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Damage Control Laparotomy in Trauma Patients: A Level I Trauma Center Experience

Anthony J. Duncan[1*], Wade A. Hopper[1], Mentor Ahmeti [1, 2]

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Abstract

Introduction: The surgical management of traumatic injury is an evolving and controversial topic. We present outcomes of laparotomy performed for blunt and penetrating trauma at a level I trauma center over a nearly 10-year period.

Material and Methods: Retrospective single-center cohort study of patients who received either damage control laparotomy or definitive laparotomy with fascial closure at the time of index procedure. The primary outcome was in-hospital mortality. Secondary outcomes were length of stay, complications, intensive care requirements, and vasopressor use.

Results: Out of 125 included patients, 69 received damage control laparotomy, and 56 received definitive laparotomy. Damage control laparotomy was associated with significantly higher mortality (20.9% vs 1.8%, p=.0015) and length of stay (16.1 vs. 9.3 days, p=.0005) than definitive laparotomy. Complications occurred significantly more frequently among damage control laparotomy patients (53.6% vs. 14.3%, p<.0001). Damage control laparotomy patients were substantially more likely to require intensive care unit admission, mechanical ventilation, and vasopressor support.

Conclusion: Patients undergoing damage control laparotomy are at significantly increased risk for adverse outcomes, including increased in-hospital mortality, prolonged length of stay, more significant complication burden, and increased need for mechanical ventilation and pressure support as compared to patients undergoing definitive laparotomy.

Keywords: Damage control surgery; Trauma, Mortality, Trauma Center

Introduction:

Traumatic injuries remain a leading cause of death and disability worldwide.[1]

The standard of care for trauma patients, particularly those with blunt trauma, has increasingly shifted towards nonoperative management (NOM) and this has caused a significant reduction in laparotomies performed for trauma.[2,3]

Consequently, the acuity level of operative cases at most trauma centers has increased because operations are often reserved for patients who are hemodynamically unstable or have hollow viscus injuries. [4]

In abdominal surgery, damage control laparotomy (DCL) is a vital strategy for managing the lethal triad of hypothermia, coagulopathy, and acidosis that proves fatal in unmitigated hemorrhagic shock.[5]

The philosophy behind DCL is to stop hemorrhage and control contamination while saving definitive repair until later. This contrasts with performing a definitive laparotomy (DL), completing all operative intervention at the index operation. By implementing DCL and leaving the abdomen open, surgeons can rapidly transition patients from the operating room to the intensive care unit (ICU).[6]

This allows time for correction of physiologic derangements before proceeding with definitive surgical interventions. [7, 8] However, leaving the abdomen open is not without risks. Studies have shown that patients with open abdomens face higher rates of sepsis, ventilator-associated

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* ***Corresponding author:***
Anthony Duncan MD,
✉ *Anthony.duncan@und.edu*

1 School of Medicine & Health Sciences, Department of Surgery, University of North Dakota, USA
2 Department of Trauma and Acute Care Surgery, Sanford Medical Center Fargo, North Dakota USA

pneumonia, ventral hernias, and loss of abdominal domain. [9-11] Furthermore, recent literature suggests there may be an overuse of DCL in some trauma centers, raising concerns about its long-term outcomes. [10, 12]

Our study aims to compare the outcomes of trauma patients who underwent DCL versus those whose abdomens were closed during their initial surgery. By reviewing these findings alongside current literature, we seek to provide clear, evidence-based recommendations on the appropriate use of DCL and its impact on patient outcomes in our population.

Material and Methods:

Data Collection; We conducted a retrospective review of patients at our Level I Trauma Center who underwent emergent laparotomies for traumatic indications between January 2015 and January 2024. Institutional Review Board (IRB) approval was received on February 28, 2024 (IRB: MOD00009828). Patients were included if they presented with either blunt or penetrating trauma and underwent an exploratory laparotomy during their hospitalization. Patients who did not undergo surgery during their hospitalization, under the age of 18 or had surgery for a non-traumatic cause were excluded.

A key variable of interest was whether the patient's abdomen was closed during the initial operation or if they required a damage control laparotomy. The primary study outcome was all-cause in-hospital mortality. Secondary outcomes included length of stay, complications, and intraoperative pressor use. Complications reported included pneumonia, cardiac arrest, acute kidney injury, and anemia requiring transfusion. Intraoperative pressor use was recorded for each patient as the amount of norepinephrine, phenylephrine, vasopressin or norepinephrine received in microgram (mcg) dose and subsequently converted to norepinephrine equivalent dosage. [13]

Finally, intraoperative administration of blood products was reported including packed red blood cells (pRBC), platelets, and fresh frozen plasma (FFP).

Prehospital demographic variables were reported including age, gender, race, type of trauma (penetrating or blunt), presence of comorbidities, and whether the patient had a positive blood alcohol or urine drug screen upon presentation.

The preoperative American Society of Anesthesiologists (ASA) physical status classification was reported for each patient. For patients admitted to the ICU we reported APACHE II and Sequential Organ Failure Assessment (SOFA) scores. [14, 15]

These scores were calculated using physiologic and laboratory variables obtained within 24 hours of index operation. We used the most extreme instance of each involved variable for calculations; for example, if a patient had documented heart rates between 80 and 130 beats per minute, then 130 beats per minute was chosen for input.

Data Analysis: GraphPad Prism 10.3.1 was used for all statistical analysis. [16] Continuous variables were analyzed using a t-test or a Mann-Whitney U test as appropriate. Categorical outcomes were analyzed using either a Chi-Square test or Fisher's exact test. All reported p-values were two-sided and values < 0.05 were considered statistically significant. Only patients with complete data for all relevant variables were included in the analysis, ensuring no subjects were excluded due to missing or incomplete information. This approach minimized potential biases and strengthened the validity of our findings.

Results:

Study Population; A total of 125 patients met inclusion criteria, 69 of whom received DCL and 56 of whom received DL. Baseline demographic information is presented in Table 1. There were no significant differences in age, gender or race between the groups. The mean age was 41.3 ± 17.1 and 42.1 ± 9.1 years old for DCL and DL respectively (p=0.8139). Both groups were predominantly male with 55 patients in DCL and 42 in DL being male (*p*=0.5299). Groups predominantly identified as being White 42.1% (n=29) in DCL and 50% (n=28) in DL (*p*=0.6731).

When presence of prehospital comorbidities was evaluated, patients receiving DCL showed lower rates with only 31 patients (45%) compared to 35 (63%) in the

	DCL (n=69)	**DL (n=56)**	***p*-value**
Demographic			
Age (Years)[1]	41.3 (17.1)	42.1 (19.1)	0.8139
Male[2]	55 (79.7)	42 (75.0)	0.5299
Female	14 (20.3)	14 (25.0)	
White[2]	29 (42.1)	28 (50.0)	0.6731
American Indian/Alaskan Native[2]	17 (24.7)	16 (28.6)	0.8842
Black[3]	3 (4.3)	6 (10.7)	0.4296
Other[3]	2 (2.9)	2 (3.6)	0.999
Comorbidities			
Any co-morbidities[2]	31 (44.9)	35 (62.5)	0.0503
Positive Blood alcohol level[2]	20 (29.0)	22 (39.3)	0.2253
Positive Urine Drug Screen[2]	17 (24.6)	27 (48.2)	0.0061*
Smoker[2]	18 (26.1)	19 (32.2)	0.4467

*Damage Control Laparotomy (DCL), Definitive Laparotomy (DL); [1]Mean (SD), T-test; [2]n (%); Chi-square, [3]n (%), Fisher's exact; *denotes p-value <0.05*

Table 1: Demographic Information

DL group (*p*=0.503). The most common co-morbidities were evaluated between groups and the only significant finding was a higher rate of positive urine drug screens in DL patients 48.2% compared to 24.6% in DCL patients (p=0.0061). Both groups had similar rates of positive blood alcohol levels and rates of smoking.

Mechanism of Injury

Injury specifics were compared between groups as shown in Table 2. ISS (IQR) was higher in patients that required DCL with a median (IQR) of 32 (23-37) compared to 15 (11-17) in the DL group (p<0.0001). Patients with blunt traumatic injuries were significantly more likely to undergo DCL compared to DL (65.2% vs. 37.5%, *p*=0.002). Conversely, patients with penetrating injury were more likely to undergo DL compared to DCL (62.5% vs. 34.8%). When we looked at body systems injured in additional to abdominal injuries we found increased rates for all body systems. (Table 2)

Operative Features

Operative features are described in Table 3. DCL patients showed higher preoperative ASA classification compared to DL patients (3.7 ± 1.0 vs. 2.7 ± 1.0, *p*<0.0001, Table 2). This was presumably due to the higher incidence of acutely life-threatening disease in the damage control cohort. Similarly, the number of patients who received intraoperative vasopressors was higher in the DCL group than in the in DL group (66.7% vs. 46.5%, *p*=0.0228) and intraoperative pressor requirements were markedly elevated in the DCL group (0.8695 norepinephrine mEq vs. 0.2480 norepinephrine mEq, *p*=0.009) However, there were no significant differences between groups with regards to intraoperative blood product administration. Significance was nearly observed for intraoperative pRBC use, with DCL patients having a median (IQR) of 1,200 mL (500, 1500) given compared to DL with a median (IQR) of 625 mL (350, 850) (*p*=0.0926).

Critical Care Outcomes:

Data relevant to intensive care is presented in Table 4. Patients receiving DCL were at much higher risk for postoperative ICU admission compared to those receiving DL (88.4% vs. 35.7%, *p*<0.0001). DCL was also associated with significantly longer ICU length of stay and significantly greater risk of requiring ventilation and continued pressors. No difference was found between groups for the median number of ventilation days or days that patients were on pressors.

Patient Outcomes:

Outcomes based on damage control versus definitive laparotomy are shown in Table 5. Treatment with DCL was associated with

	DCL (n=69)	**DL (n=56)**	***p*-value**
ISS1	32 (23-37)	15 (11-17)	<0.0001*
Mechanism of Injury[2]			
Penetrating	24 (34.8)	35 (62.5)	0.0020*
Blunt	45 (65.2)	21 (37.5)	
Injured Systems[3]			
Head	22 (31.9)	7 (12.7)	0.0114*
Spinal	15 (21.7)	3 (5.4)	0.0104*
Thoracic	44 (63.8)	19 (33.9)	0.0012*
Pelvic	17 (24.6)	6 (10.7)	0.0628
Extremity	20 (29.0)	5(8.9)	0.0065*

*Damage Control Laparotomy (DCL), Definitive Laparotomy; [1]Median (IQR), Mann-Whitney; [2]n (%); chi-square; [3]n (%); Fisher exact; *denotes p-value <0.05*

Table 2: Injury Characteristics

	DCL (n=69)	**DL (n=56)**	***p*-value**
ASA[1]	3.7 (1.0)	2.8 (1.0)	<0.0001*
Number that got pressors intra-op[2]	46 (66.7)	26 (46.5)	0.0228*
Vasopressor intraoperatively (mcq NE equivalent)[3]	0.8695 (0.3345-2.893)	0.2480 (0.1338-0.9203)	0.0090*
Blood product			
RBC (mL)[3]	1200 (500-1500)	625 (350-850)	0.0926
Platelets (mL)[3]	414 (245-784)	234 (215-519)	0.1863
FFP (mL)[3]	621 (285-519)	664 (217-1305)	0.8351

*Damage Control Laparotomy (DCL), Definitive Laparotomy (DL); [1]Mean (SD), t-test; [2]n (%); chi-square; [3]Median (IQR), Mann-Whitney; *denotes p-value <0.05*

Table 3: Operative Features

	DCL (n=69)	DL (n=56)	*p*-value
ICU Admission[1]	61 (88.4)	20 (35.7)	<0.0001*
ICU LOS[2]	6 (3-11)	2 (1-4)	0.0008 *
Needing ventilation[1]	61(88.4)	9 (16.1)	<0.0001*
Days on Vent [2]	5 (2-9)	3 (1-7)	0.5653
Needing pressors[1]	56 (81.2)	9 (16.1)	<0.0001*
Number of days on[2] pressors	4 (2-7)	2 (1-8)	0.4522
APACHE II[3]	15.3 (6.7)	16.1 (9.8)	0.7317
SOFA[3]	7.0 (3.7)	6.0 (3.0)	0.3702

*Damage Control Laparotomy (DCL), Definitive Laparotomy (DL); [1]n (%); Chi-Square; [2]Median (IQR), Mann-Whitney; [3]Mean (SD), T-test; *denotes p-value <0.05*

Table 4: ICU Characteristics

significantly greater in-hospital mortality compared to treatment with DL (20.9% vs. 1.8%, *p*=0.0015). Hospital length of stay was calculated for the two groups. On average, DCL treatment was associated with roughly one extra week of hospitalization compared to DL treatment (16.1 days vs. 9.3 days, *p*=0.005). When we looked at if the patient had any in-hospital complications, we also found that DCL treatment was associated with a significantly higher percentage of complications compared to DL treatment (53.6% vs. 14.3%, *p*<0.0001). We reported the 4 most prevalent complications seen in our DCL group which were pneumonia (8.7%), anemia requiring transfusion (7.2%), cardiac arrest (7.2%) and acute kidney injury (7.2%). There were no significant differences between DCL and DL for any individual complications. Of note, no patients had fascial dehiscence in either group.

	DCL (n=69)	DL (n=56)	*p*-value
Hospital LOS[1]	16.1 (12.3)	9.3 (8.1)	0.0005*
Mortality[2]	14 (20.9)	1 (1.8)	0.0015*
Complications[2]	37 (53.6)	8 (14.3)	<0.0001 *
Pneumonia[2]	6 (8.7)	1 (1.8)	0.1287
Anemia requiring transfusion[2]	5 (7.2)	1 (1.8)	0.2228
Cardiac Arrest[2]	5 (7.2)	0 (0.0)	0.0642
AKI[2]	5 (7.2)	1 (1.8)	0.2228

*Damage Control Laparotomy (DCL), Definitive Laparotomy (DL); [1]Mean (SD), t-test; [2]n (%), Fisher's exact; *denotes p-value <0.05*

Table 5: Patient Outcomes

Discussion:

The decision of how and when to use damage control laparotomy (DCL) continues to remain a topic of research and discussion. Selection of DCL patients often occurs intraoperatively and is based largely on subjective surgeon judgment. The DCL technique is generally selected based on physiologic criteria with special attention to core temperature, acid-base balance, and measures of coagulability. It can be a means to save a life while when used appropriately in a group of patients that has a high mortality rate.[17]

Our study evaluated difference in presentation, operative features and outcomes in patients who either underwent DCL or a definitive laparotomy (DL)

The rate of ICU admission was higher within our DCL group by over double (36% vs 88%). This is not unexpected considering out DCL patients required more intraoperative pressors and blood product transfusions. The percentage of patients that also required postoperative pressors and ventilation was also higher within our DCL group. Interestingly, between the two groups there were no significant differences in scores predicting mortality risk (APACHE II and SOFA). However, ASA classification, which is a more subjective measure of predicted mortality, was significantly higher within the DCL group. [18, 19]

The APACHE II score is calculated largely from physiologic input data including peak vital signs, blood pH, blood electrolytes, blood cell counts, and oxygen requirements.[14]

There was clearly a mortality difference between groups, and estimating mortality for operative trauma patients may rely heavily on subjective data. There might also be difference in ICU metrics that we did not find due to sample size as we also found a longer duration of ICU, LOS, number of patients requiring ventilation and pressors. Altogether, the findings suggest that traditional means of assessing ICU patient risk are nonviable in the operative trauma population. More work is needed to identify the most impactful outcome variables for operative trauma patients with hopes of constructing better risk-predictive models in this population.

Patient mortality was significantly higher in patients that underwent DCL (21% vs 2%). We attribute this mainly to predisposing injury factors rather than factors associated with the choice of treatment modality. Our study shows that patients had significantly worst traumatic injuries based on ISS with DCL having a median of 32 compared to DL of 15 (*p*<0.0001). Patients with DCL also had significantly higher rates of concurrent head, spinal, thoracic and extremity injuries. Our mortality data falls within the scope of other studies' reported mortality rates from DCL ranging from 1.5% to 26.4%.

A study from the American military assessed DCL versus DL in the combat zone environment from 2002 to 2011. [20] They included 311 patients who underwent DCL and found comparable mortality rates between DCL and DL of 1.5% and 1.4%, respectively. [20]

Harvin et al. performed a prospective trial randomizing 40 patients to receive either DCL or DL and found that in-hospital mortality was significantly lower in DCL patients (6% vs. 33%, p=.049). [21] *Lauerman et al.* reported a mortality rate of 26.4% for 330 patients undergoing DCL at an urban level I trauma center. [22]

Finally, the usage rate of damage control laparotomy in the appropriate patient populations is known to vary widely among institutions. A pooled retrospective analysis from 12 North American level I trauma centers demonstrated DCL rates varied from 33% to 83% between different institutions. [23]

This study found a 19% 24-hour mortality rate for DCL patients and a 28% 30-day mortality rate, however the choice of DCL treatment versus DL treatment was not associated with increased 30-day mortality.[23]

Data suggests that long-term mortality is not impacted by DCL if the patient survives the initial admission. [24]

Regarding hospital LOS, it was significantly increased in patients with DCL which is consistent with published data. [21, 25] Interestingly, our overall complication rate was higher in patients with DCL however no particular complication was significantly higher itself when they were individually compared. We report rates of pneumonia and acute kidney injury (8.7% and 7.2%, respectively) that are lower than similar studies, however this finding could have been affected by small sample size.

Particularly, *Lauerman et al.* reported pneumonia and acute renal failure in 13% and 22.4%, respectively, of DCL patients. [22] Additionally, *Harvin et al.* reported acute renal failure occurring in 17% of DCL patients and 33% of DL patients.[21]

Limitations: Our study is retrospective in nature thus is limited to the quality of data recorded at the time of presentation. Trauma laparotomy is an uncommon operation and our study like others similar was limited by a low sample size. We did observe some trends in key variables which approached but did not achieve statistical significance, and a more powered study may be able to detect some of those underlying trends. For example, the complications of pneumonia and cardiac arrest were more common in DCL patients but were not significant in our analysis. On the topic of complications, we only evaluated acute complications identified during index hospitalization. Damage control laparotomy is known to be associated with several chronic abdominal complications including pain, incisional hernia, enterocutaneous fistula, and small bowel obstruction. Current literature suggests there are several potential long-term complications of DCL treatment and that the true burden of these complications may currently be under-reported.[24] Future research should focus on exploring long term complications and quality-of-life outcomes related to DCL.

Conclusions:

Surgeon choice to use damage control laparotomy (DCL) aligns with the degree of injury based on ISS. With increase in traumatic injury and hemodynamic instability DCL should remain an operative option to expedite the time patient spends in the operative room so they can be stabilized in the ICU setting. Patients undergoing DCL are at significantly increased risk for adverse outcomes including increased in-hospital mortality, prolonged length of stay, greater complication burden, and increased need for ventilation and pressor support as compared to patients undergoing definitive laparotomy. At our institution, there was a significant trend towards using damage control laparotomy for blunt traumatic injury and using definitive laparotomy for penetrating traumatic injury.

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Abbreviations:

NOM - Nonoperative Management; DCL - Damage Control Laparotomy; DL - Definitive Laparotomy; IRB - Institutional Review Board; ICU - Intensive Care Unit; MOI: Mechanism of Injury; mcg - microgram; pRBC - packed Red Blood Cells; FFP - Fresh Frozen Plasma; ASA - American Society of Anesthesiologists; SOFA - Sequential Organ Failure Assessment; APACHE - Acute Physiology and Chronic Health Evaluation; IQR - Interquartile Range; IQR/M - Interquartile Range/Median Ratio; NE - Norepinephrine Equivalents; mcq - medical care quality; RBC – Red Blood Cell; LOS – Length of Stay;

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