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Damage control laparotomy utilization rates are highly variable among Level I trauma centers: PROPPR findings

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the PROPPR Study Group**Abstract**

Background—Damage control laparotomy (DCL) is intended to limit deleterious effects from trauma induced coagulopathy. DCL has been associated with mortality reduction, but may increase complications including sepsis, abscess, respiratory failure, hernia, and gastrointestinal fistula. We hypothesized that (1) DCL incidence would vary between institutions; (2) mortality rates would vary with DCL rates; (3) standard DCL criteria of pH, INR, temperature and major intra-abdominal vascular injury (MVI) would not adequately capture all patients.

Methods—Trauma patients at 12 level 1 North American trauma centers were randomized based on transfusion ratios as described in the PROPPR trial. We analyzed outcomes following emergent laparotomy using a mixed-effects logistic model comparing DCL versus definitive surgical management (DSM) with random effect for study site. Primary outcomes were 24-hour and 30-day mortality.

Results—329 patients underwent emergent laparotomy: 213 DCL (65%) and 116 DSM (35%). DCL rates varied between institutions (33%-83%), ($p=0.002$). Median ISS was higher in the DCL group, 29 (IQR: 13,34) versus 21 (IQR: 22,41) ($p<0.001$). 24-hour mortality was 19% with DCL versus 4% ($p<0.001$); 30-day mortality was 28% with DCL versus 19% ($p<0.001$). In a mixed-effects model, ISS and MVI were correlates of DCL (OR: 1.05, 95% CI: 1.02-1.07 and 2.7, 95% CI: 1.4-5.2). DCL was not associated with 30-day mortality OR 2.33 (CI 0.97-5.60). Correlates included ISS (OR: 1.06, 95% CI: 1.02, 1.09), PRBCs in 24hrs (OR: 1.10, 95% CI: 1.03, 1.18), and

age (1.04, 95% CI: 1.01, 1.06). No significant mortality difference was detected between institutions ($p=0.63$). Sepsis and VAP occurred more frequently with DCL ($p<0.05$). 80% (135/213) of DCL patients met standard criteria.

Conclusions—Although DCL utilization varied significantly between institutions, there was no significant mortality difference between centers. This finding suggests tempering DCL use may not decrease mortality, but could decrease related complications.

Keywords

Variability; Trauma; Damage; Control; Laparotomy

Introduction

Damage control laparotomy (DCL) has been widely adopted since the term was coined in 1983.¹⁻⁴ DCL is intended to limit deleterious effects from trauma-induced coagulopathy leading to hemorrhage exacerbation including hemodynamic instability, coagulopathy, hypothermia and acidosis.^{2,5} The goals are to decrease operative time to less than one hour by deferring definitive management while rapidly controlling hemorrhage and contamination.⁵ Despite this paradigm shift, hemorrhage is still the leading cause of preventable mortality after trauma in severely injured patients.⁶ Since inception there have been no randomized controlled clinical trials evaluating efficacy⁷ or DCL utilization rates between centers.³

The most frequent procedure required early after trauma presentation is emergent laparotomy.⁸ In 1993 a report by Rotondo et al. showed that the mortality rate in the 22 patients who underwent DCL and 24 patients who did not was the same (55% vs. 58%). However in patients with one or more major vascular injury and two or more visceral injuries, the mortality rate in patients who underwent DCL was 11% compared to 77% in patients who had definitive surgical management (DSM). In contrast patients who did not have one or more major vascular injuries and two or more visceral injuries, the survival rate was 27% if they underwent DCL versus 85% with DSM.² A number of more contemporary civilian and military studies have shown improved survival with DCL use⁹⁻¹¹ while others have questioned the over-use of DCL and shown improved survival rates when DCL use was restrained.¹² Additionally, a large body of recent cohort studies has shown an increased risk for sepsis, abdominal abscess, respiratory failure, acute renal failure, ventral hernia and gastrointestinal fistula complications after DCL.^{3,4,12-15} These incongruous results are explained by selection bias, retrospective data, small sample size, single institution data, regional practice patterns and variable inclusion criteria.⁷

There are regional differences in types of trauma encountered at various level 1 centers. These variations impact patient care protocols including DCL utilization. Previous single-center cohort studies have shown DCL utilization rates vary between 8% to greater than 30% of the total civilian trauma population.^{3,12} Selection is loosely based on a general literature consensus. The standard criteria include major intra-abdominal vascular injury, acidosis, coagulopathy and hypothermia.^{4,5} DCL may also be used to shorten operative time in the setting of other critical injuries such as severe traumatic brain injury. Flexibility outside of

current indications is left to the discretion of the operating surgeon leading to variability in utilization. Because of this variation, significant effort has focused on creating tools to help physicians decide which patients would benefit from undergoing DCL.^{16,17}

Since the inception of the DCL concept, the practice has gained widespread application. DCL utilization has become so ubiquitous that there is concern for overutilization.³ Due to repeat procedures, multiple trips to the operating room and increased complication rates, DCL is not a benign therapeutic intervention.^{18,19} In fact over-utilization of DCL can stress the current system unnecessarily leading to inappropriate operations, delayed fascial closure, and increased healthcare costs.^{3,4} Appropriate utilization of DCL, like any other therapy, requires improved criteria to adequately stratify which patients require DCL versus definitive surgical management DSM.

Given the previously published literature showing variable patient outcomes between those treated with DCL versus DSM, we hypothesize that: (1) DCL incidence would vary by institution; (2) mortality rates would correlate with DCL rates; (3) standard DCL cut-off values consisting of potential of hydrogen (pH), International Normalized Ratio (INR), temperature and major intra-abdominal vascular injury (MVI) would not adequately capture all patients receiving DCL. This study aims to be the first to evaluate national DCL variation rates between Level 1 institutions using standard criteria. Additionally, it examines mortality and morbidity in severely injured trauma patients undergoing DCL using multi-institutional prospective data gathered during the Pragmatic, Randomized Optimal Platelets and Plasma Ratios (PROPPR) trial.²⁰

Methods

The study population consisted of severely injured patients who met the inclusion criteria published previously described in the PROPPR trial that were predicted to receive a massive transfusion and were admitted to 12, level 1 North American trauma centers. We analyzed the subset of patients who underwent an emergent laparotomy within 90 minutes of arrival to the hospital and compared patient outcomes after DCL versus closed definitive surgical management (DSM). Patients were defined as having a DCL if they were left in discontinuity, abdominal packing was performed or the abdominal fascia was left open at the conclusion of the index case for takeback to the OR, or if the operative note stated that the operation was truncated due to unstable physiology. Standard indications for DCL criteria were defined as pH < 7.20, coagulopathy with an elevated INR > 1.5, temperature below 93°F and blood loss > 10 units.¹⁶

The primary outcomes were 24-hour and 30-day mortality. Demographics, clinical characteristics, and institutional characteristics were examined using descriptive statistics. Significant differences between those who received DCL versus those who did not were assessed using t-tests for continuous variables, Wilcoxon rank-sum tests for non-normally distributed variables, chi-squared tests, and Fisher's exact tests for categorical variables as appropriate.

Univariable associations were examined for each variable in the dataset and 30-day mortality. An interaction between DCL and trauma center, categorized as low-volume and high-volume was examined. This was not significant ($p = 0.26$). We included all variables that had a $p < 0.20$ in univariable analysis into a mixed-effects logistic regression model with trauma center as a random effect to obtain odds ratios (OR) and 95% confidence interval (CI) for 30-day mortality. Unique to the mixed-effects model is combined consideration for both fixed and random variables. In this case, study site is a random effect. This same mixed-effects logistic regression model was then re-analyzed excluding deaths within the first 24 hours. We also ran a Poisson model with trauma center as a random effect to procure risk ratios (RR) to compare with OR from the mixed-effects logistic regression model.

We assessed collinearity of variables with Pearson's correlation coefficient (r) and examination of the variance inflation factor (VIF). If there was moderate to high correlation (> 0.50) or if VIF was much greater than 1, then these variables were considered to be collinear. We centered the continuous variables that were collinear, on the mean, as an attempt to reduce the VIF.

We examined associations of those missing data with our primary outcome (30-day mortality) and our main exposure (DCL) where missing data was greater than 5%. We assessed confounding by adding one variable at a time to a model just containing the main exposure variable of DCL. If the effect measure of DCL changed by $\geq 5\%$ we defined it as a confounder and included it in our model.

Model goodness-of-fit was assessed with a C-statistic. The closer the C-statistic is to 1, the better the model fits the data. We also used Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) to compare the logistic regression mixed-effects model with the Poisson mixed-effects model to assess which of the two methods fit our data better.

Results

The PROPPR trial included a total of 680 severely injured trauma patients who were predicted to receive a massive transfusion and evaluated in regard to pragmatic blood product ratio effects on outcomes. A total of 329 patients from the PROPPR study who underwent immediate laparotomy were identified. Of these patients 213 (65%) underwent DCL, while 116 (35%) had DSM.

Table 1 illustrates selected demographic characteristics of the DCL, DSM, and combined patient groups. There were overall even distributions of 1:1:1 vs 1:1:2 blood product ratio groups as would be expected based on the randomization criteria for the original study. Among other demographic variables, there were notable differences between groups. Therefore, further analyses were performed to evaluate which variables were independently associated with mortality differences in the DCL and DSM groups.

By institution, the proportion of urgent laparotomies that were DCLs varied from 60% to 83% in 10 of the 12 institutions. Only two had much lower DCL rates compared to the rest (35% & 33%). **Figure 1** demonstrates the fluctuations in proportions of DCL and DSM procedures. These differences between institutions are also demonstrated in **Table 2**.

Mortality rates ranged from 9% to 31% across sites but were not statistically different as seen in **Table 2**. Standard DCL criteria only captured 80% of patients who had a DCL in this population, while 67% of patients with DSM met at least one of the standard DCL criteria.

Univariable analysis was performed to compare variables between the DCL and DSM groups showing multiple significant differences. Information regarding these univariable findings is also found in **Table 1**. Injury Severity Score (ISS) was greater in the DCL group with a median of 29 (IQR 13, 34) compared to the DSM group with a median of 21 (IQR 22, 41) ($p<0.001$). There was a statistically significant association between DCL rate and institutions ($p=0.001$; Fisher's exact test). INR > 1.5 (30% vs 6% $p<0.001$) and MVI (31% vs 16% $p=0.003$) were higher in DCL versus DSM patients while temperature and pH values were similar. Outcomes following surgical intervention showed increased rates of sepsis ($p<0.001$) and VAP ($p=0.02$) occurred more frequently in DCL patients while MOF was not significantly different ($p=0.06$). Typical indications for DCL, namely components of the “lethal triad” including pH, temperature, and INR were excluded from further modeling analysis due to large numbers of missing data points for these variables.

Using the mixed-effects logistic regression model in **Table 3**, two significant correlates of DCL were identified: ISS and major intra-abdominal vascular injury (MVI) (OR 1.05, 95% CI: 1.02-1.07 and 2.7, 95% CI: 1.4-5.2 respectively). Mechanism of injury (blunt vs penetrating) was not significantly associated with patients receiving DCL ($p=0.50$).

Twenty-four hour mortality was 19% for DCL and 4% for DSM ($p<0.001$). Thirty day mortality was 28% for the DCL group compared to 19% for DSM ($p<0.001$). To identify correlates of 30-day mortality, we constructed a mixed-effects model with a random effect for hospital; however, the random effect did not explain any variability in 30-day mortality, and a fixed-effects model generated identical beta coefficients. Findings from the fixed-effects model are shown in **Table 4**.

Correlates of 30-day mortality included ISS (OR: 1.06, 95% CI: 1.02, 1.09), amount of PRBCs given (OR: 1.10, 95% CI: 1.03, 1.18), and age (1.04, 95% CI: 1.06), but these had minimal impact. DCL was not significantly associated with 30-day mortality (OR: 2.33, 95% CI: 0.97, 5.60). Blood treatment ratio group, sex, and mechanism (penetrating vs blunt) were not significant correlates of mortality. Estimates of risk ratios from the Poisson model were slightly attenuated but similar to the OR from the logistic regression model. Predicted 30-day mortality rates, adjusted for variables in the mixed-effects Poisson model, varied from 14% to 33% (Table 2).

Systolic blood pressure in the intensive care unit (SBP-ICU), pH in the emergency department (PH ED) arterial, pH in the operating room (PH OR), international normalized ratio in the emergency department (INR ED), international normalized ration in the ICU (INR ICU), lactate in the operating room (lactate OR), lactate in the emergency department (lactate ED), lactate in the intensive care unit (lactate ICU), volume of saline given in the emergency department (saline ED), other crystalloids given in the emergency department (other crystalloids ED), base deficit in the emergency department (base ED), and base deficit in the operating room (base OR) all had substantial missing data ($>5\%$). Those who were

missing data among SBP ICU, PH OR arterial, INR ICU, lactate ICU, and base OR had higher risk of 30-day mortality but missingness was not associated with whether the patients had DCL or DSM. Missing data among other variables had no association with 30-day mortality or with having DCL. In our confounder assessment (Supplement table 2), only blood group and sex were not potential confounders of DCL. These variables were still included in the model because they had a p of 0.20 in univariable analysis, were clinically relevant and did not exclude subjects due to missing data.

The c-statistic of our mixed-effects logistic regression model was 0.86 indicating good model fit. The logistic regression model also had lower AIC and BIC values, compared to the Poisson model, suggesting this model was a better fit for our data.

It is possible that the effect we observed for DCL, though not significant, might be confounded by the result of selection bias stemming from the fact that DCL may be used more frequently in patients with a high risk of death in the first 24 hours. To assess for this, we conducted a sub-group analysis of 30-day mortality among just those patients who survived at least the first 24 hours. We initially constructed a mixed-effects model identical to the one summarized in Table 4, but the random effect for hospital did not explain a substantial portion of variability ($SD < 0.0001$), so a fixed-effects logistic regression model produced estimates virtually identical to those from the mixed-effects model. Indeed, when we excluded patients who died within the first 24 hours, any effect of DCL on mortality remained insignificant with (OR: 1.01, 95% CI: 0.23, 4.38) summarized in **Table 5**.

Discussion

Single institutional data reports contemporary DCL utilization rates near 30%.³ To our knowledge only one published study analyzed the change of DCL utilization rates over time at a single institution, showing a decrease in DCL utilization from 37% to 9% without negatively impacting mortality.¹² Our multi-institutional study provides compelling evidence there is significant variation in DCL utilization rates for severely injured trauma patients between Level 1 trauma centers in North America, ranging from 33% to 83%. This study identified significant differences in patient populations undergoing DCL vs. DSM including higher ISS (29 vs 21) 30-day mortality (28% vs. 19%), base deficit (9.4 vs. 7.1) and transfusion requirements. Ultimately DCL was up to the operating surgeon's discretion. Since patients undergoing DCL were more severely injured, these findings support the ability of trauma surgeons to rapidly identify severely injured patients.

Institutional variability in DCL intervention has the potential to impact mortality and morbidity in addition to the baseline rates expected for severely injured poly-trauma patients. Use of the PROPPR study data allows for a unique multi-institutional perspective of morbidity and mortality in patients undergoing DCL versus DSM. Based on a mixed effects model excluding deaths within 24-hours, undergoing DCL was not associated with a difference in 30-day mortality (OR: 1.01, 95% CI: 0.23, 4.38). This provides evidence that DCL rates may vary between institutions while mortality remains similar. The reason for the dramatic difference in DCL utilization rates between centers is not fully understood but possible explanations include variation in trauma center training, institutional protocols, pre-op planning and perioperative care.

Hypothermia, acidosis, coagulopathy and blood loss have frequently been identified as predictors for DCL intervention and are referred to as standard cut-off values. These include pH < 7.20, temperature below 93°F and blood loss >10 units. Standard DCL values only captured 80% of patients undergoing DCL in this population, in congruity with previously published literature. Of note, 67% of patients undergoing DSM met at least one of the standard DCL criteria. Antecedent studies have attempted to standardize DCL indications, with some improvement in hospital and ICU length of stay.¹⁶ Ultimately, DCL intervention is a clinical determination made by the operating surgeon, though improved criteria could limit associated morbidity such as sepsis and VAP while improving trauma care.

This study is a secondary analysis of prospectively collected data from a randomized trial. Data across institutions were collected using a standardized protocol. Due to the PROPPR study design, data collection was limited to 30-days after admission, so long-term outcomes were not measured. Additionally, we excluded a portion of the initial patient population who did not undergo emergent laparotomies. Although the percentage of patients meeting at least one standard DCL cut-off values was nearly similar between groups, the two groups were significantly different based on ISS, 30-day mortality and transfusion requirements. It is important to note patients with missing cut-off values may not be missing at random and therefore might impact results. Patients meeting criteria for emergent DCL in the PROPPR study may not be generalizable to the severely injured patient requiring emergent laparotomy in the general population. Furthermore, our multivariate and mixed effects model could not completely account for all of the inherent complexities associated with a surgeon's decision to proceed with DCL or center effect. Finally, in our thorough missing data analysis, those with missing data 5% were more likely to have died within 30 days suggesting that missing data was missing not at random (MNAR). Our dataset is limited and does not lend itself to multiple imputation, a method used to fill in missing data when data are MNAR. We used complete case analysis (CCA) which, in this patient group, underestimates the actual association between DCL and mortality. Ongoing research is necessary to provide more granular predictors of trauma patient outcomes and prospective validation regarding patient selection for DCL.

Conclusion

DCL utilization varied significantly between institutions. DCL was associated with higher morbidities including sepsis and VAP. Despite institutional variability in DCL use, there was no significant mortality difference between centers. This finding suggests tempering the use of DCL, while not worsening mortality, could decrease complications from DCL including open abdomens, increased hospital costs, ventral hernias and enterocutaneous fistulas although we did not assess these variables directly. Standard cut-off values capture only 80% of patients receiving DCL. More comprehensive indications guiding patient selection for DCL may decrease unnecessary morbidity and cost.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Absolute number of laparotomies per institution by DSM versus DCL.

Table 1

Demographics (not including institution)

Variable	DCL (n=213)	DSM (n=116)	Combined (n=329)	p-value
Blood treatment group			324	0.484 ^b
1:1:1	102 (48)	60 (53)	162 (50)	
1:1:2	109 (52)	53 (47)	162 (50)	
Age (years)	30.0 (23.0, 43.5)	34.0 (25.0, 47.0)	32.0 (24.0, 46.0)	0.064 ^c
Mechanism			324	0.029 ^b
Blunt	99 (47)	38 (34)	137 (42)	
Penetrating	112 (53)	74 (66)	187 (58)	
ISS ^d (non-categorical)	29.0 (22.0,41.0)	21.0 (13.0, 34.0)	26.0 (18.0, 41.0)	<0.001 ^c
AIS ^d head	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.073 ^c
AIS ^d chest	3.0 (0.0, 4.0)	3.0 (0.0, 3.0)	3.0 (0.0, 4.0)	0.471 ^c
AIS ^d abdomen	4.0 (3.0, 4.0)	3.0 (2.0, 4.0)	4.0 (3.0,4.0)	<0.001 ^c
RBC 24 hours	13.0 (8.0, 23.0)	7.0 (4.0, 10.0)	9.0 (6.0, 19.3)	<0.001 ^c
Plasma 24 hours	9.0 (5.0, 17.0)	3.0 (2.0, 6.0)	7.0 (3.0, 14.0)	<0.001 ^c
Platelets 24 hours	12.0 (6.0, 18.0)	6.0 (0.0,6.0)	6.0 (6.0, 18.0)	<0.001 ^c
Cryoprecipitate 24 hours	0.0 (0.0, 12.0)	0.0 (0.0,0.0)	0.0 (0.0, 10.0)	<0.001 ^c
pH ^d less than 7.2	48 (29)	24 (26)	72 (28)	0.751 ^b
INR ^d greater than 1.5	37 (30)	4 (6)	41 (21)	<0.001 ^b
Temperature less than F / 33.9 C	41 (26)	15 (17)	56 (22)	0.153 ^b
Presence of major intra-abdominal vascular injury	66 (31)	18 (16)	84 (26)	0.003 ^b

Values listed as number (%) or median (interquartile range)

When missing values are present for variables the percentage reflects the fraction of available values.

• Fisher's exact test

^b Pearson's chi-squared test^c Wilcoxon rank-sum test with continuity correction^d ISS = Injury Severity Score; AIS = Abbreviated Injury Scale; pH = Potential of hydrogen; INR = International Normalized Ratio

Table 2

Revised (a = adjusted for variables from mixed effects Poisson model)

Institution	Percent of total patients (n=329)	DCL rate (n=213/329)	DSM rate (n=116/329)	24-hour mortality rate (n=46/328) ^a	30-day mortality (n=72/326) ^b	Predicted 30-day mortality rate ^a
1	3 (9)	67 (6/9)	3 (3)	25 (2/8)	25 (2/8)	23%
2	3 (10)	60 (6/10)	4 (3)	10 (1/10)	20 (2/10)	16%
3	7 (23)	35 (8/23)	15 (13)	9 (2/23)	22 (5/23)	17%
4	9 (30)	33 (10/30)	20 (17)	10 (3/30)	17 (5/30)	19%
5	7 (23)	65 (15/23)	8 (7)	26 (6/23)	30 (7/23)	27%
6	9 (31)	71 (22/31)	9 (8)	3 (1/34)	9 (3/34)	14%
7	5 (18)	83 (15/18)	3 (3)	11 (2/18)	17 (3/18)	24%
8	8 (27)	67 (18/27)	9 (8)	26 (7/26)	31 (8/26)	24%
9	8 (27)	78 (21/27)	6 (5)	8 (2/26)	15 (4/26)	33%
10	9 (31)	65 (20/31)	11 (9)	16 (5/31)	26 (8/31)	23%
11	8 (27)	67 (18/27)	9 (8)	15 (4/27)	23 (6/26)	22%
12	22 (73)	74 (54/73)	19 (16)	15 (11/73)	27 (19/71)	24%

Table 3

Mixed-effects logistic regression model of DCL with random effect for study site

Random effects:		Std. Dev	
Hospital		0.65	
Fixed Effects:		OR (95% CI)	p-value
ISS		1.05 (1.02, 1.07)	<0.001
Penetrating (vs blunt) mechanism		0.81 (0.45, 1.48)	0.500
Major intra-abdominal vascular injury (MVI)		2.70 (1.42, 5.16)	0.003

Area under the ROC: 0.769 (95% CI: 0.711, 0.826)

Table 4

Model of 30-day mortality

	Mixed-effects logistic regression model of 30-day mortality with random effect for study site		Mixed-effects Poisson regression model of 30-day mortality with random effect for study site	
Random Effects	Std. Dev			
Hospital	0.19			
Fixed Effects:	OR (95% CI)	p-value	RR (95% CI)	p-value
DCL	2.33 (0.97, 5.60)	0.058	1.87 (0.93, 3.76)	0.079
Blood group (1:1:2 vs 1:1:1)	0.76 (0.32, 1.84)	0.549	0.96 (0.59, 1.54)	0.854
Male (vs female)	0.69 (0.32, 1.51)	0.356	0.76 (0.48, 1.21)	0.243
Age (years)	1.04 (1.01, 1.06)	<0.001	1.02 (1.01, 1.03)	<0.001
ISS	1.06 (1.02, 1.09)	<0.001	1.03 (1.02, 1.05)	<0.001
Penetrating (vs blunt) mechanism	1.41 (0.60, 3.31)	0.435	1.19 (0.72, 1.97)	0.504
AIS head (vs 0-1)		0.239		0.289
	1.88 (0.74, 4.78)		1.54 (0.88, 2.69)	
	2.57 (0.72, 9.22)		1.60 (0.75, 3.42)	
AIS abdomen (vs 0-1)		0.037		0.001
	0.22 (0.07, 0.71)		0.40 (0.23, 0.69)	
	0.29 (0.07, 1.17)		0.45 (0.29, 0.71)	
RBC 24 hours	1.10 (1.03, 1.18)	0.004	1.04 (1.01, 1.06)	0.005
Platelets 24 hours	0.92 (0.85, 1.00)	0.047	0.97 (0.95, 0.99)	0.003
Cryoprecipitate 24 hours	0.99 (0.96, 1.03)	0.661	0.99 (0.97, 1.01)	0.586
Plasma 24 hours	1.03 (0.93, 1.15)	0.570	1.01 (0.98, 1.05)	0.447

Table 5

Logistic regression model of 30-day mortality among patients who survived at least 24 hours

Fixed Effects:	OR (95% CI)	p-value
DCL	1.01 (0.23, 4.38)	0.986
Blood group (1:1:2 vs 1:1:1)	2.69 (0.65, 11.17)	0.173
Male (vs female)	0.51 (0.15, 1.73)	0.278
Age (years)	1.05 (1.02, 1.08)	0.002
ISS	1.07 (1.01, 1.14)	0.015
Penetrating (vs blunt) mechanism	1.51 (0.37, 6.21)	0.569
AIS head (vs 0-1)		0.034
2-4	6.48 (1.41, 29.81)	
5-6	9.24 (1.33, 64.37)	
AIS abdomen (vs 0-1)		0.113
2-4	0.16 (0.02, 1.22)	
5-6	0.07 (0.01, 0.86)	
RBC 24 hours	0.95 (0.86, 1.05)	0.337
Platelets 24 hours	0.98 (0.86, 1.11)	0.709
Cryoprecipitate 24 hours	1.06 (1.00, 1.12)	0.034
Plasma 24 hours	1.17 (0.99, 1.38)	0.065

Area under the ROC: 0.904 (95% CI: 0.839, 0.969)