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# Damage Control Surgery in Severe Trauma

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**Abstract**

*"The operation was successful, but the patient died."* A statement every surgeon has heard, but hopefully, did not involve his or her patient. It bears a tragic yet simple truth: even the best surgeons "need" to operate on a patient who is fit enough to survive surgery. This holds especially true in trauma surgery, where patients may arrive with very poor health conditions. The physiological stress of massive trauma may be further increased by surgery leading to decompensation and subsequently death. Damage control surgery is a concept of treatment that limits additional surgical stress to a minimum, thus giving the patient time to recover. This article was presented at the *Kosova College of Surgeons First Annual Clinical Congress* in September 2021 and aims at giving a short overview.

**Keywords:** abdominal trauma, damage control surgery

## Introduction

Trauma is the leading cause of death in younger populations, but affects people irrespective of age and other comorbidities**.** [1] Severe trauma is defined as "*significant injury or injuries that have potential to be life-threatening or life-changing."* [2] A prospective observational study from North America observed an incidence for severe traumatic injury of 37.4 per 100.000 people with a median case fatality of 46.8%. [3] Mechanisms of injury vary regionally and can be blunt or penetrating.

## (Patho-)Physiology of severe trauma

Trauma affects not only the injured organ or region, but also leads to a pathophysiological response and thus may affect the whole body and its vital functions. Usually, an average patient can handle these strains. At a certain breaking point, however, these impacts can lead to a significant physiological stress. Thus, severely traumatized patients not only suffer from the sustained injuries, but also from massive derangement of physiological processes that need to be addressed.

*Trauma Triad of Death:*

The pathophysiology of severe trauma most importantly focuses on coagulopathy, hypothermia, and acidosis which, when encountered together, have been described as the *Lethal Triad* or *Trauma Triad of Death* (Fig.1). While each of these conditions in itself is serious, the combination leads to a vicious cycle. [4,5]

**Hypothermia:** Core temperatures below 35°C are considered clinically relevant and have been shown to decrease survival rates. [6] Causes for hypothermia usually include prolonged exposure to ambient temperature, active bleeding, and hypovolemic shock. Hypothermia leads to decreased clot formation and thus contributes significantly to coagulopathy and prolonged bleeding. [7,8]

**Acidosis:** Acidosis is a consequence of inadequate tissue perfusion and anaerobic metabolism as encountered in hypovolemic shock. It negatively impacts coagulation by increasing fibrinogen consumption while prolonging clotting times. [8,9]

**Coagulopathy:** Bleeding is often the starting and end point of fatal trauma. Hemorrhage leads to shock, which leads to acidosis and hypothermia. Hypothermia and acidosis further impact coagulation which then leads to more bleeding. Additionally, exsanguinating patients loose whole blood: *i.e.*, platelets, plasma and hemostatic factors (apart from red blood cells). While initial resuscitation may focus on mere fluid and RBC (red blood cell) supplementation, the continuous loss (or dilution) of coagulation factors needs to be addressed early, before a hypocoagulative state has been reached. [10]

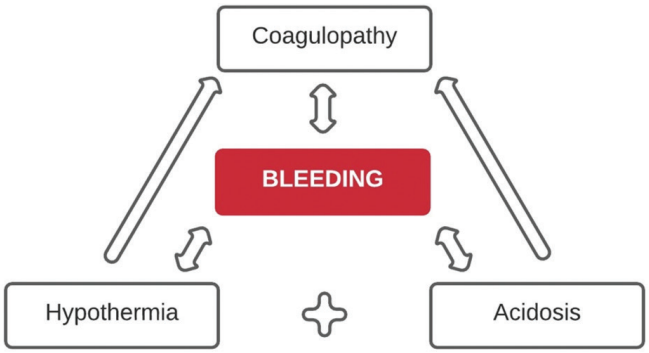



**Fig.1:** Trauma Triad of death

## Damage control surgery

Damage control surgery (DCS) describes a treatment concept that aims to minimize the initial surgical intervention in physiologically frail (*i.e.* "unstable" or even dying) trauma patients, thus allowing for stabilization. [11] Surgical intervention is limited to stopping active bleeding and controlling sources of contamination (*e.g.* perforated bowel). Definitive repair is postponed until the patient has been stabilized by ICU (intensive care unit) treatment.

**For whom?** DCS should be entertained in severely affected, poly-traumatized patients. However, while DCS may be life saving for the severely injured patients, it may lead to significant morbidity. Thus, it should not be applied too liberally. After reviewing the available evidence and an appropriateness rating by international experts, Roberts *et al.* [12] identified the following indications for DCS in civilian trauma patients (shown in Table 1).

**Table 1.** Indications for DCS according to [12]

| |
|---|
| Severe physiological injury: |
| Hypothermia, acidosis, and/or clinical or laboratory coagulopathy pre- or intraoperatively |
| Persistent intraoperative cellular shock* |
| Development of intraoperative ventricular arrhythmias |

* Oxygen consumption index <100 mL/min/m2, lactate >5 mmol/L, pH <7.2, base deficit >15 mmol/L, and core temperature <34°C.

| |
|---|
| Inability to control bleeding by conventional methods |
| Amount of resuscitation provided<br>A large volume of PRBCs (packed red blood cells) (median >10 U) or PRBCs, other blood products, and crystalloids combined (median >12 L) were administered preoperatively or across the pre- and intraoperative settings |
| Complex injury pattern identified during operation<br>Difficult to access major venous (intrahepatic, retrohepatic, retroperitoneal, or pelvic) injury<br>Major liver or combined pancreaticoduodenal injury with hemodynamic instability in the OR<br>Combined pancreaticoduodenal injury with massive hemorrhage from the head of the pancreas<br>Devascularization or massive disruption of the duodenum, pancreas, or pancreaticoduodenal complex with involvement of the ampulla/proximal pancreatic duct and/or distal CBD |
| Need for staged abdominal or thoracic wall reconstruction<br>Inability to close the abdominal or thoracic wall without tension because of visceral edema<br>Signs of an abdominal or thoracic compartment syndrome develop during attempted abdominal or thoracic |

Additionally, DCS may be considered when operative times overrun 60 to 90 minutes, as well as when human and material resources are lacking or are restricted (*e.g.* in mass casualties).

**Outcome of DSC:** Due to its emergency character and thus near impossibility for randomization, little high-quality data exist on DCS. Rotondo *et al.* [11] retrospectively compared patients with penetrating trauma undergoing definitive repair at laparotomy to DCS. In the most severely injured subgroup of 22 patients with major vascular trauma and two or more visceral injuries, DCS showed statistically significant higher survival rates (10/13; 77% *vs.* 1/9; 11%; $p < 0.02$) when compared to definitive repair. Concerning long term results, a prospective study on 88 consecutive patients undergoing DCS for blunt and penetrating trauma found a survival rate of 71.6%. Approximately, 81% of the 66 survivors were able to go back to work.[14]

***Stages of DCS:***

**STAGE 0: Damage control resuscitation**

DCS is inseparable from damage control resuscitation (DCR) - the analogue concept in the field of resuscitation. [15,16] The hallmarks of DCR are early identification of patients at risk; permissive hypotension; and proactive prevention of coagulopathy by replacement of lost blood either by whole blood or a 1:1:1 ratio of RBC, plasma, and platelets. [16-18] Coagulation can be monitored by using *thromboelastograms* and substituting fibrinogen and other clotting factors accordingly. Excessive use of crystalloids should be avoided, as it has been shown to increase the risk for dilution coagulopathy, abdominal compartment syndrome, and multi-organ failure. [19,20]

Pre-hospital and emergency room management should aim at starting resuscitation as early as possible, while keeping the time to surgical intervention to a minimum. Early recognition of patient in, or at risk for developing, shock is paramount. Special attention must be paid to prevent or counteract acidosis, coagulopathy, and hypothermia.

**STAGE I: control bleeding and contamination**

The aim at this stage is to do no more than is needed as quickly as possible: stop the bleeding and control the contamination. All injuries that can be repaired later should not be addressed. Patients are draped to access both thighs, the whole abdomen, as well as the chest.

***Hemorrhage control:*** Depending on the available information on trauma mechanism and radiological studies (*e.g.,* ultrasound, computed tomography), certain bleeding sites can be suspected. After trauma laparotomy, systematic packing of all quadrants should be performed. Then, step by step, each quadrant is assessed. Bleeding vessels without risk for ischemic sequelae can be ligated and "non-vital" organs (*e.g.* the spleen) can be resected. Large vessels, or those critical for organ perfusion (*e.g.* superior mesenteric artery), need to be shunted or repaired. Diffuse (venous) oozing areas can be controlled with pressure in combination with hemostyptic agents. Large vessels and arteries need to be controlled surgically, while smaller venous bleedings and/or ongoing oozing due to coagulopathy can be temporarily controlled by abdominal packing in combination with medical optimization. Ongoing bleeding in difficult to reach regions (pelvis, retroperitoneum) may also be controlled by selective angio-embolization (SAE).

***Source control*** After hemostasis has been achieved, the abdominal cavity must be thoroughly searched for sources of contamination. Hollow viscus injuries should be controlled by simple suturing or – in case of extensive injury – by stapling off the perforated or devascularized

segment and leaving the ends closed. Special attention must be paid to appropriate control of the mesentery: ongoing bleeding must not be overlooked. Anastomosis or stoma should not be performed at this stage. To avoid massive backlog, a nasogastric decompression tube should be inserted if the gastrointestinal tract is left in discontinuity. Biliary as well as genitourinary injuries may be controlled by external drainage (*e.g.,* with a T-tube). Laceration to the pancreas should be drained adequately. These procedures should be followed by an extensive washout using warm saline.

Stage I is completed by temporary abdominal closure (TAC). The abdominal wall is left open to avoid the development of an abdominal compartment syndrome and facilitate definitive repair after successful ICU resuscitation. While several commercial negative wound pressure therapy products are available to temporarily cover the abdomen, a simple and less expensive method is the so called *sandwich technique* [21]: an abdominal swab, covered with an adhesive plastic drape on one side, is placed inside the abdominal cavity with the plastic side facing the bowel. Two suction drains are placed on top, followed by another layer of an abdominal swab. Lastly, the sandwich is finished by another adhesive incision drape covering the skin and the open abdomen in an airtight manner (Fig. 2).

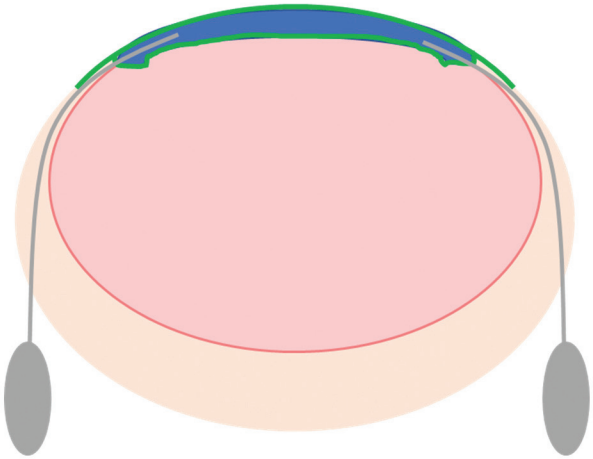


**Fig. 2:** Schematic depiction of the sandwich technique - blue: abdominal swabs; green: self-adhesive plastic sheet; grey: suction drains.

**STAGE II: ICU**

After temporized surgical control of ongoing bleeding and contamination, physiological restoration of the patient has to be achieved at the ICU. This includes:

- Rewarming of the patient
- Improving oxygen delivery and tissue perfusion (resuscitation with blood products and fluids, if necessary)
- Monitoring and correction of acidosis and coagulopathy

Abdominal compartment pressures should be monitored. The ICU is a good place to reevaluate the patient and repeat the secondary examination for any missed injuries. While the patient stabilizes, a definitive plan for surgical repair has to be drawn. If surgical expertise is lacking, transfer to another institution or consultation of specialists should be considered.

**STAGE III: second look and – if possible – definitive repair**

Surgical re-exploration can be attempted 24-48 hours post injury. However, timing strongly depends on the status of the patient. If reoperation is performed too early, it may result in a backlash of instability pushing the patient back in to a deathly triad. Late reintervention however puts the patient at a higher risk of infection as well as bowel distension and inability to close the abdominal wall among other possible risks. Thus, the ideal timing has to be decided on a case-by-case basis. Ideally, reintervention should be performed, or at least be attended, by the same surgeon. After removal of the packs, a systematic exploration of the whole abdomen has to be performed once more to screen for any missed injuries. At this point several decisions have to be taken: is definitive repair feasible? Can the abdomen be closed or not? Is other expertise needed? Even if definitive repair of injuries can be achieved, delayed closure of the abdominal wall and/or the soft tissue may be necessary.

**Conclusion**

DCS is a concept for patients *in extremis* that aims at saving a dying patient by temporizing severe injuries and delaying time consuming definitive repair procedures. Medical optimization and correction of physiological derangement (acidosis, hypothermia, anemia, coagulopathy) at the ICU stabilize the patient to allow definitive surgery to be undertaken safely. This concept should be known to every general surgeon working in an acute care setting.

**Conflict of Interest Disclosure Statement**

The authors declare no conflict of interest.

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