Damage control surgery in abdominal trauma: an integrative review

Cirurgia de controle de danos no trauma abdominal: uma revisão integrativa

Cirugía de control de daños en trauma abdominal: una revisión integradora

Pedro Miranda Vieira Bezerra[1], Mariana de Paula Ferreira[2], Esther Eloisa Magalhães de Paula[3], Eduardo Henrique Antunes Mann[4]

How to cite: Bezerra PMV, Ferreira MP, Paula EEM, Mann EHA. Damage control surgery in abdominal trauma: an integrative review. REVISA. 2025; 14(3): 1685-94. Doi: https://doi.org/10.36239/revisa.v14.n3.p1685a1694

REVISA

1. University Center of Brasília. Brasília, Federal District, Brazil.
https://orcid.org/0000-0002-1855-0284

2. Atenas University Center. Paracatu, Minas Gerais, Brazil.
https://orcid.org/0000-0001-9891-9901

3. Atenas University Center. Paracatu, Minas Gerais, Brazil.
https://orcid.org/0000-0002-9431-2587

4. Atenas University Center. Paracatu, Minas Gerais, Brazil.
https://orcid.org/0000-0002-8437-8515

Received: 17/01/2025
Accepted: 23/03/2025

RESUMO

Introdução: A cirurgia de controle de danos (CCD) é uma abordagem cirúrgica abreviada adotada em pacientes críticos, seja por causa traumática ou não. Estes pacientes frequentemente apresentam perda volêmica exacerbada que evolui para hipotermia, acidose e coagulopatia que pode evoluir rapidamente para óbito caso abordagem cirúrgica imediata não seja adotada. A CCD é o tratamento chave para esta condição, composta por três fases: seleção, laparotomia breve, estabilização em UTI e reabordagem cirúrgica definitiva. Objetivo: O objetivo deste estudo é delinear a literatura recente acerca deste tema. Método: Foi realizada pesquisa eletrônica nas bases de dados BVS, SciELO e PubMED utilizando os descritos "damage control surgery", "abdominal trauma" e "indication" utilizando o operador booleano "AND". Resultados: Foram elencados 32 artigos analisados para elaboração do presente trabalho. Estudos abordando a CCD encontram uma grande heretogeneidade de resultados acerca de indicações objetivas para CCD, com grande parte dos estudos apresentando indicadores diversos, além de grande variação de indicação dependente de mecanismo de trauma e faixa etária. As complicações decorrentes do abdome aberto remanescente pós-cirurgia abreviada podem ser graves, e fazem parte da atenção integral ao paciente submetido à CCD. Conclusão: Grande parte dos estudos elenca que revisões sistemáticas adicionais são necessárias para maior consenso de indicação de CCD no trauma agudo. A fisiopatologia da tríade letal é bem estabelecida, e a integração destes conhecimentos na indicação é essencial para seu melhor manejo.

Descritores: Cirurgia de controle de danos; trauma abdominal; abdome aberto.

ABSTRACT

Introduction: Damage control surgery (DCS) is an abbreviated surgical approach adopted for critically ill patients, whether traumatic or not. These patients often experience exacerbated volume loss that progresses to hypothermia, acidosis, and coagulopathy, which can rapidly progress to death if immediate surgical intervention is not adopted. DCS is the key treatment for this condition, consisting of three phases: selection, brief laparotomy, ICU stabilization, and definitive surgical re-intervention. Objective: The objective of this study is to outline the recent literature on this topic. Method: An electronic search was conducted in the BVS, SciELO, and PubMED databases using the terms "damage control surgery," "abdominal trauma," and "indication" using the Boolean operator "AND." Results: Thirty-two articles were analyzed for this study. Studies addressing DCS found significant heterogeneity in results regarding objective indications for DCS, with most studies presenting diverse indicators, in addition to wide variation in indications depending on the trauma mechanism and age group. Complications resulting from the open abdomen after abbreviated surgery can be life-threatening and are part of the comprehensive care of patients undergoing DCIS. Conclusion: Most studies indicate that additional systematic reviews are needed to achieve greater consensus on the indication for DCIS in acute trauma. The pathophysiology of the lethal triad is well established, and integrating this knowledge into the indication is essential for its best management.

Descriptors: Damage control surgery; abdominal trauma; open abdomen.

RESUMEN

Introducción: La cirugía de control de daños (DCS) es un abordaje quirúrgico abreviado que se adopta para pacientes críticos, ya sean traumáticos o no. Estos pacientes a menudo experimentan una pérdida de volumen exacerbada que progresa a hipotermia, acidosis y coagulopatía, que puede progresar rápidamente a la muerte si no se realiza una intervención quirúrgica inmediata. La DCS es el tratamiento clave para esta afección y consta de tres fases: selección, laparotomía breve, estabilización en UCI y reintervención quirúrgica definitiva. Objetivo: El objetivo de este estudio es presentar la literatura reciente sobre este tema. Método: Se realizó una búsqueda electrónica en las bases de datos VHL, SciELO y PubMED utilizando los términos "cirugía de control de daños", "trauma abdominal" e "indicación" mediante el operador booleano "AND". Resultados: Se analizaron 32 artículos para este estudio. Los estudios que abordaron la DCS encontraron una heterogeneidad significativa en los resultados con respecto a las indicaciones objetivas para la DCS; la mayoría de los estudios presentaron diversos indicadores, además de una amplia variación en las indicaciones según el mecanismo del trauma y el grupo de edad. Las complicaciones derivadas de un abdomen abierto tras una cirugía abreviada pueden poner en peligro la vida y forman parte de la atención integral de los pacientes sometidos a CDIS. Conclusión: La mayoría de los estudios indican que se necesitan revisiones sistemáticas adicionales para lograr un mayor consenso sobre la indicación de CDIS en traumatismos agudos. La fisiopatología de la tríada letal está bien establecida, y la integración de este conocimiento en la indicación es esencial para su mejor manejo.

Descriptores: Cirugía de control de daños; traumatismo abdominal; abdomen abierto.

REVIEW

Introduction

Damage control surgery (DCS) is an umbrella term that encompasses concepts of short-duration surgical approaches, aiming, in the context of abdominal trauma, at early management of life-threatening injuries (mainly exsanguination) and with temporary closure of the abdominal cavity for subsequent definitive management, after clinical stabilization of the patient. [1]

Currently, DCS is especially used in a select group of patients at high risk of developing or progressing to the lethal triad, a set of clinical signs that, when present, indicate an increased risk of death without immediate intervention. The goal of DCS is to quickly resolve acute causes with elevated risk of mortality (primarily due to blood volume loss), ensuring the patient can be adequately stabilized in the ICU in due time. [1,2]

The lethal triad consists of acidosis, hypothermia, and coagulation disorders. It is important to note that each of these elements tends to reinforce the physiological stress response to trauma, which intensifies the others in a positive feedback loop that can progress rapidly. [3] It is understood that the vicious cycle of homeostatic imbalance in acute trauma makes DCS indicated for patients whose condition would not tolerate the additional aggressions of an extensive laparotomy at the moment, and whose chances of survival would be better if this were performed after clinical stabilization. [4, 5]

DCS is divided into phases, ranging from the process of appropriate patient selection to abbreviated surgery with various management techniques. Finally, the surgery is concluded with an open abdomen technique, with occlusive treatment. Immediately after surgery, the patient should be transferred to the intensive care unit for early correction of hypothermia, acidosis, and coagulopathy. Subsequently, a definitive and resolutive approach to the visceral injury should be performed once stabilization occurs. [5-7]

The aim of this study is to list important information about the current consensus on damage control surgery, with an emphasis on mortality indicators and predictors of survival gains from this approach.

Methodology

This study is an integrative literature review that seeks to identify the most recent evidence regarding the profile of patients who are indicated for damage control surgery in the context of acute abdominal trauma. The methodology employed in this work was bibliographic research based on a review of scientific articles, academic materials, and online databases.

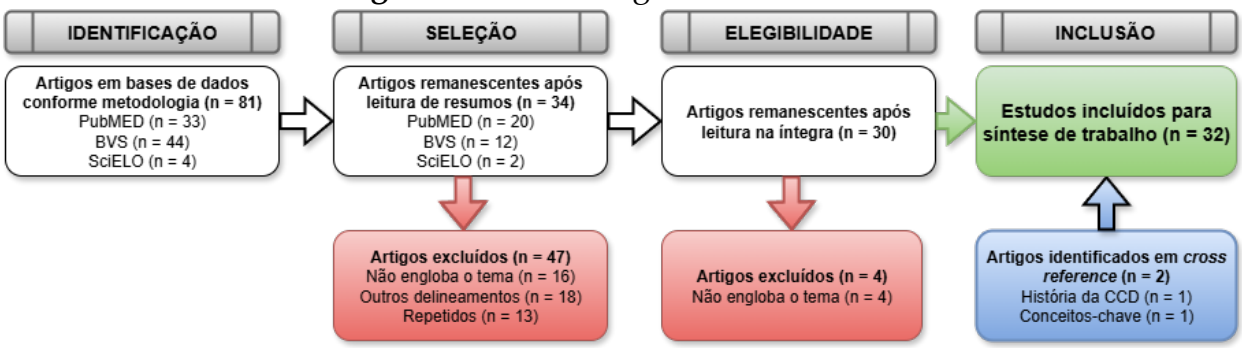
To search for references for this study, we used the Scientific Electronic Library Online (SciELO), National Library of Medicine (PubMed), and Biblioteca Virtual em Saúde (BVS) databases. The health descriptors "damage control surgery," "abdominal trauma," and "indications" were used, with the Boolean operator "AND" concomitantly. The time window for results was defined as the decade 2015 to 2025. The types of studies included for analysis were controlled clinical trials, systematic reviews, literature reviews, and original and experimental articles.

The first stage of the search yielded 81 articles in total, 33 from PubMED, 44 from BVS, and 4 from SciELO. These results were initially screened for inclusion in the study based on reading the title and abstract. After this stage, 34 papers were included for screening by reading the abstract, and 47 were excluded. articles.

Case reports, studies in non-human animals, *in vitro* studies were excluded due to their low level of evidence, and studies that did not encompass the scope and objective of the study and/or presented results of treatments other than damage control surgery in the context of abdominal trauma.

Finally, all remaining articles after the second stage were read in full, with four articles being eliminated at this stage because they did not fit the proposed methodology. In *cross-reference* analysis, specifically in search of articles with key concepts for the present analysis, two additional articles were included, bringing the total analyzed to 32 works. This methodological process is shown in **Figure 1** .

Figure 1: Methodological framework



SOURCE: Own authorship.

Results and Discussion

The most feared consequence of acute trauma is the lethal triad, a term coined by the American Trauma Society in 1982. [3] The foundation of the lethal triad is hemorrhagic hypovolemia as a trigger for vicious feedback. The decrease in peripheral tissue perfusion due to hypovolemia results in a decrease in oxygen delivery, which leads to a shift from aerobic to anaerobic cellular metabolism, leading to increased lactate and acidosis. [4]

The body's adrenergic response also results in peripheral vasoconstriction, increasing hypoperfusion. Acidosis, in turn, alters the functional capacity of coagulation-related enzymes and proteins, preventing effective hemostasis of visceral or vascular injuries. [5] Concomitantly, there is a loss of body temperature. Hypothermia is defined as a drop in body temperature (cutoff values range from <35 to <32°C), causing reduced enzymatic activity of the hemostatic system. It is noteworthy that, simultaneously, these three pathological cascades rapidly feedback on each other, requiring a swift approach to preserve the life of the affected patient. [5]

Modern damage control surgery is the result of a long historical process, stemming primarily from warfare medicine that originated in the major armed conflicts of the 20th century. [3] Its evolution was conflicting, with tentative advances and setbacks until it was established that there were gains in survival and could achieve better prognosis, especially in trauma patients. [1] The development of the technique of keeping the abdominal wall open for subsequent intervention was developed during World War II in the context of required rapid stabilization on the battlefield. [6] New technologies, such as the use of inflatable bags for perihepatic mechanical tamponade, may represent the next step in managing this condition. [8]

Classically, the topographic diagnosis of trauma injuries in unstable patients is made intraoperatively, with direct visualization of the structures during laparotomy. Trauma ultrasonography is widely used to help guide this diagnosis, but few studies address the use of tomographic imaging in this context. Its use is warranted in cases of retroperitoneal bleeding not adequately identified at laparotomy, or in cases of suspected inadequate control of visceral bleeding. [9]

The open abdomen technique is a fundamental part of the approach to acute trauma with indication for DCS, being performed mainly to abbreviate approach in the first intervention and facilitate the definitive surgical approach later. [10] Some factors, such as peritoneal inflammation, adhesions, synechiae, or fibrosis at the incision site, can affect the duration of surgery, [11] a variable that is directly linked to postoperative survival. [11, 12] Similarly, techniques that aim to shorten the closure of the abdominal *fascia* reduce complication rates and provide a better prognosis. One study included the results of the anchoring suture technique for approximating the abdominal edges, with results that facilitated tension-free closure after stabilization. [13, 14]

In a retrospective comparative study of the approach to acute abdominal trauma, comparing the approach of initial resolutive surgery *versus* abbreviated initial surgery to control years, evaluating mortality as the primary outcome, and the number of days of hospitalization in an ICU bed as a secondary outcome, showing that patients undergoing DCS have a slightly longer ICU hospitalization period compared to the group that undergoes definitive laparotomy. [15]

The intensive care unit (ICU) treatment profile for patients undergoing DCS differs according to the mechanism of homeostatic-hemodynamic instability, with trauma victims presenting higher rates of hypothermia, acidosis, and coagulopathies. Patients undergoing DCS for septic causes have, in comparison, higher rates of vasoactive drug infusion. [16]

The open abdomen technique in patients with scheduled or probable reoperation is used to reduce the risk of adhesions that cause frozen abdomen syndrome. A study evaluated the comparative prognosis between different abdominal cavity closure techniques in 73 patients undergoing open abdominal closure. The most prevalent abdominal suture methods were vacuum dressings (52.1%), followed by Wittman prosthesis (24.7%), Bogotá pouch (11%), and primary skin closure (12.3%). There was no statistical difference in mortality, complications, or time to wound closure when comparing commercial or homemade vacuum systems. [6, 17]

In a study focusing on the Bogotá pouch (BB) for abdominal closure, 193 patients were divided into groups that would receive primary skin closure (59%) and the remaining (41%) received BB as an occlusion method. It was observed that there was greater success among patients who received primary closure. [17] Also within the context of total abdominal closure after DCS, a study sought to evaluate the profile of patients with a lower rate of complications resulting from early or late closure (> 24 hours). A retrospective cohort study found that patients who underwent more than one laparostomy had a 91.5% decrease in the chance of wound closure. Reoperated patients, in turn, end up having a greater chance of complications, such as sepsis and fistulas. [12]

An Italian study evaluated the profile of open abdomen closure after open abdominal closure in the context of trauma. Analyzing the subgroup with traumatic etiology (n = 44; total n = 375), these patients most frequently underwent open abdominal closure as the primary closure method (25%, n = 11) and primary skin closure (38.6%, n = 17). Evaluating the outcome of total hospital stay, it was also

observed that among the indications for open abdominal closure, trauma was considered the most severe, concurring with other findings of prolonged hospital stay and invasive ventilation, corroborating the worse overall prognosis in this group of patients. [18]

In a retrospective cohort of 696 patients, predictors of mortality in patients undergoing DCS were listed. Abnormalities in blood gas analysis, *Revised Trauma Scale* (RTS) on admission, and Glasgow Coma Scale were identified as predictors of both early (<48 h after admission) and late (>48 h) mortality. Vital signs on admission, mechanism of injury, intra-abdominal injuries, or fluid replacement were not statistically significant in predicting early or late mortality. [5]

In a cohort of 554 patients, divided into traumatic and non-traumatic DCS, the authors evaluated the difference in postsurgical complications by comparing both groups. It was observed that in the traumatic group, there was a higher incidence of postoperative *delirium*. The authors attribute this finding to concomitant traumatic brain injury. [19] It was observed that, depending on the severity of the patient's condition, patients who scored more than 20 points on the Acute Physiology and Chronic Health Evaluation (APACHE II) score and who were older had higher mortality rates. [6, 19]

Communication between the trauma management team should follow a closed-loop model as closely as possible. In a retrospective study, victims of perforating abdominal trauma from shrapnel and projectiles were initially treated by a prehospital team and later transferred to tertiary units for definitive surgical treatment, where the team had not initially monitored the situation. The information mismatch led to increased morbidity and mortality. The study highlights the importance of efficient information transmission in the management of the condition. [20]

Indications for damage control surgery

Most of the inconsistency in the literature regarding the appropriate indication for DCS revolves around patient profile. In a multicenter quality assurance study with a surgical team from a healthcare network, DCS performed in American trauma centers were subsequently evaluated for their indication within the current clinical context. It was found that of 209 DCS performed, 47 (22%) were perceived as opportunities for direct resolution rather than a subsequent approach. It was observed that, in the group with correctly indicated DCS, these patients had lower body temperature and systolic blood pressure than the group with increased lactate. [21] In this same context, the use of digital tools such as *machine learning algorithms* with artificial intelligence can help in the early diagnosis of the need for DCS, aiding management. [22]

Interestingly, however, these results are not uniform in the context of abdominal trauma. In Japan, unlike in the Americas, a higher incidence of blunt rather than penetrating abdominal trauma is observed. In this context, a retrospective observational study of 4,447 patients with blunt abdominal trauma found that 532 underwent DCS, demonstrating that the Glasgow Coma Scale and body temperature are useful tools for advanced preparation of the attending team. [23]

Furthermore, the uniformity of indication for DCS not only contrasts population differences, but also the trauma mechanism. In a retrospective analysis of DCS and non-DCS laparotomies indicated for penetrating trauma caused by firearm projectiles, it was observed that in this specific trauma contingent, there was a higher mortality in the group of patients who underwent DCS. Of 135 patients in the DCS

group, 45 (33%) died, while in the non-DCS group (n = 290), 16 patients passed (6%). [2 4] It is evident that the choice of DCS in trauma victims should be more judicious, given the greater overall severity of these cases and the greater risk of irreversible decompensation without prompt and appropriate surgical intervention. [2 5]

In the adult population, there is considerable heterogeneity in the results of studies aiming to find uniform parameters for indication and prognostic prediction of DCS. A systematic review sought to evaluate various results of attempts to objectify these decision-making parameters. Significant locoregional variation was suggested, with approximately half of the indication criteria being based on a single threshold parameter (e.g., pH < 7.0), and a quarter of centers require concurrent findings for formal DCS indication. This finding corroborates that efforts to systematize and standardize DCS indications continue to require more data.[2, 26, 27] And when topographic diagnosis is chosen for the indication of DCS, patients with hemodynamic destabilization mostly presented lesions in the small intestine, large intestine, abdominal vasculature and liver (in decreasing order of incidence), however, without change in mortality. [28]

The pediatric population is a subsegment of the population vulnerable to trauma that is underexplored in literature. In a South African retrospective study of 136 patients under 18 years of age, the incidence of blunt and penetrating abdominal trauma was slightly more prevalent than blunt trauma (43% and 57%, respectively), and complications occurred at rates similar to those observed in other studies. In this age group, the indications for DCS continue to be the development of a triad, but mortality was lower. [29]

Conclusion

The analysis of the studies included in this research shows that the trajectory of damage control surgery continues to encompass technical improvements and indications for patients suffering from abdominal trauma, resulting in significant improvements in survival rates and an increase in the quality of data used for scientific support. [2 9] Many of the studies listed warn of the need for broader studies with larger sample groups to obtain robust data on the best indication for DCS, a fact reinforced by the variability of indicators according to the sample group. [6]

The pathophysiology of the lethal triad is widely described and researched, but it is noteworthy that the wide heterogeneity of the application of DCS indications makes it plausible that the concomitance of homeostatic imbalances may affect the clinical analysis of the patient, so that greater focus is welcome. [30]

The available literature shows that, although there is already some consensus among trauma teams regarding the indication for DCS, further research is needed to define this indication for its eventual more effective implementation. The literature lists several protocols and study designs that are easily reproducible in trauma centers and may contribute further data, specifically to provide greater clarity in the damage control surgery scenario. [31, 32]

Acknowledgment

This study was funded by the authors themselves.

References

1. Ball CG. Damage Control Surgery. Current Opinion in Critical Care. 2015 Dec;21(6):538–43.

2. Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, et al. Indications for Use of Damage Control Surgery and Damage Control Interventions in Civilian Trauma Patients. Journal of Trauma and Acute Care Surgery. 2015 Jun;78(6):1187–96.

3. Roberts DJ, Ball CG, Feliciano DV, Moore EE, Ivatury RR, Lucas CE, et al. History of the Innovation of Damage Control for Management of Trauma Patients. Annals of Surgery. 2017 May;265(5):1034–44.

4. Chabot E, Nirula R. Open Abdomen Critical Care Management principles: resuscitation, Fluid balance, nutrition, and Ventilator Management. Trauma Surgery & Acute Care Open. 2017 Sep;2(1):e000063.

5. Leonardi L, Fonseca MK, Baldissera N, Cunha CEBD, Petrillo YTM, Dalcin RR, et al. Predictive Factors of Mortality in Damage Control Surgery for Abdominal Trauma. Journal of the Brazilian College of Surgeons. 2022;49.

6. Morais M, Gonçalves D, Bessa-Melo R, Devesa V, Costa-Maia J. The Open Abdomen: Analysis of Risk Factors for Mortality and Delayed Fascial Closure in 101 Patients. Porto Biomedical Journal. 2018 Oct;3(2):e14.

7. Risinger WB, Smith JW. Damage Control Surgery in Emergency General Surgery: What You Need to Know. The Journal of Trauma and Acute Care Surgery [Internet]. 2023 Nov 1 [cited 2024 Apr 7];95(5):770–9. Available from: https://pubmed.ncbi.nlm.nih.gov/37439768/#:~:text=Damage%2Dcontrol%20surgery%20(DCS)

8. Rezende-Neto J, Doshi S, Gomez D, Camilotti B, Marcuzzi D, Beckett A. A Novel Inflatable Device for Perihepatic Packing and Hepatic Hemorrhage control: a proof-of-concept Study. Injury [Internet]. 2022 Jan [cited 2025 Aug 18];53(1):103–11. Available from: https://www.injuryjournal.com/article/S0020-1383(21)00731-2/abstract

9. Baghdanian AA, Baghdanian AH, Khalid M, Armetta A, LeBedis CA, Anderson SW, et al. Damage Control surgery: Use of Diagnostic CT after life-saving Laparotomy. Emergency Radiology. 2016 May 11;23(5):483–95.

10. Chiara O, Cimbanassi S, Biffl W, Leppaniemi A, Henry S, Scalea TM, et al. International Consensus Conference on Open Abdomen in Trauma. The Journal of Trauma and Acute Care Surgery [Internet]. 2016 Jan 1 [cited 2021 Jul 10];80(1):173–83. Available from: https://pubmed.ncbi.nlm.nih.gov/27551925/

11. Rodríguez-Holguín F, González-Hadad A, Mejia D, Ceballos C, Himmler AN, Caicedo Y, et al. Abdominal and Thoracic Wall closure: Damage Control Surgery's Cinderella. Colombia Medica. 2021 Sep 23;52(2):e4144777.

12. Kwon E, Krause C, Luo-Owen X, McArthur K, Cochran-Yu M, Swentek L, et al. Time Is domain: Factors Affecting Primary Fascial Closure after Trauma and non-trauma Damage Control Laparotomy (data from the EAST SLEEP-TIME Multicenter registry). European Journal of Trauma and Emergency Surgery. 2021 Nov 29;48(3):2107–16.

13. Nouh T, Alburakan A, Alawi K, Alshahwan N, Mashbari H, Alowais J, et al. Early Application of Abdominal re-approximation Anchor System for the Management of the Open Abdomen. Scientific Reports [Internet]. 2025 May 22 [cited 2025 Aug 19];15(1). Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12098877/

14. Gurusamy K, Davidson B. Management and Treatment Options for Patients with Open Abdomen. NursingStandard. 2016 Jan 13;30(20):51–60.

15. Peng CC, Tay J, Tham N, Tully EK, Shakerian R, Furlong T, et al. Use of Temporary Abdominal Closure in Non-Trauma Surgery: A Cohort Study. World Journal of Surgery. 2023 Feb 27;47(6):1477–85.

16. Loftus TJ, Jordan JR, Croft CA, Smith RS, Efron PA, Mohr AM, et al. Temporary Abdominal Closure for Trauma and intra-abdominal Sepsis. Journal of Trauma and Acute Care Surgery. 2017 Feb;82(2):345–50.

17. Zahid MJ, Hussain M, Kumar D, Hamza M, Zeb Jan SA, Safdar H, et al. A Descriptive Analysis of skin-only Closure and Bogota Bag Techniques for Achieving Complete Fascial Closure in Damage Control Abdominal Surgery. BMC Surgery [Internet]. 2024 Jun 20;24(1):192. Available from: https://pubmed.ncbi.nlm.nih.gov/38902655/

18. Cicuttin E, Ansaloni L, Ceresoli M, Fugazzola P, Tomasoni M, Sartelli M, et al. Trends in open abdomen management in Italy: a subgroup analysis from the IROA project. Updates in Surgery. 2019 Oct 16;72(1):171–7.

19. McArthur K, Krause C, Kwon E, Luo-Owen X, Cochran-Yu M, Swentek L, et al. Trauma and nontrauma damage-control laparotomy: The difference is delirium (data from the Eastern Association for the Surgery of Trauma SLEEP-TIME multicenter trial). Journal of Trauma and Acute Care Surgery. 2021 Jul;91(1):100–7.

20. Bickel A, Konstantin Akinichev, Weiss M, Samer Ganam, Biswas S, Waksman I, et al. Challenges in Abdominal re-exploration for War Casualties following on-site Abdominal Trauma Surgery and Subsequent Delayed Arrival to Definitive Medical Care Abroad – an Unusual Scenario. BMC Emergency Medicine. 2022 Jul 18;22(1).

21. Harvin JA, Sharpe JP, Croce MA, Goodman MD, Pritts TA, Dauer ED, et al. Better understanding the utilization of damage control laparotomy: A multi-institutional quality improvement project. Journal of Trauma and Acute Care Surgery [Internet]. 2019 Jul 1 [cited 2023 Feb 6];87(1):27. Available from: https://journals.lww.com/jtrauma/Abstract/2019/07000/Better_understanding_the_utilization_of_damage.4.aspx

22. Harvin JA, Green CE, Pedroza C, Tyson JE, Moore LJ, Wade CE, et al. Using Machine Learning to Identify Change in Surgical Decision Making in Current Use of Damage Control Laparotomy. Journal of the American College of Surgeons [Internet]. 2019 Jan 9 [cited 2025 Aug 19];228(3):255–64. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6391184/

23. Urushibata N, Murata K, Otomo Y. Decision-making Criteria for Damage Control Surgery in Japan. Scientific Reports [Internet]. 2019 Oct 17;9(1):14895. Available from: https://pubmed.ncbi.nlm.nih.gov/31624272/

24. He R, Kong V, Ko J, Narayanan A, Wain H, Bruce J, et al. A decade long overview of damage control laparotomy for abdominal gunshot wounds. European Journal of Trauma and Emergency Surgery [Internet]. 2024 Jun 18 [cited 2024 Nov 19];50. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/mdl-38888788

25. Roberts DJ, Bobrovitz N, Zygun DA, Kirkpatrick AW, Ball CG, Faris PD, et al. Evidence for use of damage control surgery and damage control interventions in civilian trauma patients: a systematic review. World Journal of Emergency Surgery. 2021 Mar 11;16(1).

26. Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, et al. Indications for use of damage control surgery and damage control interventions in civilian trauma patients: A scoping review. Journal of Trauma and Acute Care Surgery. 2015 Jun;78(6):1187–96.

27. Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, et al. Indications for Use of Damage Control Surgery in Civilian Trauma Patients. Annals of Surgery. 2016 May;263(5):1018–27.

28. Kruger A, McPherson D, Nicol A, Edu S, Navsaria P. Damage control laparotomy outcomes in a major urban trauma center. South African journal of surgery Suid-Afrikaanse tydskrif vir chirurgie [Internet]. 2022 Jun;60(2):84–90. Available from: https://pubmed.ncbi.nlm.nih.gov/35851360/

29. Reid R, Kong V, Xu W, Thirayan V, Cheung C, Rajaretnam N, et al. An audit of trauma laparotomy in children and adolescents highlights the role of damage control surgery and the need for a trauma systems approach to injury in this vulnerable population. South African journal of surgery Suid-Afrikaanse tydskrif vir chirurgie [Internet]. 2022 Jun;60(2):97–102. Available from: https://pubmed.ncbi.nlm.nih.gov/35851362/

30. Roberts DJ, Ari Leppäniemi, Tolonen M, Panu Mentula, Björck M, Kirkpatrick AW, et al. The open abdomen in trauma, acute care, and vascular and endovascular surgery: comprehensive, expert, narrative review. BJS Open. 2023 Sep 5;7(5).

31. Benz D, Balogh ZJ. Damage control surgery: current state and future directions. Current Opinion in Critical Care [Internet]. 2017 Dec [cited 2025 Aug 6];23(6):491–7. Available from: https://pubmed.ncbi.nlm.nih.gov/29035926/

32. Harvin JA, Podbielski J, Vincent LE, Fox EE, Moore LJ, Cotton BA, et al. Damage control laparotomy trial: design, rationale and implementation of a randomized controlled trial. Trauma Surgery & Acute Care Open. 2017 Apr;2(1):e000083.

Correspondent Author
Carlos Cesar Barbosa
Ferreira Penteado,1242, ZIP:13010-041-Centro. Campinas, Sao Paulo, Brazil.
carlos.barbosa@prof.fae.br