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Damage Control Surgery in Severe Trauma: A Literature Review

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Abstract

Damage control surgery (DCS) is one of the most important part of modern trauma care for the patient with severe physiological failure. Main objective of DCS is to stop bleeding and limit contamination rather than doing any anatomical repair. It got its name from Naval warfare in the early 1990s. Once we perform temporary surgery we place patient in ICU for resuscitation, later it is followed by operation for definitive repair. This literature review collected evidences from various high impact journals such as: PubMed, Scopus, and MEDLINE databases using Boolean operators to examine when to use it, how to use it, what can be possible outcomes and various debates around it in severe trauma. There is no strong criteria or rules for using it on certain group of patients. Most of the rules lacks reliability and validity.

Some important studies demonstrated that it reduces mortality in a selected patients with lethal triad if hypothermia, acidosis and coagulopathy but also many patients died due to open abdomen complications, sepsis and longer hospital stays which increases risk of getting other hospital acquired infections. There is data variation between high income countries and low income countries as well as in military and civilian. On average around 14% people dies after 24 hour of abdominal DCS and 18% within 30 days. There are lack of validated indication for using DCS. Most of published list is never fully validated for accuracy or reliability. Modern practices includes damage control resuscitation (permissive hypotension, balance blood products ratios, transexamic acid for clotting of blood) and includes only necessary surgery. Future researces must focus on (1) Which patients will be benefited from it (2) standard and reliable methods for temporary closing the abdomen (3) Quality of patient and functions, not just survival. It is very useful when used carefully on right patients while performing it on patient exclusively for each patients will results in higher mortality rates.

Keywords: damage control surgery; trauma laparotomy; lethal triad; open abdomen; damage control resuscitation

1. Introduction

1.1 Background

Severe injury is one of the main cause of death for the people under the age of 45. Heavy bleeding account for around 40% of death in trauma related cases.

In the traditional method, Doctor perform all operation at first surgery, this often leads to patients body fully collapse. Specially, if patience have lethal triad of low body temperature, metabolic acidosis and coagulopathy. [1], [2]. In 1983, Stone and his colleagues described about a quick laprotomy where they packed bleeding abdomen with clothes, which proved to improve survival rates when compared with long term operation where they tried to fix everything all at once [3]. After a decade, Rotondo and his team gave the term “damage control” where they operated on with big blood vessel damage and injuries to several organs. They witnessed a significant survival rates of 77% when they performed staged surgery versus 11% in patients who are provided with old full repair methods [4].

The concept is not only limited to abdomen it has expanded to thoracic, blood vessels, bones and brain injuries. It is combined with unique way of giving blood products early which leads to permissive hypotension and fixing clotting problems [5], [6].

Modern trauma system are utilising DCS as important component for health care for seriously injured patients. But still doctor are left with some questions about: Who must get it, when patient must go for full surgery, How to balance between Survival benefits with long term disabilities.

1.2 Problem Statement

Despite worldwide adaptation of DCS, there are still doubts about when to use it and what real results are

Systematic reviews have proved different lists of rule for DCS. However, only few are reliable or have strong evidences. [7], [8].

Different hospitals utilize DCS at different rates between 33-83% and DCS usage is directly associated with more complications and it results in longer hospital stays and higher mortality rates without saving more lives. [9], [10].

Mortality rates reaches 38% when combined for low and middle income countries after DCS laparotomy and even lower mortality rates in higher income regions [11].

In military setting it report lower 30 day mortality rates when compared with civilian injuries, pointing towards if difference in type of injury, if different way of giving blood and fluids or how medical system work in both settings [12]. Nevertheless ,the open abdomen causes more deaths due to pressure buildup inside, fistula, different hernias that may substitute benefits of saving early lives. [13], [14].

There is no strong evidences which supports which patients must get DCS and which don’t. It is difficult to assign every sick person and also different studies present different rules. It is extremely difficult to tell when DCS is beneficial and in which

patients full repair is better option.

This paper do fact checking if DCS is beneficial for severely injured patients.

1.3 Novelty and Objectives

This review collected most recent evidence On DCS in severely injured patients. It utilizes not only systematic reviews but also primary studies which were punished between the 2025 to 2026.

Main contribution of this article is that it put seperate datas for in military setting vs civilian injuries, in low income countries vs high income countries. Incoperating new ways of resuscitation along with utilisation of of traditional surgical approach.

This paper also check if facts related to utilisation of DCS are reliable or not and provide us death rates among different spectrum. The main goal is to provide doctor with research based evidence based answer for Using DCS in effective and live saving way.

Main objectives are:

(1) To describe how this technique evolved in past and how it comes to practise

(2) How strong is the evidence for using DCS

(3)To Measure short term and long term affect of DCS in different settings.

(4) To choose for important future research topics that can help doctor select only patient where DCS is effective and this it will reduce preventable death rates specially with open abdomen.

2. Methods

The authors conducted a structured search of existing scientific literature in accordance with the PRISMA principles for narrative and systematic literature reviews. The authors searched three academic databases, PubMed/MEDLINE, Scopus, and the Cochrane Library, from their inception to October 2025. In the primary search methodology, the authors employed Boolean operators to implement the following combination of keywords: (“damage control surgery” OR “damage control laparotomy” OR “abbreviated laparotomy”) AND (trauma OR “severe injury” OR “polytrauma”) AND (mortality OR outcome OR indication OR complication). The authors also conducted secondary searches using the Boolean operation of (“damage control resuscitation” OR “lethal triad”) AND (trauma). The authors used filtering for studies published in English and confined their exploration to studies involving humans and excluded conference abstracts and studies on animals. The authors not only conducted database search of

systematic reviews and landmark papers, but also consulted reference lists for additional relevant citations. The authors considered studies that provided original findings or systematic synthesis related to the indications, techniques, or outcomes of DCS in adult trauma patients as eligible for inclusion in their analysis.

3. Results

3.1 Historical Evolution and Physiologic Rationale

The concept of DCS comes back from the time when it was utilize for ships to reach at safe harbor before it sink in the water.

Doctors in mid 20th century, utilized this idea where they packed first bleeding liver. Later in 1983, it gained more popularity when it was performed on patients with liver coagulopathy. [3].

In 1993, doctors come with three steps which is still in use:

(1) Control haemorrhage and limit contamination with temporary abdominal closure; (2) Restoring physiological vitals in the ICU and (3) definitive reconstruction only when patient is fully stable [4].

Scientific basic for using it was to limit number of deaths caused by lethal triad. Hypothermia leads to coagulopathy; Low PH in blood leads to inhibition of thrombin generation, acidosis further inhibits thrombin generation, and once body utilize all clotting factors problem become worse when more plain solution is injected to the body which leads to severe blood loss. [15], [16]. Longer operation duration under these circumstances leads to faster collapse of body as body fail to withstand it.

DCS focus only surgeries which are extremely necessary to sustain life (Packing to stop bleeding, without the anastomosis, and quick closure.

This is beneficial as it not only reduce time but also let doctor give strong resuscitation.

Later DCS is integrated with special resuscitation know as DCR, which keep the blood pressure low And keep the blood and it’s products ratios to 1:1:1, Injecting early tranexamic acid and later perform bedside blood clotting test. This is beneficial in saving life specially in first few critical hours [17], [18].

This approach is now not only use for abdomen. It is extensively used for quick chest surgery, vascular shunts, in external fixation of long bone fracture and also in stage surgery to relieve pressure on brain [19], [20].

3.2 Indications and Decision-Making

One comprehensive review showcased 59 evidence for using DCS, but only few of them have validity [7].

Certain reasons are strong and valid and most of surgeon use it for example in large vascular injury in the abdome, blood transfusion when exceeded the threshold and certain combination of injuries.

While in some cases it has shown bad results for example patients with abdominal injury and pancreatic injury, iliac blood vessel injury with high acid in the blood and low body temperature associated or coagulopathy. There are cases where DCS is proved to be extremely important for example gunshot where patient immediately needsn>10 units of packed red blood cells but also have major vascular injuries and injuries in various organs [7], [8].

Various measuresment changes like systolic pressure is less than 90 mmHg, body temperature is less than 34° celsius produce only small changes that doctor will choose DCD, whereas finding durimg surgery such as: blood loss more than 4L, blood pH below 7.2 or still using blood transfusion will have greater impact on decision making [21].

Different hospitals use it at different levels. Hospitals which use it more often results in more serious complications and longer hospital stay without reducing any significant mortality rates. [9].

Experts agree on the fact that doctors must make decision immediately on when to use DCS In extremely severe patients before the physiological failure and seperating the patients who requires full repairs as their body retain sufficient strength to go through it.

Table 1. Validity Evidence for Selected Indications for Damage Control Surgery (adapted from Roberts et al. [7], [8], [21])

Indication Category (examples)	Content Validity	Construct Validity	Criterion Validity
Major abdominal vascular injury	Yes	Yes	Limited
PRBC volume > critical administration threshold	Yes	Yes	Limited
Combined vascular + pancreatic / multi-visceral injury (unstable)	Yes	Yes	Yes (selected series)
Intra-operative pH < 7.2 / persistent hypothermia / coagulopathy	Yes	Yes	Yes (selected)
Estimated blood loss > 4 L or > 10 U PRBC intra-op	Yes	Yes	Moderate
Pre-op SBP persistently < 90 mmHg or T < 34 °C	Modest	Modest	Weak
Need for staged abdominal-wall reconstruction	Yes	—	—

3.3 Outcomes: Mortality and Geographic / System Disparities

Studies combined from 52 studies which included 9 932 patients, published between 2012 to 2021. They found median 24 hour mortality was 14% (IQR 5.1–21.2%) and 17.9% within one month (IQR 9.4–28.3%) after going through abdominal DCS [12].

Significant differences were observed between military vs civilian mortality rates, where for military death rates was 2.1 % and for civilian it was 18.9%,

In middle and low income countries mortality rates for 30 days was 37.8% due to lack of medical resources, blood products shortage and also late arrival to the hospital while in the United States data showed mortality rates was only 14.6% [11], [12].

A recent analysis of more than 4 000 damage-control laparotomies in the American College of Surgeons Trauma Quality Improvement Program witnessed overall mortality of 32.4% and 36% have major complication rates. Higher usage of DCS leads to major complications with longer hospital stays. [9].

These differences can be seen in table number 2 and 3.

Table 2. Selected Landmark and Recent Studies Reporting Mortality after Damage Control Surgery

Study (Year)	Design / N	24-h Mort.	30-d / Overall Mort.	Principal Finding
Rotondo et al. 1993 [4]	Retro; 46	—	Overall 55–58%; max-injury subset 11% vs 77%	First formal DCS series; clear survival benefit in vascular + ≥2 visceral injuries
Roberts et al. 2021 [7]	SR; 36 cohorts	—	Variable	Only 6/59 indications have criterion validity evidence
Collings et al. 2025 [12]	SR; 9 932	14% (median)	17.9% (median)	Military 30-d mort. 2.1% vs civilian 18.9%; non-US 37.2% vs US 14.6%
Makhadi et al. 2026 [11]	MA LMIC; 914	—	37.8% pooled	South Africa 31.6%; other LMICs 53.6%
TQIP analysis 2025 [9]	Retro; 4 034	—	32.4%	Higher institutional DCS proportion → more complications & longer LOS
Harvin et al. (PROPPR) [10]	Prospective; 329	DCL 19% vs DSM 4%	DCL 28% vs DSM 19%	DCL utilization 33–83% across centers; no mortality difference after adjustment

Table 3. Mortality after Abdominal DCS by Military/Civilian Status and Geographic Setting

Cohort / Setting	N (studies)	24-h Mortality	30-d Mortality	Source
Military	688 (6)	—	2.1%	[12]
Civilian (overall)	9 244 (46)	—	18.9%	[12]
United States	6 572 (33)	7.5%	14.6%	[12]
Non-United States	2 092 (10)	23.8%	37.2%	[12]
LMICs (pooled)	914 (10)	—	37.8% (95% CI 31.4–44.6)	[11]
South African LMICs	704	—	31.6%	[11]
Other LMICs	210	—	53.6%	[11]
All studies 2012–2021	9 932 (52)	14% (IQR 5.1–21.2)	17.9% (IQR 9.4–28.3)	[12]

(median)				

3.4 Morbidity of the Open Abdomen and Temporary Closure Techniques

Problems which are associated when we left abdomen open includes: fascial dehiscence which account for 12%,enterocutaneous or enteroatmospheric fistula, intra abdominal abscess, and eventual large ventral hernia which needs extensive surgery to fix it.[13], [14], [22]. Special techniques to close abdomen which includes- negative pressure wound therapy or gradually pulling the edges together and using mess to pull the ends together have helped more patients to close abdomen in first time. If it stays open for more than one week it is associated with higher risk for other complications. There is limited information about condition of patients after 1 year after they required DCS. Limited data represents that most of the patient who received DCS have faced physical, mental and psychological problems.

Tables 4 and 5 represents rates of different complication and show how different closing techniques work.

Table 4. Reported Complications Associated with Damage Control Laparotomy / Open Abdomen

Complication	Reported Rate	Notes / Risk Factors	Source
Overall major complications	36%	Higher with greater institutional DCS proportion	[9]
Fascial dehiscence	12.4%	Enteric injury (OR 3.7); higher fluid balance; multiple re-operations	[14]
Intra-abdominal infection / abscess	15–30% (range)	Increases with duration of open abdomen	[13],[22]
Enteroatmospheric / enterocutaneous fistula	5–15%	Higher with prolonged open abdomen >7–10 d	[13],[22]
Ventral hernia (long-term)	>50% if not closed primarily	Requires complex reconstruction in many cases	[13],[22]
Abdominal compartment syndrome (recurrent)	Variable (5–15%)	Related to temporary closure technique & resuscitation volume	[13]
Sepsis / VAP (PROPPR DCL cohort)	Significantly higher vs definitive	$p < 0.05$	[10]

Table 5. Temporary Abdominal Closure Techniques and Reported Primary Fascial Closure Rates

Technique	Primary Fascial Closure Rate	Time to Closure (median)	Notes
Negative-pressure wound therapy (NPWT / VAC)	60–80% (modern series)	5–10 days typical	Most widely used; reduces fistula vs older methods
Sequential fascial closure / dynamic retention	70–90%	6–12 days	Often combined with NPWT
Mesh-mediated traction	High (selected series >80%)	Variable	Allows progressive

			approximation
Delayed primary closure (historical packing)	Lower; longer time	~16 days (older data)	Higher complication rates in older literature
Component separation / biologic mesh (definitive)	N/A (reconstructive)	Later stage	Used when primary closure impossible

3.5 Summary of Key Systematic Reviews

Multiple high quality systematic reviews are being utilised for making the DCS literature. Their principal quantitative findings and conclusions are presented in Table 6 for rapid reference.

Table 6. Summary of Major Systematic Reviews and Meta-Analyses on Damage Control Surgery

Systematic Review	Focus / N studies	Main Quantitative Result	Conclusion
Roberts 2021 [7]	Indications validity; 39	10 content, 9 construct, 6 criterion validity	Few indications are evidence-based; use DC only when definitive surgery impossible
Collings 2025 [12]	Outcomes 2012–21; 52	Median 24-h 14%, 30-d 17.9%	Large military–civilian and US–non-US disparities
Makhadi 2026 [11]	LMIC DCL outcomes; 10	Pooled mortality 37.8%	Higher than HIC series; data dominated by South Africa
Open-abdomen meta-analysis [22]	Closure methods; 26	DPC complications 17%; mesh 41%	Component separation or mesh may be alternatives to delayed primary closure
DCS vs definitive meta (2025) [27]	Survival benefit; 7	Heterogeneous; 1 RCT favored DCS 30-d mortality	Superiority of DCS over definitive surgery not firmly established

Modern DCS cannot be seperated from damage control resuscitation. These practices come under the normal standard of care: Giving blood products early and in balance ratios, avoid large volume of saline solution, maintain permissive hypotension untill bleeding is stopped and early transfusion oftranexamic acid comes under normal standard of care [17], [18], [23]. Viscoelastic hemostatic assays is useful in detecting which part of clotting system is failing.

So it can be useful for patient who need it rather than giving it to every patient.

During any surgery, surgeon and anesthesiologist work together as one team. Surgeon job is to operate as fast as possible and anesthesiologist make it sure that that oxygen delivery is maintained, temperature and coagulation factors are optimum.

Using vaccum type dressing to close open wound is useful for 3 main things (1) open abdomen (2) reduces fluid losses (3) decreases abdominal pressure.

Planned operation is usually take place after 24–72 hours when acidosis, hypothermia, and coagulopathy are maintained. During the reoperation, doctor fixed blood vessels, anastomosis GI and abdomen walls if possible or they use temporarily sealing method

only.

4. Discussion

According to available literature, DCS infusion in carefully selected patients can help break the deadly triad. It contributes to greater early survival compared to historical attempts where definitive repair was conducted in cases of extreme physiological stress. The original publication by Rotondo et al. on the 11% to 77% increase in survival among high-risk patients remains the most conclusive evidence [4]. Large observational studies and systematic reviews favor more moderate views on this practice: absolute mortality following modern DCS procedures is still reported at several dozens or above compared to above 30% in various settings [9], [12]. There is no need to say that comparisons of military and civilian survival results are particularly enlightening. The military has a relatively low rate of 30-day mortality, possibly thanks to the fact that servicemen are younger, evacuation takes place sooner, protocols are being followed, and military specialists have invaluable experience in penetrating injury treatment [12]. In its turn, civilian medical centers, particularly in areas with insufficient resources, look after elderly patients, blunt traumas, late presentations and limited blood products [11].

A critical question in contemporary practice involves the excessive application of damage control surgery (DCS). The differences in the rates of DCS in trauma centers with similar characteristics paired with the bond between the high DCS frequency and the rise in the number of complications but not mortality indicates the existence of possible candidates for definitive surgeries instead of DCS [9], [10]. Moreover, missing the opportunity to implement DCS will lead to a lethal triad situation. The absence of convincing preconditions for damage control surgery and the lack of sufficient randomized studies leave practitioners with only intuition and their hospitals' practices. There are severe barriers to randomizing patients requiring DCS, which leads to the need for more pragmatic studies aimed at comparing the approaches to DCS, medical protocols, etc.

There are ongoing advances in techniques. For example, the use of negative pressure wound therapy in DCS has influenced the rates of successful fascial closure and occurrence of enteric fistula [13], [22]. Besides, new methods, including component separation and biological mesh allow for more techniques of reconstruction in the absence of primary closure. However, the perfect temporary closure method is still to be found.

The limitations of the current review include the predominance of retrospective data, the variability of the definitions of outcomes, and the possible bias in publishing research that yields optimistic results. A considerable number of studies include only

information about short-term mortality without reporting further evaluations in terms of functional status and quality of life. The geographical representation of the studies is uneven as there is an over-representation of data from high-income countries in the North American and European regions compared to the extent of trauma worldwide. Still, the concordance of the results obtained in different systematic reviews makes one more confident in the main conclusions of the study: DCS contributes to saving lives of those patients who meet its indications, whereas its unchecked application may lead to the increase in morbidity and the clinical outcome may be significantly affected by such factors as the protocols of resuscitation, the availability of blood, and the surgeons' experience.

5. Conclusion

Damage control surgery has become an important surgical technique for treating patients with serious trauma who experience metabolic derangement. This surgical approach, which has its roots in observations in the 1980s and became more formalized in the 1990s, has evolved into a new method that integrates condensed surgical techniques with targeted resuscitation. Current research supports the claim that surgery can favorably decrease early mortality rates in patients with fatal traumas and dangerous injuries, but it also shows that surgery brings about significant morbidity due to the open abdomen and that patients' outcomes vary significantly in military and civilian, high-income, and low-income facilities. There are not many verified indications for this surgery, while doctors rely on their judgement impressive anatomy and physiology of the operating period. Future achievements depend on further refinement of selection criteria for patients, permanent techniques for temporary closure of the abdomen, cooperative multicenter prospective studies, and attention to the prolonged recovery of patients.

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