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Dismal outcomes following damage control laparotomy in injured older adults, a cohort study

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ABSTRACT

Background: The population of older adults is rapidly growing and more older patients are presenting with abdominal trauma. Outcomes have not been well defined for patients that require a damage control approach(DCL).

Methods: This was a retrospective study at a level one trauma center of patients age 65 years and older with abdominal trauma that required DCL. Outcomes reviewed included mortality, length of stay, discharge disposition. Presenting vital signs and laboratories were reviewed to identify predictors of mortality.

Results: 31 older patients(mean age 75.2 years) underwent DCL. Twenty-four of 31(77.4%) older patients died. Seven of 7 older DCL survivors were discharged to a rehabilitation center or nursing home. In comparisons of older DCL nonsurvivors and survivors there were not differences in presenting HR(90 versus 96; $p = 0.56$) or SBP in the emergency room(107 versus 116; $p = 0.51$). No differences in initial lactate or change in lactate concentration were found between nonsurvivors and survivors. Fifteen of 24 nonsurvivors died from multisystem organ failure.

Conclusions/Implications: The mortality rate of older patients that require damage control approach for is extremely high. Presenting vital signs and laboratory markers may not be useful in older patients to predict mortality.

Introduction

Adults over the age of 65 are the fastest growing subgroup in the United States, estimated to comprise up to 30% of the population by 2030.[1,2] Data from the Centers for Disease Control suggests that in 2014, trauma affected over 50,000 individuals in this subgroup.[1,2] Life expectancy will likely continue to increase and we expect older adults will maintain high levels of activity. Subsequently, the burden of trauma in this population will certainly increase, accompanied by a rise in the number of operative interventions performed for abdominal trauma. We question whether the outcomes and predictors of mortality after abdominal trauma that are described in younger patients are observed in older patients, particularly when considering damage control laparotomy.

Damage control laparotomy (DCL) is a principle for managing abdominal trauma that began to be recognized by trauma surgeons in the 1980's and 1990's. During this time, there was a shift away from attempting to restore abdominal anatomy definitively in the initial operation in severely injured patients. Regardless of mechanism of injury, the priorities of DCL instead became controlling hemorrhage and abdominal contamination, followed by restoration of physiology in the intensive care unit (ICU). Over these last few decades surgeons have developed a better understanding of the physiologic derangements associated with severe abdominal trauma. Stone et al. in his 1983 review of 31 patients in Annals of Surgery was one of the first to describe the concept of an abdominal hemorrhage induced coagulopathy while observing "open wound(s) in a patient whose blood will not clot and cannot be made to clot".[3] This review of patients suffering penetrating trauma included patients with a mean age of 28 years, is notably absent of

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older individuals. A decade later, Rotondo's landmark review that coined the term “damage control laparotomy” was also limited to a younger group of exclusively penetrating victims with a mean age of just over 30 years.[2]

There is significant literature regarding the prognosis and outcomes of younger trauma patients that are managed with a damage control approach and an open abdomen. It is unclear though whether older patients have the physiologic reserve to tolerate periods of coagulopathy, acidemia, and hypothermia which is required to survive this approach. A recent series of blunt abdominal trauma patients less than 65 years old that required a damage control approach identified preoperative Glasgow Coma Scale, initial base excess, and hemodynamics as factors in predicting mortality.[4] However, these predictors of outcomes in younger patients may not apply to older patients. In this study, we examined a cohort of older patients that had damage control laparotomy to define their outcomes and to identify whether certain vital signs, injury patterns, and laboratory markers are associated with mortality.

Patients and methods

Following IRB approval, we performed a retrospective trauma registry and medical record review of all patients greater than 65 years of age who underwent damage control laparotomy at our Level 1 trauma center between 2010 and 2017. We chose to review all patients greater than 65 years old (older) who underwent damage control laparotomy. Damage control laparotomy (DCL) was defined when the patient's abdominal fascia was left intentionally open at the conclusion of the index operation with intent to return to the operating room for further surgery.

We reviewed patient characteristics for mean age, gender, mechanism of trauma, injury severity score (ISS), presenting heart rate (HR), and presenting systolic blood pressure (SBP). The primary outcome measured was mortality. Secondary outcomes were number of abdominal operations, hospital length of stay, ICU length of stay, occurrence of infections, and discharge disposition. Discharge disposition for surviving patients was categorized as either to home or to a rehabilitation center/nursing home. Patient records were reviewed to determine the most proximate cause of death in the nonsurvivors.

We compared baseline characteristics and outcomes between the survivors and non-survivors. Univariate analyses were done to assess for associations between initial heart rate, initial blood pressure, laboratory values, early transfusion requirements, injury patterns and mortality. Initial laboratory values included venous HCO3, pH, lactic acid, and INR, all part of our institution's presentation lab panel for trauma patients. Early transfusion requirements were measured by number of units of packed red blood cell (PRBC) given in the emergency room and in the first 24 h after presentation.

We then compared change in lactic acid concentration from presentation (L1) to the second lab draw (L2) between older nonsurvivors and survivors, as described by Odom et al. 2013.[5] The second lactic acid was only included if it was drawn between 3 and 10 h after presentation. Change in lactic acid concentration was described as a percentage change and was calculated as follows:

$$(L1 - L2 / L1) \times 100$$

Categorical variables were analyzed using the chi-squared test and continuous variables were analyzed using the Student's unpaired samples *t* test. A p value < 0.05 was considered significant. Bivariable associations between survival and patients' physiologic, laboratory, and injury characteristics were examined using unpaired 2-sample t-tests (Tables 3 and 4). Statistical analysis was done using SAS version 9.4 (SAS Institute, Cary, NC).

Results

From 2010 to 2017, 31 patients over the age of 65 years underwent DCL. The mean age of this cohort was 75.2 years and 17 (54.8%) were male. All of the patients in our DCL cohort suffered a blunt mechanism of injury. Baseline characteristics comparing surviving and nonsurviving patients are presented in Table 1. There were no significant differences in age, gender, mechanism of injury, injury severity score (ISS), presenting heart rate, and presenting systolic blood pressure between the survivors and nonsurvivors.

Outcomes of the 31 older patients undergoing DCL groups are presented in Table 2. On average, these older patients underwent 2.3 total abdominal explorations. Twenty-four (77.4%) of the patients undergoing DCL died. All remaining 7 survivors were discharged to a rehabilitation center/nursing home. On average, survivors had a longer length of hospital stay compared to nonsurvivors (37.9 vs 15.2, $p = 0.01$). There was no significant difference in ICU length of stay, number of total operations, or infection of any kind between the survivors and nonsurvivors. Multisystem organ failure was the most common cause of death in 15 of 24 nonsurvivors (62.5%) followed by cardiac arrest in 5 (20.5%) patients.

Laboratory values and blood transfusion requirements in nonsurvivors and survivors are presented in Table 3. There were no significant differences in initial bicarbonate level, initial pH, and initial lactic acid. Older nonsurvivors had a significantly higher initial INR than survivors (1.6 versus 1.1; $p < 0.01$). There were no significant differences in number of transfusions in the emergency room or in the first 24 h after presentation between the older nonsurvivors and survivors.

The number of specific injuries in older DCL nonsurvivors and survivors are presented in Table 4. Incidence of pelvic fracture, traumatic brain injury, extremity injury, splenic injury, hepatic injury, renal injury, small bowel injury, vascular injury, and thoracic injury remained similar when comparing nonsurvivors and survivors.

Table 1
Patient characteristics – Survivors(S), Nonsurvivors(NS).

	Total n = 31	S n = 7, (%)	NS n = 24, (%)	p
Age – mean (standard dev)	75.2 (7.4)	74.9 (4.3)	75.3 (8.2)	0.87
Gender - Male	17 (54.8%)	5 (71.4%)	12 (50%)	0.41
Mechanism - blunt	31 (100%)	7 (100%)	24 (100%)	1.00
ISS – mean (standard dev)	26 (10.6)	22.1 (11.2)	25.8 (10.5)	0.46
ISS ≤ 15	5 (16.1%)	2 (28.6%)	3 (12.5%)	0.56
Presenting HR in ED – mean (standard dev)	91.5 (23.6)	96.4 (24.5)	90.1 (23.7)	0.56
Presenting SBP mm Hg in ED - mean (standard dev)	109.1 (28.4)	116.2 (31.6)	107.3 (28.0)	0.55

p values derived from Pearson's $\chi 2$ test, Fisher's exact test and 2 sample t tests.

Table 2
Outcomes - Survivors(S) versus Nonsurvivors(NS).

	Total n = 31	S n = 7, (%)	NS n = 24, (%)	p
Mortality	24 (77.4%)	–	24 (100%)	
Cause of death				
Multisystem organ failure			15	
Withdrawal of care (CMO)			3	
Cardiac arrest			5	
Myocardial infarction			1	
Discharged to a LTC facility	7 (22.6%)	7 (100%)	–	
Number of trips OR (mean, standard dev)	2.27 (1.8)	4 (2.7)	1.9 (1.3)	0.16
LOS ICU (days) (mean, standard dev)	17.5 (21.4)	28.3 (24.2)	14.3 (22.4)	0.07
LOS Hospital (days)	20.3 (22.7)	37.9 (15.4)	15.2 (22.1)	0.01 *
Infection occurrence	10 (32.3%)	3 (42.9%)	7 (29.2%)	0.65

All LOS reported in days.
p values derived from Pearson's $\chi 2$ test, Fischer's exact test (for cells <5), and 2 sample *t* tests.

Table 3
Lab criteria - Survivors(S) versus Nonsurvivors(NS).

	S n = 7, (%)	NS n = 24, (%)	p
Initial HCO3	22.7 (18–26)	21 (12–34)	0.43
Initial pH	7.30 (7.19–7.41)	7.21 (6.96–7.51)	0.19
Initial lactic acid	4.3 (1.3–6.9)	5.7 (0.9–14.3)	0.38
Initial INR	1.1 (1–1.3)	1.6 (1–3.3)	<0.01
Blood in ER	3.9 (0–17)	4.4 (0–16)	0.82
Blood 1st 24 h	3 (0–18)	10.2 (0–43)	0.30

Blood = number of units of packed red cells.

Lactic acid concentrations on presentation, on second draw, and change in lactate concentration calculated per Odom et al.'s methodology, are presented in Table 5. These values were not significantly different when compared in survivors and nonsurvivors.

Discussion

In our descriptive review of a cohort of older patients who underwent damage control laparotomy for trauma, the most notable finding was a high mortality rate, regardless of presenting vital signs and traditional serum markers of shock. These metrics have been described in the past to be predictive of survival in younger patients but were not observed to be predictive in our older cohort.[6,7] Among nonsurvivors in our cohort, multisystem organ failure was identified as the most common cause of death. Finally, all seven older survivors required long term placement in long rehabilitation facilities.

Newell et al. noted a lower mortality of only 43% among older patients undergoing DCL for trauma.[8] However this cohort was comprised of only 14 patients, and the authors defined older as greater than 55 years, an age that is physiologically significantly younger than our older cohort. Arhinful et al. demonstrated a 37% mortality among octogenarians that underwent DCL.[9] However, trauma was the indication for DCL in only 6% of their cohort. It is likely that acute care surgical emergencies which may be isolated to the abdominal cavity are less of a strain on an older patient's physiologic reserve compared to multisystem blunt trauma. In our older DCL cohort, 26 of 31 patients had an ISS >15 denoting major trauma to multiple anatomic locations.

Our finding of all 7 older survivors requiring placement in longterm facilities is similar to other series showing high rates of need for advanced care facilities post ICU discharge. Carson et al., in a review of 133 mechanically ventilated ICU patients mean age 71 years, found that 63% of patients required discharge to a skilled nursing facility, nursing home, or rehabilitation center. Only 11 patients, 8.3% of the total, were oriented, ambulatory, and independent at one year.[10] Djaini et al. and Roch et al. demonstrated dismal one year mortality for older patients following ICU discharge, ranging from 47% to 79%.[11,12] Multiple recent series have shown decreased independence with daily tasks, decreased health related quality of life scores, diminished cognitive abilities, and high rates of anxiety and depression after ICU stays in older patients.[13,14] Looking specifically at longterm trauma outcomes in older patients, Inaba et al. reviewed 128 trauma patients with a mean age of 74 years and at 3 years almost 40% had failed to return to living independently at home.[15] Awareness of the longterm challenges beyond discharge in these older patients should guide discussions with patients and family members regarding goals of care.

In younger patients, these conversations and expectations can be guided by parameters such as presenting blood pressure and heart rate, which have been found to be predictive of outcomes.[17] However, Heffernan et al. concluded that presenting hemodynamics may be unreliable predictors in older trauma patients.[16] Among our older cohort both DCL survivors and DCL nonsurvivors presented with normal systolic BP (107 mmHg versus 116 mmHg). Many international and institutional protocols use systolic BP of less than 90 mmHg, a marker of class III hemorrhagic shock, to triage patients and guide initial fluid or blood product

Table 4
Injuries - Survivors(S) versus Nonsurvivors(NS).

	S n = 7, (%)	NS n = 24, (%)	p
ISS (mean)	22.1	25.8	0.43
Pelvic	2 (28.6%)	13 (54.2%)	0.23
TBI	1 (14.3%)	5 (20.8%)	1
Extremity	7 (100%)	17 (70.8%)	0.16
Spleen	4 (57.1%)	9 (37.5%)	0.41
Hepatic	3 (42.9%)	3 (12.5%)	0.11
Renal	1 (14.3%)	1 (4.2%)	0.41
Small bowel	1 (14.3%)	5 (20.8%)	1
Vascular	1 (14.3%)	6 (25%)	1
Thoracic	3 (42.9%)	18 (75%)	0.17

p values derived from Pearson's $\chi 2$ tests and Fischer's exact test (for cell counts <5).

Table 5
Change in lactate - Survivors(S) versus Nonsurvivors(NS).

	S	NS	p values
Lactate 1	4.3	5.7	0.38
Lactate 2*	4.4	5.6	0.32
Change in Lactate	+2.3%	+1.8%	0.12

p values derived from 2 sample t tests.
*lactate # 2 excluded if > 10 h after presentation.

resuscitation.[18] Our data however supports recent contention that presenting hemodynamics of older DCL patients do not carry the same prognostic yield as in younger DCL patients.[16] The lack of association between presenting systolic BP or HR and mortality among older patients undergoing DCL may be explained by the high rate of cardiovascular comorbidities including chronic hypertension, medications such as beta-blockers, or physiologic exhaustion and inability to develop responses to hemorrhage.

Our older nonsurvivors displayed significant presenting coagulopathy compared to survivors. Initial INR may be a more reliable prognostic indicator than presenting hemodynamics in older patients. There were no significant differences in markers of hypoperfusion between older survivors versus non-survivors with respect to pH, bicarbonate or lactic acidosis. A recent systematic review of 156 DCL studies found metabolic markers such as pH, base deficit, and bicarbonate level to form a “decision threshold” in regards to performing DCL and a number of other studies have reported association between pH and mortality in DCL patients.[4,19–21] In our review of injury patterns, we were unable to find significant relationships between specific organs or regions injured. One may have expected that older patients with the combination of pelvic fracture or TBI and abdominal trauma requiring DCL would have a significantly higher mortality due to increased physiologic stress or decisions to withdraw care. We acknowledge that our sample size may have prevented us from showing this difference.

It has been shown that older blunt trauma patients presenting with an elevated lactic acid level have higher rates of mortality. Patients in Callaway's series with severely elevated lactic acid, greater than 4 mmol/L, were 4 times more likely to die compared to those presenting with normal lactic acid levels.[22] Neville demonstrated that presenting lactic acid and base deficit continued to be predictive of 24 h and in-hospital mortality in older patients with SBP greater than 110 mm.[23] In our series, initial lactic acid was not associated with mortality in older DCL patients but mean initial lactic acid levels in all of the groups would be categorized as severely elevated in multiple studies. Claridge proposed the concept of “lactic acid clearance” noting increased risk of infections in trauma patients whose lactic acid does not normalize within 12 h of presentation.[24] Odom noted that severely elevated lactic acid levels were associated with an increased risk of death in trauma patients. Patients with clearance of elevated lactic acid at 6 h had improved survival rates.[5] While the authors relate their findings to sepsis literature that supports use of lactic acid clearance as a prognostic tool they acknowledge that lactic acid metabolism in trauma is quite different. Change in lactic acid concentration was not associated with mortality in our cohort of older DCL patients. We chose to use the term “change in lactic acid concentration”, similar to Goodwin in 2014, as laboratory measurements of lactic acid do not truly measure clearance.[25]

Our study has notable limitations. Its retrospective single institution design and small number of patients limits generalizing the findings to other settings. Though we reviewed all dictated operative reports we cannot definitively state that all patients' abdomens were left open based on DCL type decision making such as temperature, pH, or coagulopathy. It is likely that most of the patients underwent DCL based on subjective decision making by the attending surgeon. Similar to Odom's work, our lactic acid level, especially the second draw, was confined to a time range but not a specific time point. This affected our ability to calculate actual change of concentration of lactic acid. We also encountered this issue in reviewing trends in INR and pH. A larger number of patients or a multi-institutional review of DCL patients may improve the ability to study dynamic changes in laboratory markers. Presenting INR values may have been affected on occasion by anticoagulation, more likely an issue in older patients. And lastly we did not investigate fluid or blood product resuscitation volumes to assess effects on changes in the laboratory markers. This is an opportunity for future study in DCL patients.

Summary

The population of older adults is rapidly growing and most of the literature regarding outcomes after damage control laparotomy are from younger adults. In our series older adults were found to have extremely high rates of mortality when a damage control approach was required.

Conflicts of interest

Each author has reviewed the lists of potential financial or personal conflicts of interest and has none to declare. This is a full disclosure.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2018.10.054.

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