
Unstable	0 (0%)	3 (27.3%)	
INR(second)	1.77 ± 0.32 (1.50-2.60)	1.91 ± 0.40 (1.50-2.79)	NS
ISS	31.81 ± 11.13 (16-50)	26.38 ± 4.99 (16-50)	NS
Blood transfusion (unit)	5.46 ± 2.73 (2-12)	8.27 ± 2.69 (5-15)	0.020
Plasma transfusion (unit)	5.08 ± 1.32 (3-7).	6.09 ± 1.38 (4-8)	NS

Group 1: non-exitus group; Group 2: exitus group; PTBA: Period of time before admission; INR: international normalized ratio; ISS: Injury severity score; NS: Not significant.

Table IV. Postoperative complications in surviving patients.

Intraabdominal abscess	6 (46.2%)
Abdominal compartment	3 (23.1%)
Perennial kidney failure	3 (23.1%)
Wound infection	2 (15.4%)
Acute respiratory distress	2 (15.4%)
Psychosis	1 (7.7%)

USA, penetrating injuries[16] are considered as the most common ones. Males constituted the 66.7% of our series, with a mean age of 32.3 years. The lowness of this mean age could be best explained by the high rate of gun ownership, and higher rates of gunshot injuries among etiological reasons.

Johnson et al[14] introduced a new period that includes both pre-hospital and ICU stages. They also emphasized the importance of early and prompt intervention along with the necessity of forming an experienced trauma team for the achievement of DCS[14,17]. The difference in PTBA between the two groups in our study revealed the importance of minutes for such patient groups. For this reason, it is vital that the patient be promptly transferred to hospital in such cases. Delayed admission was correlated in our study with mortality.

Massive hemorrhage secondary to trauma leads to acidosis, hypothermia, and coagulopathy triad. It may also result in mortality unless necessary precautions are taken[5,6]. Matsumoto et al[8] report that SBP less than 90 mm Hg, base excess less than 7.5 mmol/L, and core temperature less than 35.5°C are bad prognostic factors. On the other hand, Moore et al[18] reported the respiratory rate (>35/min), and the presentation of hypotension (<70 mmHg), hypothermia (<34ºC), coagulopathy (INR >1.9 and/or aPTT >60 s) and severe acidosis (pH <7.2) as imposing factors for DCS implementation. Massive blood transfusion and the crystalloids transfused are reported to result in hemodilution, increasing the severity of coagulopathy. In addition, massive blood transfusion is regarded as a predictive factor for mortality[18]. In our study, the exitus group was also present with severe acidosis (pH <7.2) and hypothermia (core temperature <35°C); and despite fluid resuscitation, the patients in the group were either temporarily stable or unstable in terms of SBP. These values represented the statistical difference between the groups. INR values were relatively higher in the exitus group, yet they were not statistically significant. Blood coagulation parameters may produce more accurate results when assessed at normal body temperature[8]. Thus, we consider that our patients may have not been accurately assessed because of the presence of hypothermia. There was significant difference in blood transfusion among the two groups. However, plasma transfusion did not present significance. In our series, hypothermia, (core temperature <35ºC), acidosis (pH <7.2), instability relevant to SBP, and massive blood transfusion were found as predictive factors for mortality.

The decision to apply DCS is usually dependent on hemodynamical instability and coexistence of several conditions including the inability to provide the bleeding control, the inaccessible major vascular injuries, the extra time needed for suboptimal resuscitation, the presence of life-threating extraabdominal injuries, and the need for re-evaluating the abdomen[6,18]. Similarly, the DCS indications in our study were hemodynamic unstability, failure to provide intraoperative bleeding control and co-existence of life-threatening conditions including diaphragm and major vascular injuries.

Hepatic injury is known as the most common penetrating injury due to its anatomic localization and size[19]. Grade IV and V injuries are the most feared traumas for surgeons[20]. The patients in these grades are characterized with an associated shock characterized by acidosis, hypothermia, and coagulopathy[18,21]. Intraoperative application of the Pringle maneuver is quite useful in identifying arterial hemorrhage and biliary leakage[20]. The Pringle maneuver is reported as a safe procedure to be used for a period of 60-85 mins[22]. Adversely, Aydın et al[10] explained that this period should not exceed 20 mins since the hypoxia tolerance in the liver is very low due to the presence of hypovolemic shock. Embolization of the vascular structures, in which postoperative hemorrhage is radiologically detected, is reported as

useful[20,23]. The 83.3% of our patients were present with hepatic injury, of which 75% were either grade IV or V. In our study, technical deficiencies made it impossible to perform selective angiographic embolization through radiology, which was a restrictive factor for our procedure.

The packing procedure is the most important parameter that promotes surgical success in stopping massive hemorrhages[24]. Richardson et al[25] report that the packing procedure is able to reduce mortality by 1/3 when performed promptly. However, it has a two-way risk: it leads to hemorrhage when the compression is low and it leads to acute compartment syndrome when there is excessive compression[10]. Also, another problem is related to the timing of the removal of packs[26]. The success of packing procedure relies on early identification of the need for packs in hemorrhage control and correct timing of the removal of packs[24]. Relaparotomy usually takes place between the 24th and 48th hours in DCS. And it is reported that the removal of packs is performed between the 12th and 168th hours[13]. Nicol et al[9] suggest that the removal of the packs in the 24th hour may result in a larger hemorrhage than the removal in the 48th hour; yet, Caruso et al[27] hold that the possibility of hemorrhage may increase when packs are removed before the 36th hour. As suggested in the literature, the packs in our study were removed after the 36th hour. Re-packing was performed in one patient as the packing was insufficient. Abdominal compartment developed in three patients due to excessive packing, and the packs were removed via relaparotomy.

Postoperatively, more than half of the surviving patients are present with the potential risk of several complications including hemorrhage, intraabdominal abscess, sepsis, multiple organ dysfunction and biliary leakage[28,29]. Intraabdominal abscess and wound infection are possible to occur postoperatively at a rate up to 83%, depending on the trauma size and colon injury[30,31]. Intraabdominal abscess was also confirmed as the most common complication in our study; likely because of major trauma presentation in all the patients and Bogota bag implementation in some of them.

Depending on the trauma type and the surgical procedures performed, the mobilization and recovery periods in the postoperative stage may take a long time for the patient[10]. In the same way, the patients in our study had longer periods both in ICU and hospital stays when compared to the periods in other procedures.

This study is retrospective with a small number of patients and surgeon-dependent indications for DCS. For this reason, prospectively designed large series are needed.

Conclusions

Despite leading to high morbidity and mortality, DCS remains a life-saving procedure in severe injuries. The predictive factors associated with mortality are found as hypothermia (core temperature <35ºC), acidosis (pH <7.2), instability related to systolic blood pressure, massive blood transfusion and delayed admission.

Conflict of Interest

None to declare.

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