



Abdelkader Boukerrouche*

Department of Digestive Surgery, Hospital of Beni-Messous, University of Algiers, Algiers, Algeria

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*Corresponding author: Abdelkader Boukerrouche, Department of Digestive Surgery, Hospital of Beni-Messous, University of Algiers, Algiers, Algeria, Tel: +213 661 22 72 98; E-mail: aboukerrouche@yahoo.com

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Review Article

Damage control surgery Concept

Abstract

Damage control surgery concept (DCS) consists of performing a staged surgery and allowing resuscitation in severe trauma patients who require surgical management. Initially, the DCS has been described in severe liver trauma associated with coagulopathy. Over time, Due to the observed advantages, the DCS approach has become standard practice for abdominal trauma with the extent to extra-abdominal trauma and acute abdominal emergencies. Currently, despite the widespread use by the surgical communities, the indications of DCS strategies have not been clearly defined in the absence of high data level and concerns have hence risen about the overuse and related adverse outcomes of DCS approach in surgical trauma patients. However, Advanced progress in trauma-resuscitation techniques have significantly improved the outcomes and reduced the requirement of DCS strategies in trauma injured patients. In sum, DCS remains an important strategy to surgically manage a specific cohort of patients. The continued research and development in trauma care particularly in patient resuscitation will likely lead to more further decreasing the DCS requirement in severe trauma patients.

Introduction

Traumatic injuries are the leading cause of mortality in people with age under to 44 years. The haemorrhage was the major preventable primary cause of death with 30–40% of fatalities in traumatically injured patients [1]. Definitive surgery for severe traumatic injuries in the patient with severely physiological disorders is reputed to be detrimental to the outcome and resulting in aggravating the injury and delaying the exhaustion of physiological storage that may cause death [2–4]. The main preoccupation of trauma surgeons was the early and effective control of primary injury and prevention of the secondary injury. The concept of damage control surgery (DCS) had been endorsed as an approach to optimize surgical treatment of severe trauma injured patients with severe physiological disorders and that require surgical intervention [3]. The DCS principles consisted of the early effective primary control of bleeding and abdominal contamination by performing abbreviated surgery; delaying definitive surgery and allowing patient resuscitation and stabilization. The definitive surgery will be achieved once patient physiology has almost been restored [5,6]. The DCS approach incorporates four components including [4]: (1) identification of the unwell trauma patient on the basis of injury characteristics and physiological disorders, (2) controlling bleeding and abdominal cavity contamination by performing abbreviated surgery, (3) continued resuscitation during operation and in the ICU by providing physiological restoration and vital organ support to optimize patient hemodynamic and correct acidosis, hypothermia and coagulopathy. (4) Performing definitive surgery in resuscitated

and stabilized patient. The DCS approach has demonstrated improved survival in critically trauma injured and choked patients [6,7]. This approach is currently estimated to be required in 10% of patients with trauma injuries [8,9]. Despite the several advantages, the patients required DCS approach are subjected to multiple surgeries, prolonged ICU stays and may develop abdominal compartment syndrome with acute respiratory distress and multiple organ failure [10]. Clearly, the benefits of the DCS strategies depend on the appropriate indication by selecting the correct patients. As a results research on trauma care specifically the patient resuscitation, the damage control resuscitation (DCR) has been added to DCS approach. This new concept of resuscitation incorporates the early and more aggressive correction of coagulation and metabolic disorders with restriction of isotonic fluids and rapid administration of blood components [11–15]. These advances in early trauma resuscitation have increased the rate of definitive surgery during the initial operation.

History and evolution of damage control surgery concept

The concept of the DCS emerged from the clinical achievement of liver trauma management in the later 1970s [16,17]. As a favourable result from clinical experiences and observations, staged laparotomy with perihepatic packing to achieve haemostasis became widespread in liver trauma [16,17]. However, the benefit of intra-abdominal packing and delayed definitive surgery on patient survival in liver trauma has been proved later in 1981. Uncontrolled bleeding and refractory coagulopathy had been also identified as the major

cause of death of liver trauma patients [18,19]. In fact, the peri-hepatic packing technique has been advocated as a life-saving method in severe liver trauma with refractory coagulopathy [20,21]. So the fundamental objective of staged laparotomy and delayed reconstructive surgery has been to rapidly allow the patient physiology restoration and coagulopathy correction. In penetrating abdominal trauma, the benefit of staged surgery on patient survival has firstly been outlined in 1983 [22]. Compared to definitive laparotomy, staged surgery has been associated with a benefit on survival in patients who developed intraoperative coagulopathy, and the definitive surgery has been completed once the coagulation returned to normal level [22]. In addition to coagulopathy, it has been observed that death was exacerbated by hypothermia and metabolic acidosis. Therefore, emphasizing hypothermia and metabolic acidosis have been proposed as key factors to promote lethal coagulopathy [4]. A decade after and in 1993, the concept of 'Damage Control Surgery' has been clearly described in trauma care by Rotondo et al. by outlining the three-phase approach [6]. This three-phase approach consisted of, staged surgery with the first control of bleeding and intestinal content spillage, patient physiological restoration and optimization, and performing definitive surgery on resuscitated and stabilized patient [6]. The staged surgery for induced injury coagulopathy was widely accepted as a care practice in trauma patients [7,23,24]. Furthermore, patient survival has markedly been improved by the implementation of this practice approach (DCS) in major abdominal trauma injuries [6,7,23,24]. The patient resuscitation was considered as a crucial step of the damage control surgery concept. It must be started in the emergency room and continued in the intra and postoperative period. However, the shocked patient with major trauma who received excessive fluid volumes (crystalloids) experienced a subsequent pulmonary and intestinal tissue oedema [25,26]. In addition to intestinal oedema and large volume resuscitation, a tightly packed and closed abdomen led to increasing the intra-abdominal pressure and the development of the abdominal compartment syndrome (ACS) [27,28]. The reported ACS incidence was superior to 30% and associated mortality was greater than 60% in major trauma patients [24]. The death resulted from ACS complications such as respiratory, renal and cardiac failure. Over time, the combined use of open abdomen surgery and modified traumatic shock resuscitation techniques have increasingly reduced the incidence of lethal ACS syndrome [29]. Therefore the prevention of the lethal ACS constitutes the greatest documented achievement of the modern post injury critical care. Over the last 10 years, the research conducted on ACS and advances in trauma shock resuscitation had led to adding the damage control resuscitation approach (DCR) to the damage control paradigm. Compared to previously described resuscitation, the DCR consisted of early and more aggressive correction of coagulopathy and metabolic disorders. The isotonic fluid restriction for plasma volume expansion, permissive hypotension, early and rapid administration of blood components to correct post-traumatic coagulation disorders are the key concepts of the DCR [11]. DCR allows the restoration of normal patient physiology and early correction of the post-

traumatic bloody vicious cycle, facilitating the completion of definitive surgery at the first operation with reduced perioperative morbidity and improved outcomes [13,15,30]. This strategy starts in the emergency room and continues during the surgical procedure and in the ICU [12]. The DCS is now considered as a component of DCR and its benefit is now well demonstrated in the context of DCR. Indeed DCS combined to DCR form the modern trauma care continuum. [31,32]. The recently published reports (2011) showed the clear benefits of DCS on survival in injured patients who have been managed with DCR compared to conventional resuscitation methods [33]. Also, the stay length in ICU has increasingly been reduced in patients requiring DCS and managed with DCR [30]. DCR implementation in a specifically selected patient who required emergency surgery for trauma has significantly decreased the need for DCS laparotomy and reduced mortality and increased the rate of definitive surgery at the first operation in level 1 trauma centre [34]. The shift towards performing complete surgery was associated with significant reductions in health care costs and resources utilization. Additionally, important studies reported higher rates of primary abdominal closure in the context of DCR approach [35,36]. More recently and related to continued advances in trauma care, the DCR strategies have reduced the need for surgical haemostasis in severe liver trauma (>20%) by the direct address of trauma-induced coagulopathy, increased the rate of definitive surgery and reduced the need for DCS approach in a critically injured patient [37].

Damage control surgery indications and current evidence data-base

The DCS has become a standard approach in trauma care only on the basis of clinical experiences and observations. Until 2014, and due to the lack of high evidence level from the published studies comparing DCS approach to immediate definitive surgery, the DCS practice has not been validated in major abdominal trauma [38]. Indeed the indications for DCS were historically based on patient factors (physiology reserve, comorbidities), injury factors (blunt vs penetrating trauma, peritoneal contamination, major bleeding), physiological parameters ('lethal triad of trauma' -hypothermia, acidosis, coagulopathy), and treatment factors such as resuscitation requirements (volume and type of administered fluids) and expected duration /physiological effect of definitive care [31,38,39,40]. In addition, the PH level, hypothermia, administered volume fluid and transfusion have been showed to be sensitive indicators of patient prognosis [41,42]. The indications for damage control strategies have been increased with the growing opinion that these strategies should be made early, prior to irreversible physiological compromise [43]. Despite its accepted benefits, the overuse of DCS in trauma practice has resulted in augmentation of complications and resource utilization [44]. These variations in the indication of DCS were attributable to the lack of consensus on the appropriate use of this treatment approach among the surgical community [45]. Regarding the large variations in the indications of the DCS strategies, a panel of trauma surgery experts reviewed the peer-reviewed papers published between 1983 and 2014 in order

to synthesize and rate the appropriateness of DCS indications in surgical practice for civilian trauma [41]. The studies involving exclusively non-civilian trauma, neurological and orthopaedic injured population are excluded from analysis. The report of trauma surgery expert panel suggested that the indications for DCS should be defined on the basis of several factors including the preoperative transfusion of more than 10 units of PRBCs, administration of more than 12l of PRBCs/ whole blood/ other blood product/ crystalloids during the pre and intraoperative phase, bleeding uncontrollable with conventional treatment methods, and the degree of physiological disorders as demonstrated by pre or intraoperative hypothermia (<34.88C), acidosis (pH<7.2) and/or coagulopathy (prothrombin time and partial thromboplastin time >1.5 x normal and the absence of visible blood clots during operation/ diffuse oozing from all injured tissues) . Specific injury characteristics as severe multiple injuries (ISS ≥25), associated severe hemorrhagic shock (diastolic pressure <70 mmHg) on admission, abdominal and thoracic compartment syndrome were also an indication to DCS. The prolonged operative procedure more than 90 min with partial response to resuscitation was interestingly considered as an indication for DCS. Difficulties to make the appropriate decision regarding the treatment priorities in the presence of severe and complicated injury and limited technical conditions. In sum, the DCS approach should be applied in the presence of the previously described prognosis factors, and the surgical management strategy must be based on the dynamic response to resuscitation rather than the patient physiology indicators or injury characteristic at the presentation. Due to the absence of high-level evidence data regarding the appropriate indications, a recent report (2017) highlighted the inconsistent use of the DCS approach with significant variation across tertiary trauma centres [46]. However, the damage control strategy remains primordial in the management of shocked patients or those not responding to intensive resuscitation. As acknowledged by authors, the benefits of DCR on patient physiology and survival in trauma care currently constitute a domain of active investigation and clinical research [14,47-49]. Therefore, further original research studies are required to validate the indications of the DCS strategy on the basis of evidence-based results.

Damage control surgery and abdominal emergencies

The DCS strategies have been widely used in abdominal trauma injuries with well-demonstrated benefits on patient survival. During the last 15 years, efforts have been made to manage the patients presenting acutely surgical abdominal emergencies associated with a physiological compromise by using the DCS approach [50]. However, the published results of a few studies with a reduced sample of the population are preliminary and inconclusive regarding the definitions and principles of DSC strategies in the context of surgical abdominal emergencies [51,52]. Oppositely, published individual experiences on the DCS approach, showed real benefits on patient survival [53,54]. Therefore, despite the lack of evidence-based data, the trends towards the adoption of DCS strategies in abdominal surgical emergencies are comparable to those seen in the damage control orthopaedic approach (DCO) for trauma care before its spread and acceptance as a treatment strategy in orthopaedic trauma.

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