SAJS

Trauma

Predicting mortality in damage control surgery for major abdominal trauma

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Summary

Background. Damage control surgery (DCS) has become well established in the past decade as the surgical strategy to be employed in the unstable trauma patient. The aim of this study was to determine which factors played a predictive role in determining mortality in patients undergoing a damage control laparotomy.

Materials and methods. A retrospective review of all patients undergoing a laparotomy and DCS in a level 1 trauma centre over a 3-year period was performed. Twenty-nine potentially predictive variables for mortality were analysed.

Results. Of a total of 1 274 patients undergoing a laparotomy for trauma, 74 (6%) required a damage control procedure. The mean age was 28 years (range 14 - 53 years). The mechanism of injury was gunshot wounds in 57 cases (77%), blunt trauma in 14 (19%) and stabs in 3 (4%). Twenty patients died, giving an overall mortality rate of 27%. Factors significantly associated with increased mortality were increasing age (p=0.001), low base excess (p=0.002), pH ($p<0.001$), core temperature (p=0.002), and high blood transfusion requirement over 24 hours (p=0.002).

Conclusion. The overall survival of patients after damage control procedures for abdominal trauma was excellent (73%). The main factors that are useful in deciding when to initiate DCS are age, base excess, pH and the core temperature.

Over the past two decades, damage control surgery (DCS) rather than definitive repair of all injuries has become established as the appropriate surgical strategy in the severely injured patient needing operative intervention. This change has increased the survival rate after major trauma to over 50%.[1-6]

The term 'damage control' was defined by Rotondo *et al.*[4] in 1993 as 'initial control of hemorrhage and contamination followed by intra-peritoneal packing and rapid closure, resuscitation to normal physiology in the intensive care unit (ICU) and subsequent definitive re-exploration'. Two further stages have been added to the three traditional stages of operation, restoration of physiology and definitive surgery. These comprise the first stage, namely the decision as to when to perform DCS, and the final stage of abdominal wall closure.[7] However, little appears to have been documented on factors predicting mortality in this setting.

The aim of this study was to determine factors that may predict mortality in patients undergoing a damage control laparotomy.

Patients and methods

Seventy-four patients who underwent DCS for abdominal injury were retrospectively reviewed. All were admitted to the Groote Schuur Hospital Trauma Centre between January 2002 and December 2004. DCS was defined as an abbreviated laparotomy performed either because of poor physiological status or the extent of the injury, with definitive surgery to be performed 48 hours later after resuscitation in the ICU. The indications for DCS were major multiple and complex injuries, evidence of disseminated intravascular coagulation (DIC), a base excess greater than 10, a core temperature less than 35°C, and transfusion of more than 10 units of blood.

All patients admitted were resuscitated in accordance with treatment protocols outlined in the Advanced Trauma Life Support course (ATLS) of the American College of Surgeons.[8] All charts were reviewed and the data collected included age, sex, mechanism of injury, the Revised Trauma

Score (RTS), the Injury Severity Score (ISS), and the Penetrating Abdominal Trauma Index (PATI). Also included were the worst recorded values for core temperature, pH and base excess in the first 24 hours. The presenting haemoglobin concentration and the total number of blood transfusions over 24 hours were noted, as were the highest values for international normalised ratio (INR) and partial thromboplastin time (PTT) and the lowest value for platelets. The total number of operations required, duration of ICU and total hospital stay, and complications were recorded.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows, version 12.0 (SAS Systems International, Cary, NC, USA). The collected variables consisted of two different types of parameters: continuous and categorical. The chi-square test was used for the categorical variables, and the independent-samples *t*-test for the continuous variables.

The significant variables of both the chi-square test and the independent-samples *t*-test were used as input for the logistic regression to determine significance of sets of variables in relation to mortality. In all tests, a *p*-value <0.05 was considered statistically significant.

Results

Over the duration of this 3-year study, 1 274 patients underwent a laparotomy following trauma. Seventy-four (6%) of these patients required DCS. The mean age of these patients was 28 years (range 14 - 53 years). There were 64 males and 10 females. There were 133 organ injuries in these 74 patients, distributed as set out in Table I. The mechanism of injury was gunshot wounds in 57 cases (77%), blunt trauma in 14 (19%; 11 patients had been involved in motor vehicle accidents and 3 in train accidents) and stabs in 3 (4%).

Twenty patients died, giving an overall mortality rate of 27%. The mortality rates for gunshot wounds, blunt trauma and stab wounds were 28.0%, 28.5% and 0%, respectively.

Nine patients died in the ICU within 24 hours after the initial damage control laparotomy. An emergency re-look was necessary in 12 patients after a mean of 12 hours because of bleeding in 7 patients, abdominal compartment syndrome in 4 and bowel leakage in 1. Of these patients, 5 died within the next 2 weeks. Forty-nine patients (66%) underwent a planned re-look after a mean of 40.8 hours, and 3 (6%) of these patients died. Three patients died within 1 week after their initial DCS procedure, 1 from cardiac failure and 2 from head injuries.

The mean age of the patients who survived was 26 years, compared with 34 years in the non-survivor group. Increasing age was found to be a statistically significant factor predicting mortality, with a *p*-value of 0.001. The other pre-operative factors predictive of mortality are set out in Table II. These include low base excess (p=0.002), pH (p<0.001) and core temperature (p<0.001).

The postoperative factors that were predictive of mortality were the total number of blood transfusions required over 24 hours, the INR and the total platelet count (Table III). The factors that were not predictive of mortality are listed in Table IV.

In total, there were 147 complications. Forty patients developed DIC, 38 required inotropes, 21 were diagnosed with systemic inflammatory response syndrome (SIRS), 17 developed abdominal compartment syndrome, 14 were treated for nosocomial pneumonia, and 8 were treated for septic shock. The development of DIC (p<0.001), the need for inotropes (p<0.001) and the presence of septic shock (p=0.017) were found to be significant predictors of mortality.

Logistic regression analysis was undertaken to find out whether any of the parameters tested were independently predictive of mortality. In both the pre-operative and postoperative groups, only pH (p=0.001), age (p=0.006) and INR (p=0.046) were independent predictors of mortality.

Discussion

The main factors influencing outcome in trauma surgery are hypothermia, acidosis and coagulopathy. These three factors, also called the 'triad of death', can create a situation in which

TABLE I. ORGAN INJURIES IN 74 PATIENTS

Organ injured	Frequency
Inferior vena cava	**18**
Small bowel	**18**
Large bowel	**16**
Liver	**15**
Kidney	**14**
Spleen	**12**
Duodenum	**8**
Iliac vessels	**8**
Diaphragm	**7**
Bladder and ureter	**7**
Stomach	**6**
Pancreas	**4**

TABLE II. PRE-OPERATIVE FACTORS PREDICTIVE OF MORTALITY

Factor	Survivor (mean)	Non-survivor (mean)	*p*-value
Age (yrs)	**26**	**34**	**0.001**
Base excess	**–10.5**	**–16.3**	**0.002**
pH	**7.20**	**7.03**	**<0.001**
Temperature (°C)	**35.0**	**33.5**	**<0.001**

TABLE III. POSTOPERATIVE FACTORS PREDICTIVE OF MORTALITY

Factor	Survivor (mean)	Non-survivor (mean)	*p*-value
Platelets	**148.1**	**60.4**	**0.03**
INR	**1.8**	**2.5**	**0.02**
Blood units/24 h	**11.8**	**18.7**	**0.002**

TABLE IV. FACTORS NOT PREDICTIVE OF MORTALITY

Factor	Survivors	Non-survivors	*p*-value
Glasgow Coma Score (median)	**14**	**13**	**0.25**
Penetrating Abdominal Trauma Index (median)	**35**	**40**	**0.09**
Revised Trauma Score (mean)	**7.4**	**6.8**	**0.11**
Injury Severity Score (median)	**25**	**34**	**0.07**
Total operations (mean)	**3.4**	**2.7**	**0.24**
Hb (g/dl) (mean)	**9.3**	**9.2**	**0.90**
Mean ICU stay (d)	**10.4**	**9.2**	**0.72**

the physiological state of the patient will deteriorate very rapidly, leading to death. Hypothermia causes deterioration of coagulopathy and increases acidosis. A decreased temperature results in cold haemoglobin that cannot release its oxygen in tissues as readily as normothermic haemoglobin. In hypothermia, enzymatic function is decreased as well, resulting in a decrease in the rate of the cascade reaction and a decrease in the production of clotting factors. The adverse links between hypothermia and coagulopathy have been extensively reviewed.[9,10]

DCS is used in patients who would not survive regular surgery because of their physiological state. However, some patients do not survive DCS. Hypothermia, acidosis and coagulopathy have already been proven to be related mortality.[2,11-14]

Sharp and Locicero[12] showed that packing the abdominal cavity to prevent the development of acidosis, hypothermia and coagulopathy can be done safely. In their search for predictive factors for mortality, they found that a pH <7.18, temperature <33°C, PTT >50 and transfusion of 10 units or more of blood are highly predictive of outcome. Their study population consisted of 39 patients of whom the majority had been involved in traffic accidents; only 6 injuries were gunshot wounds.

Aoki and colleagues[11] performed a retrospective study to identify risk factors associated with mortality in 68 patients who underwent DCS. They found an overall mortality rate of 66% and concluded that inability to correct pH and PTT at the conclusion of initial damage control laparotomy may be predictive of death.

The incidence of DCS as a component of definitive surgery varies in the literature from between 8.9% to 18%.[15-17] In our study, 6% of laparotomies for trauma were DCS. Mortality rates for DCS have been reported to range from 26% to 67%.11,12,14,16,17 In our series, the mortality rate was 27%. The mortality rates for gunshot wounds, blunt trauma and stabs were 28.0%, 28.5% and 0%, respectively.

DCS is becoming an increasingly accepted form of surgery in the severely injured patient.[18] One of the most important key points is when to initiate DCS.[1] Many studies have been undertaken to determine the correct timing. Morris *et al.*[16] proposed early use of damage-control laparotomy in patients with temperatures of <35°C, base deficit worse than 14, and coagulopathy. Cosgriff *et al.*[19] stressed the importance of the damage control approach if coagulopathy is present. The conditions that predict its onset are hypotension, pH <7.10, temperature <34°C, and an ISS ≥25. Johnson *et al.*[15] proposed that a pH <7.30, transfusion requirement of 10 or more units of packed red cells with an estimated blood loss of >4 litres, and temperature ≤35°C in combination were trigger points to initiate DCS. Another study, which focuses solely on core temperature measurement intra-operatively using a dynamic computer simulation, showed that there is a window of opportunity of 60 - 90 minutes to salvage a patient before the temperature drops below 32°C.[20] Beyond this point, mortality is as high as 100%, as Jurkovich *et al.* described.[21] All the above studies agree that DCS is indicated when there is derangement of temperature, pH and coagulation but differ in respect of the specific values at which it should be initiated. It could therefore be proposed that DCS should be initiated according to severity of injury and early recognition of changes in core temperature, acidosis and coagulation.

Rutherford *et al.*[24] identified base deficit after logistic regression analysis as a parameter predicting mortality. In our study, pH remained a significant predictor for mortality after logistic regression. Base deficit, on the other hand, was only significant when the independent-samples *t*-test was used.

DCS is an effective method of managing the critically injured trauma patient. To prevent death, it is of crucial importance that the need for a damage control procedure is recognised as early as possible.

This study found that age, base excess, pH and core temperature were significant pre-operative predictors of mortality. DCS should be performed when the pH falls below 7.20, the base excess is under 10.5 or the core temperature is less than 35°C.

There were no sources of financial support.

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