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REVIEW

Damage control: Concept and implementation



B. Malgras^{a,h,1}, B. Prunet^{b,1}, X. Lesaffre^{c,1},
G. Boddart^d, S. Travers^c, P.-J. Cungi^b, E. Hornez^e,
O. Barbier^f, H. Lefort^c, S. Beaume^b, M. Bignand^c,
J. Cotte^b, P. Esnault^b, J.-L. Daban^g, J. Bordes^b,
E. Meaudre^{b,h}, J.-P. Tourtier^{c,h}, S. Gaujouxⁱ,
S. Bonnet^{e,h,*}

^a Service de chirurgie viscérale, hôpital d'instruction des armées Bégin, 69, avenue de Paris, 94160 Saint-Mandé, France

^b Fédération anesthésie-réanimation-brûlés, hôpital d'instruction des armées Sainte-Anne, boulevard Sainte-Anne, 83000 Toulon, France

^c Brigade des sapeurs-pompiers de Paris, 1, place Jules-Renard, 75017 Paris, France

^d Service de chirurgie thoracique et vasculaire, hôpital d'instruction des armées Percy, 101, avenue Henri-Barbusse, BP 406, 92141 Clamart cedex, France

^e Service de chirurgie viscérale et générale, hôpital d'instruction des armées Percy, 101, avenue Henri-Barbusse, BP 406, 92141 Clamart cedex, France

^f Service de chirurgie orthopédique et traumatologique, hôpital d'instruction des armées Bégin, 69, avenue de Paris, 94160 Saint-Mandé, France

^g Service d'anesthésie-réanimation, hôpital d'instruction des armées Percy, 101, avenue Henri-Barbusse, BP 406, 92141 Clamart cedex, France

^h École du Val-de-Grâce, 1, place Alphonse-Laveran, 75230 Paris cedex 05, France

ⁱ Service de chirurgie digestive, hépatobiliaire et endocrinienne, hôpital Cochin, 27, rue du Faubourg-Saint-Jacques, 75014 Paris, France

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Summary The concept of damage control (DC) is based on a sequential therapeutic strategy that favors physiological restoration over anatomical repair in patients presenting acutely with hemorrhagic trauma. Initially described as damage control surgery (DCS) for war-wounded patients with abdominal penetrating hemorrhagic trauma, this concept is articulated in three steps: surgical control of lesions (hemostasis, sealing of intestinal spillage), physiological restoration, then surgery for definitive repair. This concept was quickly adapted for intensive care management under the name damage control resuscitation (DCR), which refers to

* Corresponding author at: Service de chirurgie viscérale et générale, hôpital d'instruction des armées Percy, 101, avenue Henri-Barbusse, BP 406, 92141 Clamart cedex, France. Fax: +33 1 41 46 61 69.

E-mail address: bonnet.stephane2007@gmail.com (S. Bonnet).

¹ Brice Malgras, Bertrand Prunet and Xavier Lesaffre contributed equally to the authorship of this manuscript and should be considered co-first authors.

Remote damage control resuscitation;
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Lethal triad

the modalities of hospital resuscitation carried out in patients suffering from traumatic hemorrhagic shock within the context of DCS. It is based mainly on specific hemodynamic resuscitation targets associated with early and aggressive hemostasis aimed at prevention or correction of the lethal triad of hypothermia, acidosis and coagulation disorders. Concomitant integration of resuscitation and surgery from the moment of admission has led to the concept of an integrated DCR-DCS approach, which enables initiation of hemostatic resuscitation upon arrival of the injured person, improving the patient's physiological status during surgery without delaying surgery. This concept of DC is constantly evolving; it stresses management of the injured person as early as possible, in order to initiate hemorrhage control and hemostatic resuscitation as soon as possible, evolving into a concept of remote DCR (RDCR), and also extended to diagnostic and therapeutic radiological management under the name of radiological DC (DCRad). DCS is applied only to the most seriously traumatized patients, or in situations of massive influx of injured persons, as its universal application could lead to a significant and unnecessary excess-morbidity to injured patients who could and should undergo definitive treatment from the outset. DCS, when correctly applied, significantly improves the survival rate of war-wounded.

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Introduction

The mortality of war-wounded patients follows a tri-modal distribution: 60% of the wounded die at the pre-hospital level, mainly from lethal neurological injuries, uncontrollable hemorrhage or acute respiratory distress; 30% die within hours of hospital admission; and 10% die in the days following admission, secondary to infectious complications and multi-organ failure (MOF). Over the last thirty years, a special effort has been made to reduce the mortality of war-wounded patients, with the development of a sequential surgical strategy for the rapid restoration of a normal physiology rather than a strategy of definitive repair: this is the concept of damage control surgery (DCS). This therapeutic strategy is articulated in three steps: a first-phase abbreviated surgical procedure aimed at control of the bleeding or leaking lesions; a second phase of physiological restoration; and then a third delayed surgical phase during which lesions can be treated definitively and anatomically [1].

Having become a proven concept in surgery, the principle of DC has been extended to resuscitation under the term damage control resuscitation (DCR), whose aim is the prevention and treatment of coagulopathy in order to obtain the necessary conditions for acquiring and maintaining surgical hemostasis. Thus, DCR relies mainly on targeted hemodynamic resuscitation and early and aggressive hemostatic resuscitation aimed at fighting against the lethal triad of hypothermia, acidosis, and coagulation disorders. Subsequently, DCR has been extended beyond the hospital walls to pre-hospital resuscitation. DC is now integrated into pre-hospital practice and has evolved in an efficient and original way to guide the pre-hospital care of the most serious traumatized. Thus, DC management is now proposed from the moment of encounter with the injured person in the field, to initiate the control of hemorrhage and hemostatic resuscitation as early as possible. This has evolved into the concept of remote DCR (RDCR) [2].

Concept of damage control

Definition

The term damage control comes from the US Navy and was described in the 1940s for control of battle damage to ships.

It describes measures taken in three phases: rapid repairs to keep the ship afloat, return to port, and finally definitive repairs. Rotondo et al. introduced the concept of DC to the management of medical and surgical emergencies in 1993 [1]. The application of DC has allowed an increase in the survival of war-wounded patients with penetrating hemorrhagic abdominal trauma for whom rapid control of hemorrhage and peritoneal contamination is combined with hemostatic packing and temporary closure of the abdomen rather than definitive and complete treatment of the lesions. As in the naval context, the sequence, is articulated in three phases:

- initial surgery for lesion control (hemostasis, coprostasis, aerostasis);
- physiological restoration;
- surgery for definitive repair.

Initially described for visceral surgery under the term of abbreviated laparotomy, the principle has subsequently been widely applied to other surgical specialties. It is during the first stage that the gestures of DCS are properly performed. The duration of the surgical procedure should be less than 60 minutes, with performance of gestures that are summary or even temporary and are essentially aimed at achieving hemostasis, coprostasis and aerostasis without definitive closure of the patient. The philosophy is to privilege physiology and homeostasis over an exhaustive anatomical repair, *ad integrum*, which can be deleterious in patients with massive trauma. During the second stage, resuscitation continues with the objective of correcting physiological disorders, mainly hypothermia-acidosis-coagulopathy. Finally, the third re-operative stage is carried out 24–48 hours later, once the patient has stabilized, in order to achieve definitive repair.

Why adopt a damage control strategy?

Serious trauma and the resulting hemorrhagic shock are the roots of what is traditionally described as the lethal triad of Moore [3] or bloody vicious circle, composed of hypothermia, acidosis, and coagulopathy: this is the first hit. Trauma also initiates a systemic inflammatory response syndrome and a compensatory anti-inflammatory response syndrome whose intensity is proportional to what can be called the initial traumatic stress burden. If this traumatic burden exceeds a certain threshold, the response is inadequate and may lead to the multi-organ failure syndrome (MOFS) or to

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