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The association between diastolic blood pressure and massive transfusion in severe trauma: a retrospective single-center study

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Abstract

Objective: To evaluate the association between diastolic blood pressure and massive transfusion in severe trauma.

Methods: The retrospective study was conducted at a tertiary emergency medical centre in Gwangju , Republic of Korea, and comprised data of severe trauma patients with injury severity score >15 presenting between January 2016 and December 2017. Multivariate logistic regression analysis was performed to evaluate the association between diastolic blood pressure and massive transfusion. Receiver operating characteristic curve analysis was performed to estimate the prognostic performance of diastolic blood pressure. Data was analysed using SPSS 18.

Results: Of the 827 patients, 64(7.7%) underwent massive transfusion. After adjusting the confounders, diastolic blood pressure was found to be an independent factor in predicting massive transfusion (odds ratio: 0.965; 95% confidence interval: 0.956–0.975).

Conclusion: Initially low diastolic blood pressure was found to be an independent predictor for massive transfusion in severe trauma cases.

Key Words: Trauma, Diastolic blood pressure, Massive transfusion.

Introduction

Severe trauma is a major cause of death in patients presenting to the emergency departments (EDs).[1,2] Approximately 50−60% of the deaths caused by trauma occur within the first 24h of hospitalisation.[3,4] Among the major causes of death related to severe trauma, haemorrhagic shock is the most common, similar to central nervous system (CNS) injury, accounting for approximately 33% of all trauma-related deaths.[5] Worldwide, approximately 1.9 million deaths per year are caused by haemorrhagic shock, of which 1.5 million deaths result from trauma.[6] If the haemorrhage is uncontrolled, it may quickly lead to adverse effects such as acidosis, hypotension, cognitive dysfunction and death.[6] To prevent these, early transfusion of blood products and definitive haemostasis are highly recommended.[6,7]

To evaluate the severity of trauma and predict the probability of blood transfusion, many clinicians use trauma scoring systems. In a previous study, injury severity score (ISS) and revised trauma score (RTS) had a significant association with massive transfusion (MT) and mortality in patients with trauma.[8,9] However, these scoring systems only include anatomical parameters and systolic blood pressure (SBP) as the variables. In patients with chronic hypertension (HTN), low diastolic blood pressure (DBP) was associated with subclinical myocardial infarction (MI) and other adverse outcomes.[10] In septic shock, higher and lower DBP were associated with higher survival rate[11] and MI,[12] respectively. However, data on the association between DBP and haemorrhage in severe trauma is insufficient. The present study was planned to evaluate the association between DBP and MT in severe trauma cases.

Materials and Methods

The retrospective study was conducted at a tertiary emergency medical centre in Gwangju, Republic of Korea, and comprised data of severe trauma patients with presenting between January 2016 and December 2017.Severe trauma was defined as ISS >15.[13] Those excluded were aged <18 years, had cardiac arrest after trauma before ED visit, had burns, drowning, or hanging as the cause of trauma, and cases with missing data. The study was approved by the institutional review board of Chonnam National University Hospital, Gwangju. The sample size was calculated to detect differences at 5% significance level and with a statistical power of 90%.

Data retrieved for each patient included age, gender, trauma mechanism, vital signs on admission, like SBP, DBP, pulse rate, and respiratory rate, initial Glasgow Coma Scale (GCS) score, amount of transfused packed red cells (PRCs), and 30-day mortality. In-hospital mortality does not reflect accurate mortality,[14 and,] as such, the study instead assessed 30-day mortality. It was also noted whether or not an emergency operation or intervention was performed. RTS was obtained from SBP, respiratory rate and GCS score on admission. ISS was calculated upon patient arrival in the ED. MT was defined as transfusion >10 units of PRCs within 24h of presentation at ED.

To evaluate the association between DBP and MT, DBP was categorised into four groups: ≤20mmHg, 21–40mmHg, 41–60mmHg, and >60mmHg. Receiver operating characteristic (ROC) curves were used evaluate DBP as a predictor of MT. The resulting ROC curves were compared using the method described in literature.[15]

Differences between MT and non-MT groups were analysed using Mann-Whitney U test for continuous variables. Fisher's exact or chi-squared tests were used to compare categorical variables. Continuous variables did not satisfy the normality test and were presented as median values with interquartile ranges (IQRs).Multivariate analysis was performed to evaluate the association between DBP and MT after adjusting for relevant covariates. DBP as a continuous variable was analyzed in Step 1. Step 2 was performed with DBP as a categorical variable. All variables with $p<0.1$ in the univariate analysis were included in the logistic regression analysis. Backward selection method was used to construct the final model.

Data analyses were performed using PASW/SPSS 18. and MedCalc 16.1. A two-sided $p<0.05$ was taken as significant.

Results

Of the 971 patients, data of 827(%) was included. Of them, 611(73.9%) were males. The overall median age was 61.1 years (IQR: 48.1–73.1 years). MT was performed in 64(7.7%) patients, and the 30-day mortality rate was 123(14.9%). Mean DBP in MT group was 71.3+/-23.0mmHg and it was 43.4+/-29.9mmHg in the non-MT group. The mechanism of trauma had a greater effect, the ISS was higher, and the RTS and DBP were lower in the MT group than in the non-MT group, while the MT group had more surgical cases and a higher mortality rate than the non-MT group (Table 1).

Patients with lower DBP had higher ISSs, lower RTSs, and lower SBPs than the patients with higher DBP, while emergency operations were performed more often in patients with lower DBP than in patients with higher DBP ($p<0.05$). MT was performed in 14(2.9%), 17(7.9%), 19(22.1%), and 14(37.8%) patients with DBPs of >60mmHg, 41–60mmHg, 21–40mmHg, and ≤20mmHg groups, respectively. MT in patients with severe trauma showed statistically significant differences among the DBP groups ($p<0.001$). Patients with lower DBP had higher mortality rates than patients with higher DBP (Table 2).

The areas under the curve (AUCs) for DBP, RTS and ISS in predicting MT were 0.777 (95% confidence interval [CI]: 0.747–0.805), 0.742 (95% CI: 0.710–0.771), and 0.670 (95% CI: 0.637–0.702), respectively. The AUC for DBP differed significantly from that for ISS ($p=0.023$), but not from that for RTS ($p=0.330$).

DBP was independently associated with MT (odds ratio [OR]: 0.964; 95% CI: 0.954–0.974). DBP groups were also independently associated with MT except for the >60mmHg group (Table 3).

Discussion

In the present study, DBP showed a better prognostic performance for MT than ISS.

The ISS is used to assess the severity of trauma based on anatomical findings.[13] In the present study, ISS had the lowest AUC in predicting MT among the three assessed variables. Several factors may have contributed to these results. First, the ISS is calculated based on the anatomical areas. However, only the highest score for each anatomical area is included in the calculation. Thus, other injuries in the same anatomical area are not considered. Second, the ISS does not take into account any physiological parameters, such as blood pressure (BP), pulse rate, and GCS score, which differed significantly between the MT and non-MT groups in the present study. On the contrary, the RTS assesses the severity of trauma using different physiological parameters, and is calculated using the GCS score, SBP and respiratory rate. In the present study, the AUC of RTS in predicting MT was better than that of ISS. The use of physiological parameters likely played a significant role in this result.

Shock occurs when oxygen delivery cannot meet the oxygen demand for cellular metabolism because of several reasons.[6] Decreased perfusion to the end organ is an important mechanism of shock. The mean arterial pressure (MAP) is considered the main driving pressure for the perfusion to most vital organs, and DBP accounts for 66% of total MAP.[16] Therefore, DBP is more important than SBP for adequate tissue perfusion. In other illnesses, such as sepsis or chronic HTN, diastolic hypotension is considered an adverse outcome. A study reported that low DBP was associated with myocardial ischemia in patients with septic shock.[12] Other studies showed higher mortality in patients with chronic HTN and low DBP.[17] According to another study, low DBP (<70mmHg) was associated with a higher risk of subclinical myocardial injury in patients with SBP >140mmHg.[10] Similarly, low DBP may result in adverse outcomes and a state of severe shock in trauma. In the present study, low DBP was associated with MT and 30-day mortality.

DBP and SBP represent the vascular tone and stroke volume, respectively. According to a study, systemic venous resistance (SVR) in the Han and Korean populations is attributed to DBP.[18] To compensate for the reduced venous return, vagal tone is inhibited, and sympathetic tone is increased. This results in the initiation of reflex tachycardia, thereby increasing the SVR. However, if the bleeding progresses and blood-loss is over 20–30% of the total blood volume, sudden onset of vagus-mediated bradycardia and reduced SVR occur.[19] As previously mentioned, DBP represents the SVR; thus, patients with severe haemorrhagic shock have low DBP and SBP due to the lack of compensation. This is reasonable under the presumption that the reduction in DBP in patients with trauma indicates a large amount of blood loss. In the present study, the mortality and the amount of PRCs increased linearly along with a reduced DBP.

Definitive haemostasis by emergency operation or angioembolisation by emergency intervention is a vitally important treatment method for massive bleeding.[6] This also means that active bleeding causing haemorrhagic shock cannot be appropriately treated with conservative methods alone; a finding consistent with that of the present study. The frequencies of emergency operation and emergency intervention increased linearly as the DBP decreased. Only the fourth group with a DBP <40mmHg showed a lower frequency of operation than the third group with a DBP of 21–40mmHg. This finding was likely due to the rapid onset of death before surgery despite intensive resuscitation. The results of the present study show significant association between reduced DBP and severe blood loss.

During resuscitation of patients with trauma, recent studies and guidelines recommend restriction of massive isotonic crystalloid infusion and early initiation of MT protocols. Several scoring systems have been established for the faster application of MT. The Assessment of Blood Consumption (ABC) score, Trauma-Associated Severe Haemorrhage (TASH) score, and Prince of Wales Hospital/Rainer (PWH) score are used by clinicians worldwide in initiating the MT protocol. Several highly accurate and validated scores in predicting MT in trauma exist.[7] However, except for the ABC score, the TASH and PWH scores use laboratory and simple radiographic imaging parameters, such as haemoglobin level/hematocrit, base deficit, and presence of pelvic or long bone fracture.[7] Evaluation using these complicated parameters in unstable patients takes time. Delays in MT protocol activation and initial blood cooler delivery were associated with increased mortality.[20] In comparison with other scoring systems, DBP can be measured swiftly and easily. Therefore, this study suggests that DBP has the following advantages: less time to measure, ease of measurement, and accuracy of predicting MT. For example, when a patient with trauma shows diastolic hypotension upon arrival at the ED, a clinician can administer universal donor blood products to the patient based on the patient's low DBP and evaluate other parameters, such as haemoglobin level, base excess, and score in the focussed assessment with sonography in trauma (FAST) while concurrently activating the MT protocol, hence reducing infusion time.

The present study has several limitations. First, it was a single-centre retrospective study. Hence, future studies shall include larger sample size at multiple centres, and shall be prospective in design. The current study did not compare the AUC of DBP in predicting MT with the AUC of the other scoring systems because of insufficient FAST results in the ED and pelvic radiography data was missing. Future studies shall compare DBP with the other scoring systems as well.

Conclusion

Initially decreased DBP was an found to be an independent predictor for MT in severe trauma cases, with ease of measurement and being less time-consuming compared to the other scoring systems.

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Table 1: Comparison of the baseline characteristics according to massive transfusion.

	All patients n = 827	Non-MT n = 763	MT n = 64	*P*-value
Age, years				0.158
Median	61.1	61.1	57.5	
IQR	48.1–73.1	48.1–73.1	38.0–72.1	
Male, n (%)	611 (73.9)	562 (73.7)	49 (76.6)	0.611
Mechanism of trauma				0.003
Blunt, n (%)	813 (98.3)	753 (98.7)	60 (93.8)	
Penetrating, n (%)	14 (1.7)	10 (1.3)	4 (6.3)	
Injury severity score				<0.001
Median	22	22	26	
IQR	17–25	17–25	20–34	
Revised trauma score				<0.001
Median	7.84	7.84	6.38	
IQR	6.38–7.84	6.38–7.84	4.55–7.11	
GCS score ≤ 12, n (%)	260 (31.4)	229 (30.0)	31 (48.4)	0.002
SBP, mm Hg				<0.001
Median	110	120	80	
IQR	100–140	100–140	60–100	
DBP, mm Hg				<0.001
Median	70	70	40	
IQR	60–90	60–90	30–60	
Respiratory rate, /min				0.011
Median	20	20	20	
IQR	20–22	20–22	20–24	
Pulse rate, /min				0.003
Median	88	86	96	

IQR	78–98	78–98	79–120	
Intervention, n (%)	92 (11.1)	81 (10.6)	11 (17.2)	0.108
Operation, n (%)	221 (26.7)	182 (23.9)	39 (60.9)	<0.001
Mortality, n (%)	123 (14.9)	94 (12.3)	29 (45.3)	<0.001
PRC, units				<0.001
Median	1	1	13	
IQR	0–4	0–3	11–16	

MT: Massive transfusion; IQR: Interquartile range; GCS: Glasgow Coma Scale; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PRCs: Packed red blood cells

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Table 2: Comparison of the characteristics stratified according to diastolic blood pressure (DBP).

	DBP, mm Hg				*P*-value
	>60 n = 489	41–60 n = 215	21–40 n = 86	≤20 n = 37	
Age, years					<0.001
Median	64	56	63	59	
IQR	51–75	39–68	45–74	41–71	
Male, n (%)	367 (75.1)	166 (77.2)	58 (67.4)	20 (54.1)	0.012
Mechanism of trauma					0.828
Blunt, n (%)	481 (98.4)	211 (98.1)	84 (97.7)	37 (100.0)	
Penetrating, n (%)	8 (1.6)	4 (1.9)	2 (2.3)	0 (0.0)	
Injury severity score					<0.001
Median	22	22	22	25	
IQR	17–25	17–25	18–30	20–34	
Revised trauma score					<0.001

Median	7.84	7.84	6.38	2.83	
IQR	6.90–7.84	7.11–7.84	5.05–7.11	1.90–5.18	
GCS score ≤ 12, n (%)	157 (32.1)	51 (23.7)	24 (27.9)	28 (75.7)	<0.001
SBP, mm Hg					<0.001
Median	130	100	70	40	
IQR	120–150	90–100	60–80	40–50	
Respiratory rate, /min					<0.001
Median	20	20	22	20	
IQR	20–22	20–22	20–24	10–24	
Pulse rate, /min					<0.001
Median	84	86	100	102	
IQR	78–96	78–96	84–117	90–126	
Intervention, n (%)	26 (5.3)	38 (17.7)	19 (22.1)	9 (24.3)	<0.001
Operation, n (%)	116 (23.7)	60 (27.9)	34 (39.5)	11 (29.7)	0.021
Mortality, n (%)	57 (11.7)	23 (10.7)	21 (24.4)	22 (59.5)	<0.001
Massive transfusion, n (%)	14 (2.9)	17 (7.9%)	19 (22.1)	14 (37.8)	<0.001
PRC, units					<0.001
Median	0	2	5	8	
IQR	0–3	0–4	2–9	4–12	

IQR: Interquartile range; GCS: Glasgow Coma Scale; SBP: Systolic blood pressure; PRCs: Packed red blood cells.

Table 3: Multivariate logistic regression analysis in predicting massive transfusion.

	Adjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Penetrating	3.719 (0.975–14.183)	0.054	4.341 (1.113–16.936)	0.035
Injury severity score	1.050 (1.015–1.085)	0.004	1.050 (1.016–1.085)	0.004
Revised trauma score	0.868 (0.718–1.048)	0.142	0.842 (0.688–1.031)	0.095

Pulse rate, /min	1.005 (0.992–1.018)	0.448	1.005 (0.992–1.018)	0.423
Intervention	1.352 (0.587–3.115)	0.478	1.382 (0.606–3.150)	0.442
Operation	4.855 (2.691–8.760)	<0.001	4.499 (2.495–8.114)	<0.001
DBP, mm Hg	0.964 (0.954–0.974)	<0.001		
First group (DBP, >60 mm Hg)			Reference	
Second group (DBP, 41–60 mm Hg)			2.740 (1.299–5.782)	0.008
Third group (DBP, 21–40 mm Hg)			6.979 (3.188–15.281)	<0.001
Fourth group (DBP, ≤20 mm Hg)			19.469 (7.705–49.196)	<0.001

OR: Odds ratio; CI: Confidence interval; DBP: Diastolic blood pressure.