MATHEWS

Research Article

Mathews Journal of Surgery

Trauma Laparotomy: A Surgical Odyssey

Mark L Walker, M.D., F.A.C.S*

Surgical Health Collective, Georgia, USA

ABSTRACT

A retrospective analysis of 203 trauma patients undergoing laparotomy over an 18-year period by a single surgeon at a level 1 trauma center was performed. These were young (mean age=33.84+/-14.74) seriously injured (mean ISS=22.32+/-11.61) patients who sustained a mix of blunt (52%) and penetrating injury (48%). Many of these patients were in shock at the time of admission (mean base deficit 7.30+/-5.06). Patients requiring a massive transfusion protocol (MTP) were stratified. Those with a single laparotomy and MTP had more balanced resuscitation when compared to those with MTP and damage control. The overall mortality was 5.4%. A damage control laparotomy was performed in 34 patients with a mortality of 23.5%(8 patients). 4 patients received ultra-massive transfusion (more than 20 units of Packed red cells) during their initial operation. 3 of these patient survived. A stepwise regression analysis yielded GCS (Glasgow Coma Score) as the sole predictor of outcome. Individual trauma surgeons can continue the search for better outcomes by reviewing their overall care.

Keywords: Trauma Patients, Laparotomy, Hemodynamic Stability, Surgical Infection.

INTRODUCTION

Trauma laparotomy is increasingly viewed as an index procedure that reflects quality of trauma care. Comprehensive global data covering trauma laparotomy remains inadequate but an international study seeks to close this deficit [1]. Busy trauma centers have reported mortality rates varying from 5% to 40% based on the need for damage control procedures [2,3]. Goals of initial care include restoring hemodynamic stability and limiting peritoneal contamination.

This paper will review one surgeons 18-year experience with trauma laparotomy. It will delineate the role of damage control intervention in the setting of a massive transfusion protocol (MTP) and contrast this outcome data with a subset of patients who had MTP implemented during a single laparotomy (SL).

METHODS

203 patients managed by one surgeon at a Level1trauma center over an eighteen-year period were reviewed. Patients that survived for more than 4 hours were included in this review. Medical charts containing initial

Vol No: 08, Issue: 01

Received Date: January 02, 2025

Published Date: February 18, 2025

***Corresponding Author**

Mark L Walker, M.D., F.A.C.S.

Surgical Health Collective, 1691 Phoenix Boulevard Suite 120 Atlanta, Georgia 30349, USA, Phone: 404-761-7482, **E-mail:** SurgHC1@aol.com

Citation: Walker ML. (2025). Trauma Laparotomy: A Surgical Odyssey. Mathews J Surg. 8(1):35.

labs, vital signs, imaging studies, anesthesia operative flow sheets, operative reports, pathology reports, post-operative notes and laboratory values were reviewed. Electronic Medical Records were utilized in addition to paper charts. Records of patients seen on an outpatient basis were also assessed.

Categorical and continuous variables were cataloged. Demographic variables included age, sex, type of trauma (blunt vs. penetrating), Injury severity score, Glasgow Coma Scale, blood pressure, pulse, respiration, base deficit, lactate, INR, estimated blood loss and operative transfusions. These variables were described for the group as a whole and for designated subsets. Specific organ injuries were determined for each patient and graded by the AAST organ injury scale. The use of preoperative FAST and or an abdominal CT scan was also documented.

Means plus standard deviations were determined. An analysis of variance was performed comparing subsets. A T-test was used for continuous variables. Outcomes were defined including mortality and morbidity. A step-wise regression analysis was used to determine those factors associated with mortality. Post-operative complications were cataloged. Deep space surgical infection, wound infection, sepsis, pneumonia, urinary tract infection, catheter related infections, acute respiratory distress syndrome (ARDS), and acute kidney injury (AKI) were assessed. MedCalc Statistical Software version 22.066 was used for the general statistical analysis. StatSoft, Inc.,2011 Statistica Version 10 was used for the regression analysis.

RESULTS

A total of 4500 patients were cared for during the study period. 230 of this group had a laparotomy during their hospital admission. 203 patients fulfilled the study criteria. 27 patients either did not have charts available for review or did not fulfill the study criteria. These were young (mean age 33.84 +/- 14.74) seriously injured (mean ISS-22.32 +/- 11.61) patients who sustained blunt trauma (52%) and stayed in the hospital for a mean of 15 +/-16.035 days. Table 1 describes the group as a whole. Many of these patients were in shock at the time of admission with the initial mean base deficit of 7.30 +/- 5.06 and a mean baseline lactate of 3.76 +/-2.25. Mortality was 5.4% (11 patients). Table 2 depicts post-operative complications for the group as a whole.

Table 3 depicts the damage control laparotomy group. Patients treated with DCL had high injury severity scores and base deficits along with very large blood loss during operative intervention. The low GCS in this group reflects either severe closed head injury or in field intubation. Intensive care unit and hospital length of stay were both prolonged in the DCL group. Table 4 depicts the SL/MTP cohort. SL/MTP patients were then compared to DCL/MTP patients (Table 5). Balanced resuscitation was evident in both but achieved (1:1= PRBC: FFP) in the SL/MTP group. As expected DCL/MTP patients had higher ISS (mean 33.14+/-12.0), lower GCS (7.53+/-5.45), chemical evidence of shock (base deficit=11+/-6.36) and greater blood loss (mean of 4 liters+). These differences were statistically significant. 4 patients received ultra-massive transfusion (more than 20 units of blood during initial operative care). Three of these patients survived.

All patients with SL/MTP were survivors. Of the 34 patients with DCL, 8 did not survive (23.5%).

Overall there were 11 deaths. Exsanguination occurred in 6 patients. Fatal brain injury was causative in 2 patients. 1 patient succumbed from multi-organ failure and sepsis. 1 from a massive pulmonary embolus and a final patient from ARDS. Using step-wise regression GCS emerged as the sole factor associated with survival. ISS, base deficit, lactate and EBL did not correlate with outcome.

Regarding specific injuries; there were 56 patients with liver injuries (5 with grade V and 14 with grade IV). There were 68 patients with spleen injuries (21 grade V and 23 grade IV). There were 27 kidney injuries (6 with grade V and 8 with grade IV). There were 20 patients with pancreas injuries (1 Grade IV and 5 with Grade III). There were 76 patients with colon trauma. There were 23 grade I, 7 Grade II, 19 Grade III, 19 Grade IV and 8 Grade 5 injuries. Colon repair was performed in 33 and colon resection was performed in 34. 21 patients had a colostomy. There was overlap between the repair, resection and colostomy groups. There were 36 small bowel resections and 28 small bowel repairs. There were 11 Pringle maneuvers, 9 finger fractures and ligation and one hepatic lobectomy. 65 splenectomies, 14 nephrectomies and 9 pancreatectomies performed, 17 patients with named vascular injuries were cared for 3 aorta, 4 inferior vena cava, 4 retrohepatic cava/hepatic venous injuries, 1 portal vein, 1 middle sacral artery, 1 inferior mesenteric artery, 1 right hepatic artery, 2 internal iliac vein and 1superior mesenteric vein near the origin of the portal vein. All aortic injury patients recovered. 2 were related to stab wounds and 1 was from a gunshot wound. Three of 4 IVC injured patients survived. One retrohepatic caval injury was combined with a right hepatic artery injury and this patient succumbed from hemorrhage. Two patients with a retrohepatic caval wounds from blunt trauma survived with packing. One patient had a Grade V liver injury associated with atrio-caval rupture from blunt trauma. He survived with packing and an atrio-caval repair.

The most common post-operative complication was sepsis (17%). More than half of these patients had documented bacteremia. The most common source of infection was pneumonia. Wound infection occurred in 5.4% and deep space infection in 6%. 4 patients developed an enterocutaneous fistula and 2 of these closed spontaneously prior to discharge to home.

Table 1. Group as a whole N=203

Parameter	Mean	Standard Deviation
Age	33.84	14.74
ISS	22.32	11.61
GCS	12.53	4.61
BPS	115.96	27.55
BPD	79.64	20.89
Pulse	100.54	22.29
Resp	20.21	5.76
Lactate	3.76	2.25
Base Deficit	7.3	5.06
EBL	1467.52	2060.17
PRBC	6.67	6.06
FFP	5.32	4.35
INR	1.23	0.346
ICU LOS	9.95	11.86
Hospital LOS	14.97	16.035

EBL = Estimated Blood Loss

PRBC = Packed Red Blood Cells

INR = International Normalized Ratio

BPS = Blood Pressure Systolic

LOS = Length of Stay

FFP = Fresh Frozen Plasma

BPD = Blood Pressure Diastolic

Table 2. Complications

Complications		
Wound Infection	11	5.40%
Pneumonia	29	14.30%
DVT	1	0.05%
AKI	4	2.00%
ARDS	5	3.00%
IAA-Deep Space	12	6.00%
ECF	4	2.00%
Sepsis	35	17.00%
Bacteremia	18	9.00%
Biloma	4	2.00%
Pancreatic Fistula	5	3.00%
Urinoma	1	0.05%
UTI	7	3.50%

DVT =Deep Vein Thrombosis

IAA = Intraabdominal Abscess

ECF = Enterocutaneous Fistula

AKI = Acute Kidney Injury

ARDS = Acute Respiratory Distress Syndrome

UTI= Urinary Tract Infection

Table 3. Damage Control Laparotomy

Damage Control Laparotomy		
N=34	**Mean**	**S.D.**
Age	39	15
ISS	32	13
GCS	7.6	5.5
BPS	95	34
BPD	59	27
Pulse	102	35
Resp	16	7
Lactate	5	2.4
Base Deficit	11.03	6.4
INR	1.5	0.44
PRBC	11.3	7.6
FFP	6.2	5.6
EBL	3957	3643
ICU LOS	14	14
LOS	27	22

Table 4. Single Laparotomy/MTP

Single Laparotomy/MTP		
N=17	**Mean**	**Standard Deviation**
Age	32	14.3
ISS	22.5	9.8
GCS	12	4.8
BPS	105	27
BPD	72.3	30
Pulse	101	18
Respiration	21	7
Lactate	5	3
Base Deficit	5	3
EBL	2112	1215
PRBC	7.5	5.1
FFP	6.3	3.6
ICU LOS	10.5	18
INR	1.35	0.6
LOS	20.93	21.95

ISS=Injury Severity Score

GCS= Glasgow Coma Scale

EBL=Estimated Blood Loss

INR=Internationalized Normative Ratio

LOS=Length of Stay

ICU LOS= Intensive Care Unit length of stay

Table 5. Massive Transfusion n=17 & SL vs. DCL n=22

MASSIVE	TRANSFUSION n=17	SL vs. DCL n=22	
Parameter	**SL/MTP**	**DCL/MTP**	**p-value**
Age	32.35+/-14.28	36.09+/-14.36	p=0.4244
ISS	22.5+/-9.81	33.14+/-12.0	p=0.0054*
GCS	11.64+/-4.82	7.53+/-5.45	p=0.0360*
Systolic	104.68+/-27.46	102.75+/-32	p=0.8480
Diastolic	72.33+/-30.14	62.55+/-28	p=0.3302
Pulse	101+/-18.37	103.8+/-33.26	p=0.7763
Resp	21+/-6.8	17.0+/-6.212	p=0.1310
Lactate	5.03+/-3.24	5.38+/-2.5	p=0.7687
Base Deficit	4.75+/-3.52	11+/-6.36	p=0.0045*
INR	1.35+/-0.6245	1.64+/-0.2476	p=0.2476
PRBC	7.53+/-5.15	13.5+/-7.7	p=0.0090*
FFP	6.3+/-3.62	7.66+/-6.11	p=0.4202
EBL	2111.76+/-1215	4482.335+/-4061	p=0.0278*
ICULOS	10.5+/-17.7	13.56+/-14.01	p=0.6302
LOS	20.9+/-21.9	29.68+/-26.5	p=0.2992

* Statistically significant = p <0.05

Table 6. Pre-Operative Imaging

Pre-op FAST	**n=128**	**128/203 (63%)**
Positive FAST and No CT	52/128 (41%)	
Negative FAST and No CT	12/128 (9.4%)	
Pre-opCTscan	**n=96**	**96/203 (47%)**
Pre-op CT scan and Negative FAST	50/96 (52%)	
Pre-op CT scan and Positive FAST	14/96 (15%)	

Table 7. Mortality Data

Num	Age	Sex	ISS	GCS	Lactate	B.D.	Injuries	Cause of Death
1	33	F	50	3	4	-12	C1 Fx Disloc, and TBI (IPH)	Severe TBI
2	48	F	20	3	4.3	-12	Mesenteric Bleed Pelvic Bleed	Bleeding
3	50	F	35	3	14.7	-24	Humerus Fx, Femur Fx, Spleen,+BCI	Bleeding
4	X	M	31	3	X	X	CHI, Spleen	Bleeding +TBI
5	18	M	34	X	X	-6	Liver (V), IVC, Rt Hepatic	Bleeding
6	72	F	25	X	X	X	Liver (IV)	Bleeding
7	56	M	25	3	ED-Chest	X	Liver (IV), Spleen, IVC, SMV	Bleeding
8	69	M	41	3	4	-8	IMA, Bleed Femur Fx	Sepsis MOF
9	27	M	50	3	X	X	Basilar Skull Fx, Spleen (V)	TBI +Bleeding
10	25	M	15	15	X	X	Small Bowel	PE
11	56	M	33	6	10.8	X	Spleen (IV)	ARDS

DISCUSSION

This report illustrates some of the current principles of trauma care and highlights areas that require improvement. First a rapid assessment in the trauma bay involves searching for occult sources of hemorrhage [4]. The expeditious use of the focused abdominal ultrasound for trauma has been a mainstay in this regard. Alerting the trauma team (including anesthesiology) that a massive transfusion protocol should be instituted early when 2 or more ABC (assessment of blood consumption) criteria have been met is necessary [5]. In this series PRBC: FFP was more balanced in the single laparotomy/MTP group. All of these patients survived. In contrast the DCL/MTP group received a 2:1 ratio of PRBC: FFP. The PROPPR trial data did not reveal a difference in overall outcome between a 1:1:1 vs. 1:2:1 ratio. However, a post-hoc analysis suggested that exsanguination occurred more often in the 1:2:1 group [6]. This may be a factor in the outcome difference noted although some of our patients likely had non-survivable injuries (retrohepatic cava + right hepatic artery bleeding is an example). Time to hemorrhage control has been documented as a quality indicator by several groups [7-9]. We did not report complete data herein but a subset analysis of the most critically injured revealed a mean time of 44 minutes to hemorrhage control. The liberal use of FAST in this series (128 patients 63%) likely has some bearing on this. FAST was positive in 52 patients and no CT scanning was done in this group. A preoperative CT was performed in 96 patients. 14 of these patients had a positive FAST (Table 6). One of the difficult issues in trauma care decision making involves when to go to the scanner as opposed to the operating room. In a cohort of 383 patients from the United Kingdom a preoperative CT was performed for the majority of patients but FAST was performed in only 57 patients (16%). If CT had been omitted, the time to hemorrhage control may have been shortened. More than half of the patients who died in that series had a preoperative CT [10]. CT remains an important part of the work up of patients with tangential penetrating trauma in the setting of normal hemodynamics [11-13]. CT provides useful information that might allow the clinician to follow a course of observation instead of abdominal exploration. Sensitivity of the modern generation scanners for detecting bowel injury in blunt trauma has improved to 95% [14].

There was one missed bowel injury in our series. This patient had a normal admission CT scan and mild tenderness in the region of a seat belt contusion on examination. He had a femur fracture and was cleared for orthopedic intervention. A repeat CT post-operatively detected the mesenteric and bowel injury. A small bowel resection and ileostomy was performed. Full recovery followed.

Common causes for acute trauma mortality include hemorrhage and traumatic brain injury [15-17]. 11 patients succumbed after admission. 6 died from exsanguination, 2 from severe TBI (one patient with a basilar skull fracture was also bleeding) one from a massive pulmonary embolus, another from ARDS and a final patient from multi-organ failure and sepsis. These results are depicted in Table 7. Using a step-wise regression analysis, GCS was the only independent predictor of mortality.

In a mature trauma network patients are now making it to the hospital with injuries that they may have succumbed to decades earlier. Newer tools including resuscitative endovascular balloon occlusion (Reboa) may help us salvage more of these patients in the setting of non-compressible truncal hemorrhage [18-21]. We did not use Reboa in any of the patients described and this likely represents a quality improvement area.

Another concern is the utilization frequency of damage control laparotomy. The 17% rate reported in our study does not seem excessive given the high grade of liver injuries and the estimated blood loss (4 liters) reported in the DCL group. Quality improvement efforts have successfully reduced the application of damage control laparotomy at one level 1 US trauma center from 30% to 17% with no adverse consequences regarding outcome [22]. A large range exists between institutions and individual surgeons for the application of damage control laparotomy [23-25]. It is clear based on this study that the mere implementation of a massive transfusion protocol does not mandate a damage control approach.

The open abdomen exposes the patient to significant risks of infection, fistula formation and ventral hernia. The significant rate of infection reported in our patients (sepsis in 17%, wound infection 5.4% and intraabdominal abscess 6%) is consistent with what is often described in damage control observational studies [26-28]. All four patients with an enterocutaneous fistula had open abdomens in the damage control setting. 3 with colon and small bowel wounds requiring resection and anastomosis. Colon injuries requiring resection and repeated re-explorations are two clear risk factors for fistula formation in the setting of an open abdomen [29,30].

Fortunately, 2 closed prior to discharge and one was repaired after several months. The final patient had a low output fistula that was managed with local wound care. It has been closed and his colostomy has been reversed. He is tolerating oral intake.

SUMMARY AND CONCLUSIONS

We report a retrospective series of 203 patients managed by one surgeon over an 18-year period in a Level I trauma center. These young severely injured patients had significant base deficits and elevated lactates reflecting compromised flow on admission. Patients treated with a massive transfusion protocol and a single laparotomy were compared to those treated with damage control laparotomy and massive transfusion. ISS, blood loss, base deficit and lactate were greater in the damage control group. GCS was significantly lower in the DCL group. Balanced resuscitation was evident in those patients managed with a massive transfusion protocol and a single laparotomy. Mortality was 5.4% with most patients succumbing to hemorrhage. Although not utilized in this cohort, we remain hopeful that the application of Reboa may allow us to salvage patients in the future from non-compressible truncal hemorrhage.

ACKNOWLEDGMENTS

None.

CONFLICTS OF INTEREST

The author declares that there is no conflicts of interest.

REFERENCES

1. Bath MF, Bashford T; GOAL-Trauma Collaborative. (2024). The trauma laparotomy-A key procedure that lacks global data. World J Surg. 48(5):1001-1003.
2. Weale R, Kong V, Buitendag J, Ras A, Blodgett J, Laing G, et al. (2019). Damage control or definitive repair? A retrospective review of abdominal trauma at a major trauma center in South Africa. Trauma Surg Acute Care Open. 4(1):e000235.
3. Hietbrink F, Smeeing D, Karhof S, Jonkers HF, Houwert M, van Wessem K, et al. (2019). Outcome of trauma-related emergency laparotomies, in an era of far-reaching specialization. World J Emerg Surg. 14:40.
4. Stewart RM, Rotondo MF, Henry SM, Drago M. (2018). Advanced Trauma Life Support 10th edition Library of Congress Number: 2017907997. pp.47.
5. Cotton BA, Dossett LA, Haut ER, Shafi S, Nunez TC, Au BK, et al. (2010). Multicenter validation of a simplified score to predict massive transfusion in trauma. J Trauma. 69(Suppl 1):S33-S39.
6. Holcomb JB, Tilley BC, Baraniuk S, Fox EE, Wade CE, Podbielski JM, et al. (2015). Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. JAMA. 313(5):471-

482.

7. Thomas AC, Campbell BT, Subacius H, Bilimoria KY, Stey AM, Hamad D, et al. (2022). Time to OR for patients with abdominal gunshot wounds: A potential process measure to assess the quality of trauma care? J Trauma Acute Care Surg. 92(4):708-716.

8. Meizoso JP, Ray JJ, Karcutskie CA 4th, Allen CJ, Zakrison TL, Pust GD, et al. (2016). Effect of time to operation on mortality for hypotensive patients with gunshot wounds to the torso: The golden 10 minutes. J Trauma Acute Care Surg. 81(4):685-691.

9. Barbosa RR, Rowell SE, Fox EE, Holcomb JB, Bulger EM, Phelan HA, et al. (2013). Increasing time to operation is associated with decreased survival in patients with a positive FAST examination requiring emergent laparotomy. J Trauma Acute Care Surg. 75(1 Suppl 1):S48-S52.

10. Marsden MER, Vulliamy PED, Carden R, Naumann DN, Davenport RA; National Trauma Research and Innovation Collaborative (NaTRIC). (2021). Trauma Laparotomy in the UK: A Prospective National Service Evaluation. J Am Coll Surg. 233(3):383.e1-394.e1.

11. Dreizin D, Boscak AR, Anstadt MJ, Tirada N, Chiu WC, Munera F, et al. (2016). Penetrating Colorectal Injuries: Diagnostic Performance of Multidetector CT with Trajectography. Radiology. 281(3):749-762.

12. Fikry K, Velmahos GC, Bramos A, Janjua S, de Moya M, King DR, et al. (2011). Successful selective nonoperative management of abdominal gunshot wounds despite low penetrating trauma volumes. Arch Surg. 146(5):528-532.

13. Peponis T, Kasotakis G, Yu J, Alouidor R, Burkott B, Maung AA, et al. (2017). Selective Nonoperative Management of Abdominal Gunshot Wounds from Heresy to Adoption: A Multicenter Study of the Research Consortium of New England Centers for Trauma (ReCoNECT). J Am Coll Surg. 224(6):1036-1045.

14. Fakhry SM, Allawi A, Ferguson PL, Michetti CP, Newcomb AB, Liu C, et al. (2019). Blunt small bowel perforation (SBP): An Eastern Association for the Surgery of Trauma multicenter update 15 years later. J Trauma Acute Care Surg. 86(4):642-650.

15. Callcut RA, Kornblith LZ, Conroy AS, Robles AJ, Meizoso JP, Namias N, et al. (2019). The why and how our trauma patients die: A prospective Multicenter Western Trauma Association study. J Trauma Acute Care Surg. 86(5):864-870.

16. Oyeniyi BT, Fox EE, Scerbo M, Tomasek JS, Wade CE, Holcomb JB. (2017). Trends in 1029 trauma deaths at a level 1 trauma center: Impact of a bleeding control bundle of care. Injury. 48(1):5-12.

17. DiMaggio C, Ayoung-Chee P, Shinseki M, Wilson C, Marshall G, Lee DC, et al. (2016). Traumatic injury in the United States: In-patient epidemiology 2000-2011. Injury. 47(7):1393-403.

18. Brenner M, Inaba K, Aiolfi A, DuBose J, Fabian T, Bee T, et al. (2018). Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 226(5):730-740.

19. Pieper A, Thony F, Brun J, Rodière M, Boussat B, Arvieux C, et al. (2018). Resuscitative endovascular balloon occlusion of the aorta for pelvic blunt trauma and life-threatening hemorrhage: A 20-year experience in a Level I trauma center. J Trauma Acute Care Surg. 84(3):449-453.

20. Asmar S, Bible L, Chehab M, Tang A, Khurrum M, Douglas M, et al. (2021). Resuscitative Endovascular Balloon Occlusion of the Aorta vs Pre-Peritoneal Packing in Patients with Pelvic Fracture. J Am Coll Surg. 232(1):17.e2-26.e2.

21. Gupta BK, Khaneja SC, Flores L, Eastlick L, Longmore W, Shaftan GW. (1989). The role of intra-aortic balloon occlusion in penetrating abdominal trauma. J Trauma. 29(6):861-865.

22. Harvin JA, Kao LS, Liang MK, Adams SD, McNutt MK, Love JD, et al. (2017). Decreasing the Use of Damage Control Laparotomy in Trauma: A Quality Improvement Project. J Am Coll Surg. 225(2):200-209.

23. Watson JJ, Nielsen J, Hart K, Srikanth P, Yonge JD, Connelly CR, et al. (2017). Damage control laparotomy utilization rates are highly variable among Level I trauma centers: Pragmatic, Randomized Optimal Platelet and Plasma Ratios findings. J Trauma Acute Care Surg. 82(3):481-488.

24. Roberts DJ, Faris PD, Ball CG, Kirkpatrick AW, Moore EE, Feliciano DV, et al. (2021). Variation in use of damage control laparotomy for trauma by trauma centers in the United States, Canada, and Australasia. World J Emerg Surg. 16(1):53.

25. Hu P, Jansen JO, Uhlich R, Hashmi ZG, Gelbard RB, Kerby J, et al. (2022). It is time to look in the mirror: Individual surgeon outcomes after emergent trauma laparotomy. J Trauma Acute Care Surg. 92(5):769-780.

26. Dubose JJ, Scalea TM, Holcomb JB, Shrestha B, Okoye O, Inaba K, et al. (2013). Open abdominal management after damage-control laparotomy for trauma: a prospective observational American Association for the Surgery of Trauma multicenter study. J Trauma Acute Care Surg. 74(1):113-120.

27. George M, Adams SD, McNutt MK, Love JD et. al. (2018). The Effect of Damage Control Laparotomy on Major Abdominal Complications: A Matched Analysis Am J Surg. 216(1)56-59.

28. Brenner M, Bochicchio G, Bochicchio K, Ilahi O, Rodriguez E, Henry S, et al. (2011). Long-term impact of damage control laparotomy: a prospective study. Arch Surg. 146(4):395-399.

29. Bradley MJ, Dubose JJ, Scalea TM, Holcomb JB, Shrestha B, Okoye O, et al. (2013). Independent predictors of enteric fistula and abdominal sepsis after damage control laparotomy: results from the prospective AAST Open Abdomen registry. JAMA Surg. 148(10):947-954.

30. Dubose JJ, Scalea TM, Holcomb JB, Shrestha B, Okoye O, Inaba K, et al. (2013). Open abdominal management after damage-control laparotomy for trauma: a prospective observational American Association for the Surgery of Trauma multicenter study. J Trauma Acute Care Surg. 74(1):113-120.