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Damage Control Surgery: A Strategic Resource!

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ABSTRACT

Introduction: damage control surgery is a surgical strategy, applicable to traumatic and non-traumatic patients, in a context of severe physiological instability, addressing a complex surgical situation in stages. Objective: experience of the strategy of damage control surgery in trauma surgery, complicated elective surgery or a non-traumatic surgical emergency. Method: retrospective, longitudinal, observational and descriptive study. Reviewing the records of patients treated surgically applying damage control surgery, for 5 years. Results: 21 of 221 patients were documented applying the strategy, 9.95%, 19 were men (90.47%), 2 women (9.53%) with an average age of 25 years, range 17 to 64 years. Discussion: hemorrhagic shock is the most common immediate cause of death in trauma and requires immediate and coordinated action to reverse it. When there are few resources or limited infrastructure, trauma surgeons take the options of resuscitative thoracotomy and/or abdominal packing, at lower costs. Observations: the surgical technique of damage control surgery and the reasons that support it for the first time are detailed; coining innovative terms such as: "damage control surgery cycle", "planned hemostatic compression", "infection containment" Conclusions: damage control surgery is an effective, economic, and ethical strategic resource, which, if well carried out and allowed by the case, saves human lives and with an early closure cycle reduces morbidity, without sequelae and mitigates mortality.

Keywords: Damage control surgery, Planned hemostatic compression, Surgical strategy, Surgical technique, Infection, Hemorrhagic shock.

INTRODUCTION

Surgery is as old as the human being, the word surgery in its etymological root is derived from the greek that means "to work with the hands". The technology and innovation in surgery of these times has been the result of constant evolution, whose origin dates to the Neolithic to the end of the stone age. In prehistory there were three types of medicine: 1) Instinctive. 2) The empirical. 3) The magical-religious. It was then empirical medicine that was practiced as a product of experience: as the trepanation of the skull to relieve pain or as rest after a fracture; etc. [1] The watershed between prehistory and history occurs in the year 1976 B.C. found in the Hammurabi code, which describes 10 norms and 282 rules on the practice of medicine, in its application and punishments for malpractice, especially that referring to surgical interventions. In the Edwin Smith Papyrus 1540 B.C., it was found that the Egyptians limited themselves to healing wounds, removing small external tumors or splinting fractures, without going any deeper. [2] Surgery as a profession from the beginning was classified more as a manual art than as a science. After almost 300 years of frustrated attempts by surgeons to regulate their university training, in 1540 king Henry VIII of England accepted that the surgeon-barbers of the time could enroll in the faculties of medicine, with the aim of acquiring a university and scientific training. [3] Advances in anesthesia methods, asepsis, antisepsis, the invention of

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gloves, improvements in blood transfusion techniques, and the discovery of antibiotics finally made surgery safer until just the second half of the twentieth century. [4, 5]

Currently, the surgical evolution focuses on options such as damage control surgery (DCS), which is defined as a surgical strategy applied to traumatic and non-traumatic patients, in which, in a context of severe physiological instability, a complex surgical situation is addressed in stages, aiming in the first intervention to save the patient's life even without solving all the injuries and [6, 7] that in addition, surgery should be completed quickly after controlling the bleeding that can threaten life and avoiding contamination (infection and sepsis) and then reaching the correction of physiological abnormalities and a definitive management, aimed at avoiding the lethal triad, where massive bleeding ends in acidosis, hypothermia and coagulopathy. [8] The origin is from an idea resulting from a U.S. Navy military strategy called "damage control", a coined term that was defined as "the ability of a ship to absorb damage and maintain mission integrity". [9]

The origin of the DCS strategy in Surgery dates back to 1976 with the publication of Lucas and Ledgerwood, where they refer to the use of temporary internal compresses with a second to third subsequent surgical intervention (an experience that was reported only in 3 patients). Later it was published by Feliciano in 1981 applying this strategy in 10 patients; [10, 11] but it was not until Retondo in 1993 who coined the term DCS in his publication with a practice applied in 46 patients during a 3-year study, where overall survival improved markedly in patients treated with DCS; concluding to be a promising approach to increase survival in exsanguinating patients with significant vascular penetrating abdominal lesions and/or visceral multiples. [12]

OBJECTIVE

To present the experience of the Surgery services, of the strategy applied in DCS surgeries, in the different classes such as: trauma surgery, complicated elective surgery or non-traumatic surgical emergency, during 5 years of surgical practice, in a multicenter study.

METHOD

It is a study with a retrospective, longitudinal, observational and descriptive design. The records and files of all patients surgically treated with the DCS strategy in trauma surgery, complicated elective surgery, and non-traumatic surgical emergency, during a period of 5 years of surgical practice, are reviewed in a multicenter study in three hospitals in Mexico City and the State of Mexico, which are:

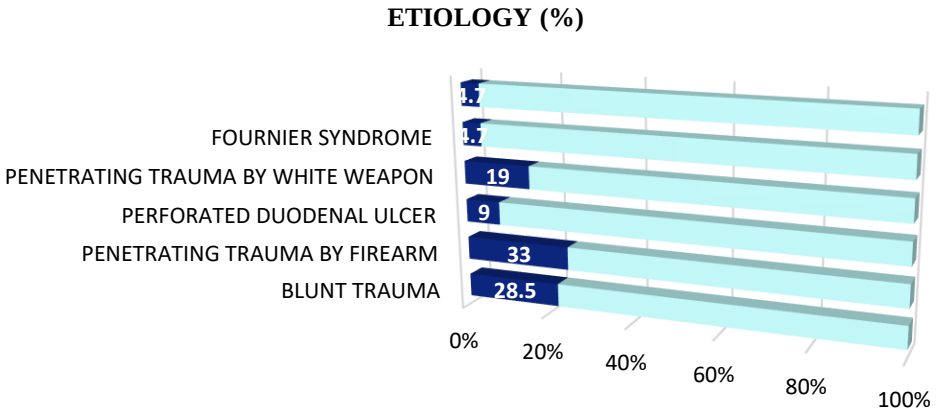
1. Specialty Hospital of Mexico City "Dr. Belisario Domínguez" of the Ministry of Health. Mexico City. Country: Mexico. 3rd Level of medical care.
2. "Dr. Rubén Leñero" General Hospital of the Ministry of Health. Mexico City. Country: Mexico. 2nd Level of medical care.
3. "Las Americas" General Hospital of Ecatepec. State of Mexico, of the Ministry of Health of the State of Mexico. Country: Mexico. 2nd Level of medical care.

In the study period that comprised from January 2020 to January 2025. Age, sex, etiological and surgical diagnosis, pathological history and associated factors, previous surgical treatments/number of surgeries/complications/sequelae, quantified bleeding, surgical time, days of hospital stay and including the intensive care unit support service, morbidity and

mortality were documented. With a follow-up of each patient upon discharge from the hospital, a week, a month or the time necessary until their definitive discharge. The study and presentation of the results is carried out using descriptive biostatistics procedures.

RESULTS

A total of 211 files were reviewed, of which 168 cases (79.62%) were men and 43 women (20.37%), with an average age of 28 years, in a bimodal value of 21 and 53 years. Of this study group, only 21 patients were documented where the DCS strategy is performed, representing 9.95% of these cases 19 were men who represented 90.47% and 2 women who were 9.53% with an average age of 25 years and range from 17 to 64 years. With a diagnostic etiology as diverse as that of an elective/or scheduled surgery that becomes urgent due to its evolution, emergency surgery of first instance in a first surgical time or in a subsequent one, by non-traumatological emergency surgery and/or with open/closed abdominal trauma due to accident/aggression by third parties. The etiology, diagnosis, number of surgeries, initial or subsequent, where the previous surgery was scheduled or urgent, the previous surgical technique if any, and the complications that justified the use of the DCS strategy are specified in table and graph 1.



Graph 1

Table 1: Etiology/Diagnosis/Previous Surgery/Number of Surgeries/Initial/Subsequent in the Total Number of Patients Where Damage Control Surgery is Performed From 2020 to 2025 in the Three Hospitals, Expressed in Number/Percentage.

Etiology/Diagnosis/Number of Surgeries/Initial/Subsequent/Previous Surgical Technique/Urgent or Not	Number/%
Blunt Trauma/Liver Injury/3/Si/Hepatic Rafia+Packing/Yes	6/28.57
Penetrating Gunshot Trauma/Mesenteric Injury, Renal, Spleen/5/Si/Bowel Resection, Nephrectomy + Colon Control With "Drawstring" + Packing/Yes	7/ 33.33
Perforated Duodenal Ulcer/Perforated Gastric Ulcer/6/No/Bilrroth Ii/ Packing/No	2/ 09.52
Penetrating Stab Trauma/3/Si/Suprerenal, Splenic and Renal Cava Injury/3/Si/Packing/Si	4/ 19.09
Fournier Syndrome/9/Non/Debridement and Surgical Lavage, Colostomy+Packing/No	1/04.76

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Pancreate Pseudocyst/4/No/Yeyunogastroanastosis/Packing+Gastrostomy, Jejunostomy/No	1/04.76
Total Number of Patients	21 / 100

First, the etiology of the initial diagnosis due to blunt or penetrating trauma where DCS was applied was carried out in 17 cases, representing 80.95%, and in an urgent/emergency surgery. The remaining group of patients was performed in 4 patients, which are 19.04%, considered as complications of an initial emergency surgery (second surgery) or elective surgery.

The pragmatic surgical action or decision to apply DCS was carried out in the 19 cases representing 90.47%, due to the main cause/factors involved in this strategy, which are:

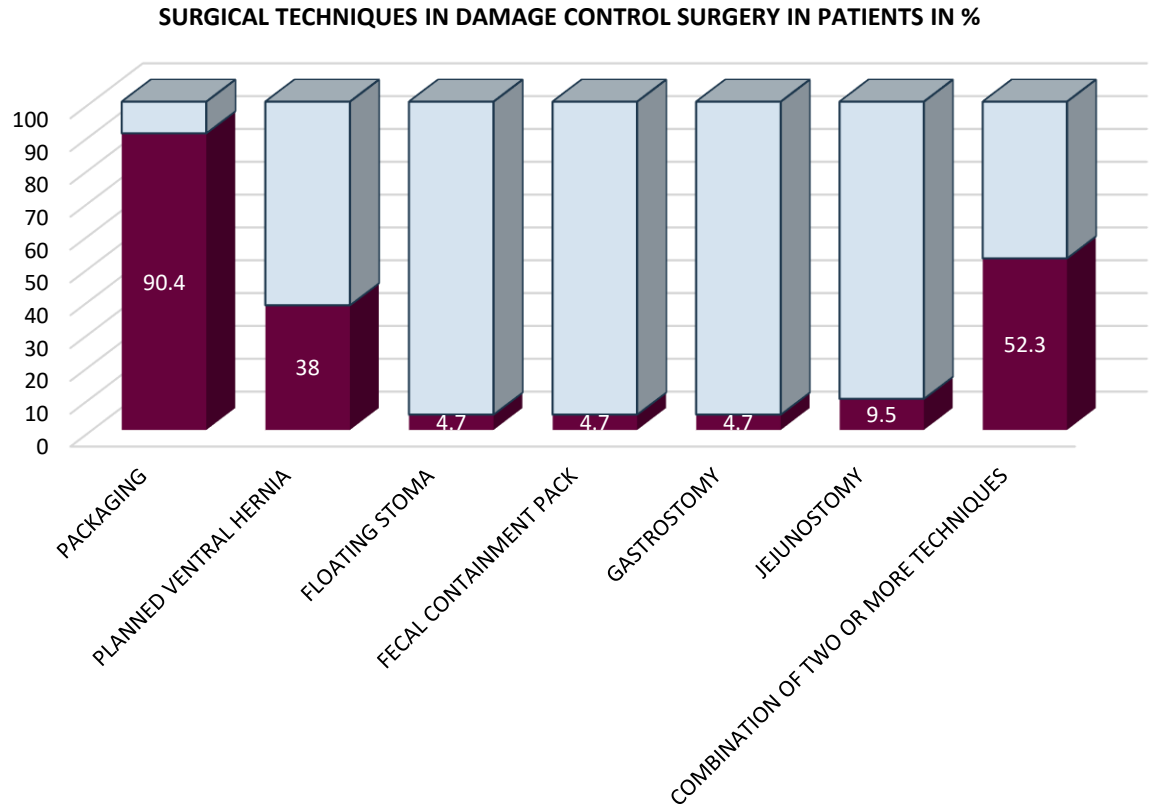
1. Uncontrollable bleeding or "continuous bleeding in layer".
2. The individual presents with hemodynamic instability due to a state of hypovolemic/septic shock III/IV.
3. And the great lack/absence of resources or supplies, such as the lack of red blood cells at that time, substitutes/derivatives/hemostatic agents, systemic/topical, etc.

Only in 3 patients of the DCS, representing 14.28%, it was carried out for infection control, fecal contamination, septic shock that potentially or with an increased risk, that occurred with hemodynamic instability and that due to the lack of supplies or resources, temporary closures or tactical drains were carried out.

A total of 96 patients underwent surgery on a total of 96 occasions, with a range of 2 to 9 procedures, where the average of patients of traumatic etiology in the initial surgery (healthy, young and uninfected subject) was especially 2 surgical procedures, without added morbidity. The exponential increase in surgeries was most reflected, with an average of 6 per patient, were the cases that occurred with a lack of control of the infectious process already installed in a severe way (septic shock, perforations or the so-called enteroatmospheric fistulas). [13] The tactics of the surgical techniques of the DCS that were adapted/conditioned in each of the patients are listed and mentioned, according to the case that is estimated or assessed at that time of the surgical act, being pointed out in table and graph 2:

Table 2: The Tactics of The Surgical Techniques Applied to Damage Control Surgery in Patients from 2020 To 2025 of the Three Hospitals, Expressed in Number/Percentage.

Surgical Techniques Applied in Damage Control Surgery	Number/%
Packaging	19/90.47
Planned Ventral Hernia	8/ 38.09
Floating Stoma	1/ 04.76
Fecal Containment Drawstring	1/ 04.76
Gastrostomy	1/04.76
Yeyunostomia	2/09.52
Combination of 2 or More Techniques	11/52.38
Total Number of Patients	21 / 100



Graph 2

In most individuals, a "packing" is planned with an incidence expressed as a percentage of 90.47% and at the same time a giant planned ventral hernia is performed with the technique of subcutaneous polyethylene bag or "Blanco bag" [14, 15] in 3 cases (37.5%) or only skin closure in 5 cases (62.5%). See Figure 1.

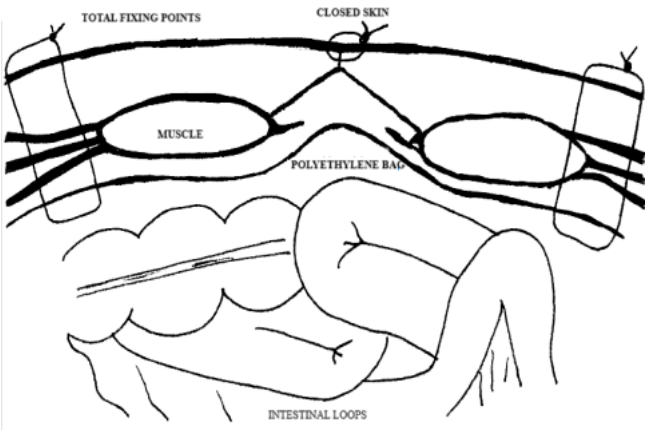


Figure 1

"Placement of the subcutaneous polyethylene bag. Polyethylene contains the intestinal loops and is fixed by 4 to 5 total points. The aponeurosis is open, and the skin is closed above the polyethylene." Figure taken from the reference: Martínez-Ordaz J.L., Cruz-Olivo P.A., Chacón-

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Mora E., et al. Management of the abdominal wall in sepsis. Comparison of two techniques. Journal of Gastroenterology of Mexico. 2004; 69(2): 88-93. [15]

And by frequency, in third place was the creation of jejunostomy in only 2 patients (9.52%). Two unusual adaptations or surgical techniques, such as the creation of a floating stoma in one case and the fecal containment jar in the colon in another patient. **See Figure 2.**

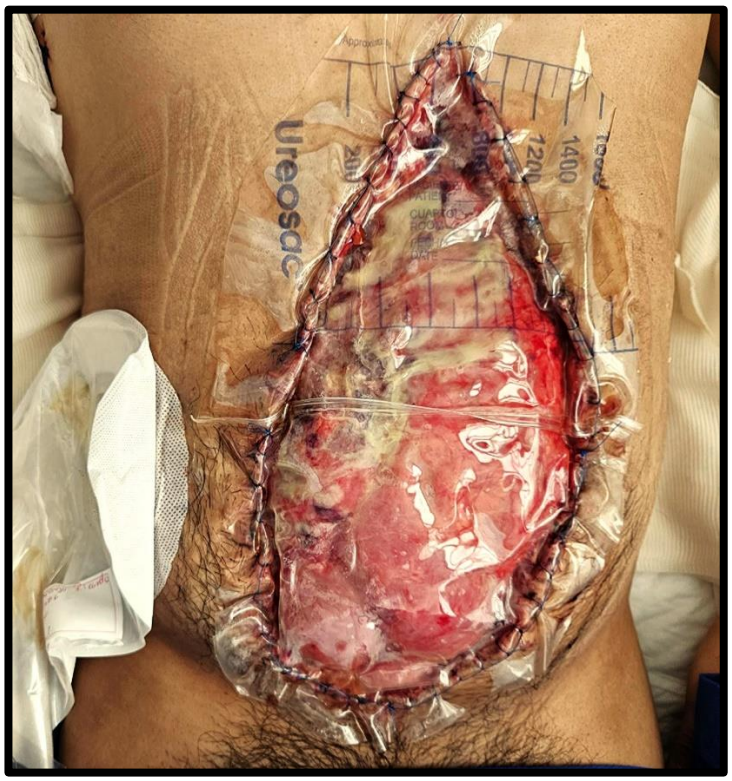

Figure 2

Open abdomen with Bogota bag. A 24-year-old male underwent elective surgery for intestinal reconnection of the terminal ileus (terminal ileostomy) with transverse colon anastomosis, with anastomotic leakage at 7 days: with surgical reoperation with primary closure of the intestinal anastomosis and a third surgery for intestinal perforation in another site with primary closure of the intestine equally and the abdomen open.

Regarding chronic-degenerative diseases/comorbidities in this study group where the DCS strategy is established, the first place is occupied by obesity in 5 patients (23.80%), in second place by diabetes mellitus in 3 patients (14.28%) and third place by arterial hypertension in 2 (9.52%) cases.

Regarding the time of surgical reintervention, it ranged from 48 to 72 hours in the vast majority of patients, however, one patient lasted up to 30 days (due to a planned ventral hernia and floating stoma), with a range of 48 to 718 hours, in common reintervention is prioritized until an average of 60 hours after the initial surgery where the DCS strategy was applied; patients without trauma etiology and with previous surgery, and where hemodynamic deterioration of the patient and what causes it is evidenced, are concluded in two options: massive hemorrhage

(hypovolemic shock) or perforation with secondary infection (septic shock). In addition, the reinterventions, repacking, bleeding reported by surgery and in total, the effectiveness of the strategic tactic applied, their combination and the last reintervention that concludes the DCS surgical strategy *closing the cycle*, at the discretion of the surgeon, are documented. The eight patients who were left with giant planned ventral hernias who are reoperated on up to a year or more are discarded.

Regarding the total documented bleeding, several factors must be considered that alter the total real values:

1. The blood loss that occurred at the time of the trauma until surgical care.
2. What is sequestered or stored in the virtual spaces of the abdomen or clots (anterior and retroperitoneal space) or of the extremities in the muscular interfacial spaces or in the fascicles themselves.
3. Hemorrhage as such in the surgical procedure, as a cause (which is not individualized).
4. The removal of a lower or upper extremity, organs from the abdomen, the blood calculated or contained as normal within that organ, etc.

The above is expressed in **Table 3**:

Table 3: Characteristics that are Detailed in Each Surgical Tactic, Where Damage Control Surgery is Performed on Patients from 2020 to 2025 in the Three Hospitals, Expressed in Number/Percentage.

Time/Total Bleeding/Effectiveness/Final Reoperation	Number/%
60-72 Hours/1,750 Milliliters/If/Packing/Non-Repacking	19/90.47%/0
72 Hours/If/1,300-1,750 Milliliters/If/Controlled Eventration/Priority Wall Closure	8/ 38.09%/3/37.5%
718 Hours/Yes/390 Milliliters/Floating Stoma/Yes/Temporal Stoma/Colostomy	1/ 04.76%
48 Hours/550 Milliliters/Si/Fecal Containment Colon Drawstring/Temporary Stoma/Colostomy	1/ 04.76%/1
504 Hours/Yes/250 Milliliters/If/Temporary Gastrostomy	1/04.76%
618 Hours/Yes/380 Milliliters/Yes/Jejunostomy/Temporary	2/09.52%
24-718 Hours/380-1,750 Milliliters/Si/Combination of Two or More Techniques	11/52.38%
Total Number of Patients	21 / 100%

The quantified bleeding in surgery must be performed correctly, as accurately as possible or as close to reality as possible; it is imperative to weigh clots, compresses and gauze impregnated with blood as well as surgical drapes, subtracting the water or fluids entering the surgical field (which are now made of plastic, they do not absorb, break and drain or transmit any substance since most are not impermeable or modifiable to size or shape, which greatly limits their quantification). Scales graduated in milligrams/corrected or adjusted to milliliters must be available, an aspirator reservoir completely graduated in milliliters; personnel such as instrumentalists or competent surgical and circulating nurses (who quantify the entry of fluids into the surgical field such as water or other substances); in addition, it should be taken into account that it is not real to account for what is spilled on the table and on the floor of the surgical room, etc. All the above is not done in any operating room known to the authors. In

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addition, in Mexico it is calculated by habit or dogma, by the doctor specializing in Anesthesiology empirically at his or her discretion, emotion and/or experience. All the above observations yield values of suspicion or relative quantifications in terms of truth. Table 3 shows hemorrhage values that average 480 milliliters, with ranges from 250 to 1,750 milliliters, pointing out that 90.47% of the DCS was due to continuous or incoercible bleeding or what is called in colloquial language "layer hemorrhage". And the surgical technique of "packing" is performed, which in most cases is combined with a planned/controlled eventration for a timeless wall closure (planned ventral hernia) in the short term or in the long term at the discretion of the Surgeon, which was used in up to 38.09%. The effectiveness of the so-called "packaging" was 100% in all patients, despite the variations in the technique of its applicability. Finally, DCS tactics were carried out at the time of surgery, which were adopted according to each specific patient, such as the creation of stomas (colostomy, ileostomy, floating stoma), jars, gastrostomies and/or jejunostomies, achieving their conjunction with very good results and for the benefit of the patients. See Figure 3.

Figure 3

The Wittmann patch as a method of late abdominal closure prevents loss of address and facilitates primary closure of the abdominal wall. Image taken from the reference: Galindo F., et al. Open abdomen indications, management and closure. Encyclopedia of Digestive Surgery www.sacd.org.ar Volume I, 148: 1-21 [16]

The *DCS cycle* in most patients where the strategy was used is explained by the author, in three possible processes: *application, early cycle closure or late cycle closure*.

1. The urgent etiology that led to the use of the DCS strategy in the first surgery: *application*.
2. Surgical reintervention or second priority surgery at 48 to 72 hours, where the effectiveness of the applied DCS tactic is evaluated, with complete cure in this second surgical time: *"Early Cycle Closure".*
3. The culmination of 100% total hemostasis of the patient, with no slope or surgical pathology to resolve. > to 2 surgeries: *"Late Cycle Closure".* It may have been planned/projected in the long term by the Surgeon in several subsequent surgeries or also due to the same failure of the surgical tactic for the same cause or consequence,

causing a new packing for the second or even third time, or due to other complications such as: intestinal perforations, creation of stomata, open abdomen, etc.

An average surgical time of 51 minutes was legitimized, with ranges from 15 to 184 minutes, and this numeral was extended by previous elective/scheduled surgeries, before the DCS strategy, or a posteriori at the end of the DCS surgical cycle.

The morbidity of the patients in this study is shown in table 4.

Table 4: Morbidity Reported in the Surgical Strategy of Damage Control Surgery from 2020 To 2025 in the Three Hospitals, Expressed in Number/Percentage.

TYPE OF MORBIDITY	NUMBER/%
Healthcare-associated pneumonia	4 /14.81
Trachoectomy	5 /18.51
Insuficiencia renal aguda	6 /22.22
High-output intestinal fistula	1 /03.70
Open/catastrophic abdomen	1 / 03.70
Urinary tract infection	3 /11.11
Open/hostile abdomen	5 /18.51
Stoma complications	2 /07.40
Total	27/29.62

Morbidity was described by the events or complications that patients experienced in number and percentage with the application of the DCS strategy, in the understanding that a single case or individual can present 2.3 or more complication events, concluding that there was a total of 27, so the risk of each patient is calculated with an incidence in morbidity of up to 29.62%. But the total detected in this study was 8 patients and representing 38.09%.

The days of in-hospital stay documented from the patient's admission to the emergency room or to the intensive care unit or on the operating floor, presents an average of 9 days with the range of 7 to 43 days. The patient spent an average of 8 days and a range of 6 to 18 days in the intensive care unit were tabulated in the intensive care unit. The reported mortality was nil, until the time this manuscript was completed.

DESCRIPTION OF THE SURGICAL TECHNIQUE: DAMAGE CONTROL SURGERY

In the perception of the author Dr. Morelos Adolfo García Sánchez:

Directions

1. The *"packing"* or *"planned hemostatic compression"*: of a patient in the trans operative is a criterion/decision of the Surgeon, although the main cause is that of a massive, continuous and incoercible hemorrhage and/or called "layer bleeding" (due to consumption of coagulation factors) which in the vulgar is identified as such.
2. The *"Control of the causal contamination of exponential and continuous infection"*

Factors or Conditions

1. And that at the same time the patient in question has hemodynamic instability and/or no response to aggressive fluid/blood products/medication therapy.

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2. Or that there is the impossibility of continuing the surgical procedure, due to lack of supplies: sutures, grafts, vascular balloons, catheterization, contrast medium, vascular probes, blood products, substitutes for topical hemostatic agents, systemic agents, etc.

Description of the technique *"Planned hemostatic compression"* (packing): in the scenario of a trans operative incoercible hemorrhage with prior possible hemostatic control and contamination and/or infection. Prior to the closure of the abdominal cavity. 3 to 4 moist and well-squeezed compresses are placed (it will depend on the size of these, the patient's constitution) around continuous bleeding. With the prior placement of sterile plastic to isolate the textiles from the fabrics or in some cases even the use of gloves that wrap them, thus avoiding the adherence of the compress to the native tissue and its laceration or trauma. The abdominal cavity is usually closed with the muscular aponeurosis with continuous surgete, as well as skin with anchored surgete and without leaving any type of drainage.

In 48 to 72 hours, depending on conditions or factors, the patient is reoperated to remove the foreign bodies that were left planned.

Description of the technique *"Containment of infection"* in the scenario of fecal/intestinal contamination that could perpetuate an infectious process; the use of an umbilical band is performed by placing a drawstring to the colon or small intestine, with the aim of absolutely and immediately containing its effusion, avoiding contamination or the perpetuity of an imminent infectious process. On the other hand, the use of a stoma in the feasible case (where only the intestinal loop is externalized) and "matures" in the next surgery or in the patient's bed locally. Finally, the use of drains is an auxiliary/immediate/simple measure for an adjuvant/palliative objective.

In 48 to 72 hours, depending on conditions or factors, the patient is reoperated.

DISCUSSION

Hemorrhagic shock is the most common immediate cause of death in trauma and requires immediate and coordinated action to reverse it, in this already published study protocol DCS was performed with packing in 33.8%. patients with a success rate in hemostasis of 84.02% and repacking was necessary in 5.4%. [17, 18]

In the management strategy in trauma surgery where DCS is applied, the following statements should be conscientiously considered to reduce morbidity and mortality: [19]

(a) Selective hypertensive resuscitation (SBP target >70 mm Hg or MAP target >50 mm Hg) not indicated in case of brain injury.
(b) Prevent and control hypothermia (temperature <36°C) [20]
(c) Reverse anticoagulation
(d) Correcting acidosis
(e) Treatment of hypocalcemia [21]
(f) Trauma-Induced Coagulopathy
(g) The administration of tranexamic acid and low levels of vasopressin dosage, (a strategy to decrease the amount of blood loss and reduce the risk of transfusion with the use of antifibrinolytic medication. [22]

When there are few resources or limited infrastructure, trauma Surgeons take the options of a resuscitative thoracotomy and/or abdominal packing, also considering the lowest costs. [23] However, when endovascular balloon occlusion of the aorta is available, this possibility leads to higher survival rates than resuscitative thoracotomy. [24] It is important to consider this endovascular surgery option with sufficient diagnostic and treatment benefits. [25]

On the other hand, protection of the spine during emergency surgery is of utmost importance to reduce injuries secondary to the injured spine. Imaging, especially nuclear magnetic resonance, is useful for decision-making regarding the surgical management of the affected spine. Early decompressive surgery (within 24 hours of trauma) is associated with better neurological outcomes. [26] Recent geopolitical events must be considered today, which require preparation for the possibility of high-intensity conflicts, such as modern injury agents, which consist mainly of explosive devices and high-velocity projectiles. Every trauma Surgeon should be familiar with the specific mechanisms of injury of armed conflict. Initial care for these injuries is based on the correct application of DCS to save the patient's life, save their limb if possible, and preserve their function. [27, 28]

Once active bleeding is identified, bleeding control techniques should be implemented expeditiously. Depending on the known or suspected source of the hemorrhage, with the application of techniques such as compression bandages, placement of a tourniquet, placement of a pelvic girdle or performing an endovascular occlusion with balloon of the aorta. [29] Decision-making, which consists of limb salvage or amputation with the goal of preserving the patient's life, is conducted by applying orthopedic principles of damage control, with the goal of minimizing surgical duration, bleeding, and achieving rapid and early stabilization of the fracture through temporary measures. such as external fixation, fasciotomy and even a vascular shunt. [30, 31] However, it has been reported that performing a DCS in patients with lesions in the small intestine or in the emergency colon, mortality, readmissions, and postoperative septic complications were studied and that they did not change during the research period, although the results were that the incidence of preoperative septic shock increased, length of stay decreased, while mortality remained unchanged. [32]

In addition, health care projects have been carried out in conjunction with DCS, such as the U.S. Army, which uses small surgical teams deployed on the front lines to provide surgical care in austere environments, with the aim of performing resuscitation and DCS in the event of a high-casualty incident, where time is the first critical factor in preventing both morbidity and mortality. The second factor is the capacity of a deployed surgical team to coordinate surgical care. [33] Success in DCS is not always possible with a hybrid approach, such as what has been reported for the purpose of combining endovascular therapy and direct surgical intervention on the carotid artery in the neck.

- The initial treatment included resuscitation with fluids and blood transfusion, with continuous manual compression to control profuse bleeding.
- A balloon catheter is placed to achieve better bleeding control. (however, he continued to bleed)

Cardiovascular surgeons performed direct surgery and clearly detected damage to the anterior and posterior walls of the artery. [34]

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DCS is also applied in penetrating head trauma, which is usually treated less aggressively due to low expectations of a good recovery, where the fundamental concepts in the critical care management of moderate and severe head injuries focus on relieving intracranial pressure, avoiding hypotension and hypoxia. Intracranial tamponade is performed in damage control neurosurgery to mitigate severe intracranial hemorrhages, which can be a neurosurgical maneuver that saves lives, and then the patient is transferred to be surgically operated on by the specialty of neurosurgery and treated intensively in a third level of medical care. [35]

OPEN ABDOMEN

Previous work has been reviewed in DCS by means of the open abdomen, where the author (in the year 2007) Timothy C. Fabian: divides or classifies it into stages, with specific actions for each of them:

- **Stage I:** Where the rapid termination of laparotomy before definitive surgical procedures and to allow resuscitation of the coagulation system, shock and hypothermia in the intensive care unit are mentioned.
- **Stage II:** The projection of a planned ventral hernia. When prosthetic material is inserted in stage I, patients recover, and which will allow gradual closure of the abdomen or else may develop varying degrees of multiple organ dysfunction or sepsis.
- **Stage III:** Definitive reconstruction of the abdominal wall. [36]

Similarly, the use of resuscitation in cases of trauma that incorporates endovascular occlusion with balloon resuscitation of the aorta has been compared to standard care for the management of severe bleeding with DCS, finding mortality due to hemorrhage without significant differences. [37] Although DCS has its historical origins in orthopedic pathology, where timely intervention for wound debridement and joint stabilization plays a crucial role, it is important to plan multiple surgeries and a multidisciplinary orb. [38] In massive and difficult abdominal wall defects requiring complex reconstruction of the abdominal wall itself, which pose a major surgical challenge in the presence of significant comorbidities, the most consistent independent predictors of adverse outcomes were emergency surgery requiring damage control laparotomy, extensive adhesion lysis, and severe adhesion lysis. obesity, Centers for Disease Control and Prevention class of contaminated wound, loss of abdominal dominance and delayed wound closure. [39]

The first question is, what is the indication to leave the patient with an open abdomen? Regarding the response of intentionally performing controlled exposure of the viscera of the abdomen are variable, relative, or with the appropriate infrastructure none, the following possible causes are listed: [40]

- Abdominal compartment syndrome: absolute indication. [41] It is described as intra-abdominal pressure with a sustained value >20mmHg, associated with multiple organ failure. However, if the resource is available from the beginning of closure with vacuum-assisted aspiration (VAS), it is no longer an ignominious morbid evolution. Where it has been successfully achieved the complete fascial closure of the abdomen in up to 76%. [42]
- The physical loss or impossibility in the patient by technique of a safe or possible closure of the abdominal wall or by necrotizing fasciitis of the wall; this is relative since it can be modified with the VAS and by the joint management with reconstructive plastic surgery

(this is not real in Mexico, since the specialty of Reconstructive Plastic Surgery does not do it). [42, 43]

- The relative indications that will depend on the experience/knowledge of the Surgeon and the infrastructure itself that is available:
    - DCS in trauma surgery [44]
    - Sepsis abdominal [45]
    - Isquemia intestinal [46]
    - Vascular surgery [47]

In addition, if the patient has an open abdomen, it becomes a high risk or is condemned to disastrous or fatal complications; a mortality of up to 53% has been reported in the literature, without it being possible to evaluate the morbidity, the quality of life of the patient and even the cost to the health system, thus being a true Armageddon to take this option or behavior inappropriately called "therapeutic", in the opinion of the authors of this manuscript. Therefore, this behavior should be abandoned or reduced to the slightest expression, it should only be justified if the underlying pathology endangers the patient's life, so it is concluded that it is only recommended in a surgical emergency. [40]

MASSIVE TRANSFUSION

When humans lose 40% of their blood volume, they develop profound hypovolemic shock. Replenishing the lost volume with resuscitation fluids and blood products leads to further dilution. At the beginning of this century the initial replacement of bleeding was similar in elective surgeries or exsanguination scenarios, coagulation tests were used to guide blood product orders and, while waiting for these results, aggressive resuscitation with crystalloids was recommended. The high mortality rate in severe bleeding justifies the so-called "Damage Control Resuscitation" (DCR). [48] Prehospital resuscitation with blood products, such as whole blood or dry plasma in their absence, has the potential to improve outcomes in patients with hemorrhagic shock, due to storage, transport, and administration issues in field settings; the functional and structural properties of lyophilized plasma represent a viable alternative to conventional plasma in DCR, offering significant logistical and storage advantages for prehospital and remote applications, especially in scenarios where whole blood is not available. [49] It is now well established that minimal crystalloid administration should be used, as they are fatal at large volumes, as blood components are not available and are proven to cause: [50]

- Intestinal edema
- Retroperitoneal edema
- Abdominal compartment syndrome
- Acute respiratory syndrome
- Intensified bleeding due to clot disturbance
- Coagulopathy established by over dilution of plasma
- Electrolyte disturbance
- Multiple organic dysfunction
- Increase in mortality

Coagulopathy in massive transfusion in patients traumatized by previous surgery or other causes, although infrequent, is associated with increased mortality; traditional tests to assess coagulation status are limited by the slow time to obtain results, do not evaluate all phases of

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coagulation, and are not predictive in nature. [51] There must be specific regulations for the use of whole blood, with an established mass transfusion protocol, and then the patients do not develop the so-called traumatic coagulopathy, where the most appropriate conduct or measure is to replace blood by blood with the aim of euvolemic resuscitation. [52] Baseline hemoglobin significantly predicts massive hemorrhage, as part of the massive transfusion protocol and therefore hemostatic surgery in cases with hemorrhagic shock, where a cut-off value of 11.45 g/dl is used in 79% of cases in a study of 2,731 trauma patients. [53]

Massive transfusion is defined as administering to the patient ≥ 10 units of red blood cells in 24 hours, it is common to apply this strategy as documented in a study that was carried out in 1,029 patients, and where 651 cases (63.3%) did require it. [54]

Rapid and definitive control of bleeding is the main objective in the treatment of patients with active bleeding. DCR is the current pillar to improve survival in this group of patients. Whole blood resuscitation and/or balanced component therapy should be initiated in the prehospital setting and adjuncts, such as early fibrinogen administration (cryoprecipitates) and calcium replacement, should begin immediately upon arrival in the trauma ward as part of the DCR. [29]

REMARKS

1. The *"Planned Hemostatic Compression"* (packing), does not cause any compartment syndrome, nor any abdominal hypertension, since the volume occupied by 3 to 4 textile compresses is less than one liter, and the abdomen suddenly has the capacity to purify, catabolize or have an anabolism of 9 liters on average of gastrointestinal fluids, adding the intake or increase of the gastric chamber from 500 ml to 1000 milliliters, urine 300 to 500 milliliters, fecal matter in 3 liters. With an average of the sum of all the above in 6 liters circulating, of sudden and adaptive volume increase; all the above supports this argument.
2. In *"Planned Hemostatic Compression"*, for congruence, no type of drains should be placed due to the continuous loss of fluid, volume and consequently due to loss of pressure, the main objective of this strategy. Unless this drainage is isolated, controlled and does not impact on the volume/pressure loss due to the underlying pathology. (Cecostomy, jejunostomy, gastrostomy, etc.)
3. *"Planned hemostatic compression"* (packing), the abdominal cavity should always be closed for the following reasons:
   - A planned compression is evident that consequently the objective of hemostasis will be met, giving the opportunity to improve the patient's conditions and have the possibility of protocolizing it, of planning and correcting as much as possible or eliminating the factors that increase morbidity/mortality and thus, gives the opportunity to definitively resolve the surgical pathology that caused its genesis.
   - Avoid retraction of the muscle fascia/aponeurosis and resign as much as possible a planned giant ventral hernia that causes more morbidity and a new long-term reoperation with an evident permanent physical sequela, even surgically repaired in the best hands, with the highest technology, with the best supplies and projecting an adequate evolution.
   - Protection from complications: perforations (the so-called "enteroatmospheric fistulas") and infections such as peritonitis, fasciitis, tissue necrosis, dermatitis; or

paralytic/post-surgical ileus, poor fluid control and hemostasis (hypothermia and insensible leakage).

4. DCS is a set of surgical strategies applied with a certain number of surgical interventions; 2 on average, however, can be more; and that gives the option or possibility of palliating/renouncing the cause of the patient's hemodynamic instability at that time, in a very short time and giving the patient the opportunity to live. Preparing afterwards or planning the best conditions for an optimal closure of the cycle, without morbidity and without mortality as the case allows.
   - The *cycle of DCS* will depend on each case, but the objective is to close *the cycle early*, prioritizing it, since for obvious reasons it decreases morbidity, costs and increases the possibility of recovering the patient's health almost 100% manifested in their quality of life a posteriori. Saving the lives of patients and without sequelae or taking it to its slightest expression.
   - The *cycle of DCS* carried out in a *late cycle closure* is the cause of a multiple and variety of morbidities that counteracts the objective of the strategy, since the factors, conditions, comorbidities or chronic pathologies become exponential in the long run, since it is remembered that the patient is an integral entity, for example:
     - Depletion of nutritional reserves, affecting healing, immunity, etc.
     - Tissue wear, weight loss, lability to opportunistic or nosocomial infections
     - Metabolic uncontrol of diabetes mellitus, high blood pressure, etc.
     - Lack of control of patients' mental state such as depression, stress, anxiety, psychosis, etc.

     This consequently generates greater morbidity, greater sequelae and higher cost, with much less benefit to the patient, to the institution and that impacts the family economy (impossibility to work and generate resources) and institutional. With devastating sequelae, rehabilitation and decrease in work skills (planned ventral hernia, a permanent stoma or both) condemning the patient to limitations and permanently affecting their quality of life.
5. Most patients presenting with "abdominal sepsis" with abdominal distention and "intestinal edema" due to purulent, fecal or chemical peritonitis or the combination of two of the three were formerly listed as candidates for the management of the open abdomen. However, when resolving the cause of sepsis or its control with adequate palliation in DCS, by means of an energetic and exhaustive surgical wash, together with the placement of drains in strategic places and the use of catheters: nasogastric/bladder to empty the virtual spaces; together with the early initiation of frequent empirical antibiotic therapy and finally, cooperation and/or participation in the surgery of the relaxation of the patient by the Anesthesia service in the closure of the cavity, the closure of the abdominal cavity of the patients is achieved.

Finally, the DCS is a strategy and should not be confused as a failure of the surgeon's expertise, but as a heroic, ethical, intelligent and effective action, in the face of limitations as only being a human actor.

However, the patient is given the opportunity to stay alive and prepare him for a new surgical event, thus projecting the best scenario to complete or continue his therapy in a greater benefit.

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CONCLUSIONS

DCS is an effective, economic and ethical strategic resource, which, if well carried out and allows it, saves human lives and with an *early closure cycle* exponentially reduces morbidity, without sequelae and mitigates mortality. On the other hand, when the *cycle closes late*, the costs in health, physical/mental competence (of patients and health personnel) and economic costs are very considerable or stratospherically catastrophic, together with the permanent sequelae in the patients, who remain alive, with limitations or disabled, greatly affecting the quality of life very deficient, even if mortality is reduced, this should be a reason for reflection to prioritize as much as possible a leverage for an *early cycle closure* in the DCS.

Conflict of Interest

The authors stated that they had no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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