QUANTITATIVE RESEARCH

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Seeking a Relevant Description of Major Trauma Bleeding: Comparison of Four Major Bleeding Definitions

Darcy L. Day, BSN, RN, CCRN, TCRN, CEN ■ Karen Ng, RN ■ Richard Severino, MS ■ Josh Ng-Kamstra, MDCM, MPH

BACKGROUND: The traditional definition of massive transfusion is 10 red blood cell units transfused within 24 hr. This definition has been faulted for excluding patients who die early from exsanguination. Alternative major bleeding definitions in the trauma literature include time-based (e.g., Resuscitation Intensity) and event based (e.g., Sharpe) transfusion thresholds.

OBJECTIVE: The study objective was to compare four definitions of major bleeding, including a modification to the Sharpe definition, on clinically relevant processes and outcomes.

METHODS: This is a retrospective cohort study of adult trauma patients admitted from the field to a Level I trauma center from 2014 to 2019. Data sources were the trauma registry, blood bank, and electronic medical records. Transfusion thresholds were defined as follows: Resuscitation Intensity—4 units of any combination of crystalloids, colloids, or blood products within the first 30 min of arrival; Sharpe—10 red blood cell units from trauma bay presentation to inpatient admission (a proxy for the interval of hemorrhage control); Modified Sharpe—10 units of any combination of blood products during the same interval. The study analysis consisted of descriptive statistics.

RESULTS: The cohort contained 187 subjects. Of 39 deaths, 28 (72%) occurred within 6 hr following arrival. Modified Sharpe captured 27 (96%) of these 28 subjects, whereas Resuscitation Intensity captured 20 (71%). Sharpe and the traditional definition each captured 22 subjects (79%). Modified Sharpe captured 17%–25% of deaths missed by the other definitions.

CONCLUSION: Modified Sharpe may optimally indicate major bleeding during trauma resuscitation.

KEY WORDS: Hemostasis, Major bleeding, Massive transfusion, Resuscitation, Trauma

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BACKGROUND

Uncontrolled bleeding is the most frequent cause of preventable death during the first 24 hr following injury (Callcut et al., 2019). The use of damage control resuscitation, which has been found to improve mortality (Black et al., 2021; Fox et al., 2017), includes both immediate hemorrhage control to stop bleeding and hemostatic resuscitation emphasizing early transfusion with appropriate ratios of blood components (Black et al., 2021). Major bleeding is commonly defined by the total quantities of transfused blood products, but the most clinically relevant definition of such massive transfusion (MT) remains unclear.

The traditional definition of MT is transfusion of 10 red blood cell (RBC) units over 24 hr. This 24-hr time period has been criticized for not accurately reflecting the first 2–6 hr when most deaths from bleeding occur (Chang et al., 2019; Holcomb et al., 2015) and when hemostasis should be achieved (Chang et al., 2019; Fox et al., 2017; Meyer et al., 2018). Furthermore, the traditional definition of MT excludes both patients who die before the 10th RBC unit can be given (creating survivor bias) and patients with substantial bleeding but who still fall short of the threshold (Meyer et al., 2018; Tran et al., 2019; Zatta et al., 2014). Patients receiving 6–9 RBC units may carry a mortality risk of more than 20% (Stanworth et al., 2010). Given that balanced resuscitation with appropriate ratios of plasma and platelets decreases overall RBC requirements (Kautza et al., 2012), the traditional definition

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Author Affiliations: Crisis/Rapid Response Program, Nursing Division (Ms Day), Division of Trauma (Ms Ng), Division of Surgical Critical Care (Mr Severino), and FRCSC General Surgery & Adult Critical Care Medicine, Trauma, Acute Care Surgery, and Surgical Critical Care, Department of Surgery (Dr Ng-Kamstra), The Queen's Medical Center, Honolulu, Hawaii; and Department of Surgery, John A. Burns School of Medicine, Honolulu, Hawaii (Dr Ng-Kamstra).

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Darcy Day and Karen Ng had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Correspondence: Darcy L. Day, BSN, RN, CCRN, TCRN, CEN, Crisis/Rapid Response Program, Nursing Division, The Queen's Medical Center, 411 Hobron Lane #3101, Honolulu, HI 96815 (rhinoday55@gmail.com).

KEY POINTS

- Most trauma patients die from hemorrhage during the first 6 hr following trauma bay arrival.
- Bleeding is addressed during this time, the period of hemorrhage control, from trauma bay arrival to inpatient admission.
- Modern trauma resuscitation includes early transfusion of multiple blood components versus solely red blood cells.
- The Modified Sharpe definition includes multiple blood components during the period of hemorrhage control.
- This study shows Modified Sharpe described major bleeding, as Modified Sharpe captured 96% of mortality at 6 hr.

may become less relevant as modern trauma transfusion practices change.

Several alternative definitions of major bleeding in trauma have been proposed to address the shortcomings of the traditional MT definition. An early time-based threshold, Resuscitation Intensity, is defined as 4 units of any combination of fluid resuscitation products administered during the first 30 min of trauma bay presentation (Rahbar et al., 2013). One unit is equal to 1 L of any type of crystalloid, 500 ml of any type of colloid, 1 RBC unit, 1 plasma unit, or 1 pooled platelet unit. To address bleeding during the period of hemorrhage control, Sharpe et al. (2012) defined major bleeding as 10 RBC units transfused during the period when bleeding is addressed in the trauma bay, operating room, or interventional radiology, referred to as the "interval of hemorrhage control," using the time of intensive care unit (ICU) admission as a proxy for the conclusion of this interval. To include both this clinically relevant interval and the current practice of balanced resuscitation, we proposed a modification to the Sharpe threshold, which we refer to as the *Modified Sharpe* definition of major bleeding: 10 units of any combination of RBCs, plasma, or platelets during the period of hemorrhage control prior to inpatient admission.

The comparative performance of these definitions in identifying a clinically relevant population of patients experiencing major traumatic bleeding for audit, quality improvement, and clinical protocol has not yet been determined. We present our analysis at a single Level I trauma center.

OBJECTIVE

We sought to compare four definitions of major bleeding (Resuscitation Intensity, Sharpe, Modified Sharpe, traditional MT definition) and the clinical characteristics of the patients they identify for blood product utilization, provision of hemostatic interventions, and outcomes.

METHODS

Study Design, Setting, and Population

This study was a retrospective cohort analysis of trauma patients admitted to The Queen's Medical Center in Honolulu, HI, from January 1, 2014, to December 31, 2019. The Queen's Medical Center is an academic hospital licensed for 566 beds. Verified by the American College of Surgeons, The Queen's Medical Center is the only Level I trauma center serving the state of Hawaii and the Central Pacific region. During the study period, annual trauma admissions increased from 2,600 to nearly 3,000 patients.

The data for the study were obtained from the trauma registry, blood bank, and electronic medical record. Patients presenting directly from the field with trauma team activation prior to arrival, who received a procedure related to bleeding control, and who were transfused at least 2 RBC units during the first 6 hr following arrival were eligible for inclusion. Exclusion criteria included age less than 18 years, documented pregnancy, or isolated traumatic brain injury. Patients who died during the first hour after initial presentation were excluded to minimize survivorship bias, as many of these patients would not have survived long enough to meet relevant thresholds. Procedures related to bleeding control consisted of surgery, interventional radiology, emergency department (ED) thoracotomy, resuscitative endovascular balloon occlusion of the aorta (REBOA), tourniquet placement, or pelvic binder placement. The Queen's Medical Center Research and Institutional Review Committee approved this research and waived informed consent (IRB No. RA-2020-014). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were consulted in the preparation of this article (Vandenbroucke et al., 2007).

Data Variables and Outcome Measures

The trauma registry and blood bank records were queried for the initial list of patients, for whom "trauma blood" (emergency uncross-matched blood products) was requested or the MT protocol was activated. Following screening for study inclusion, the electronic medical record was reviewed for demographics (age, gender), mechanism, trauma bay arrival date and time, type of bleeding control attempted and time initiated, time of arrival to inpatient unit, vital sign data on arrival to the trauma bay (temperature, heart rate, systolic blood pressure, shock index), laboratory data (base excess, hemoglobin, platelet count, prothrombin time, international normalized ratio), and transfusion data (number of fluid and blood product units given during the first 30 min from trauma bay arrival; number of blood products given during the first 3, 6, and 24 hr following trauma bay arrival; and number of blood products given by time of arrival to an inpatient unit). The time of trauma bay arrival was designated as the time zero reference for the 30-min, 3-hr, 6-hr, and 24-hr transfusion amounts. The Injury Severity Score was provided by the trauma registry. Subjects meeting none of the chosen major bleeding definitions were excluded without further analysis. Process measures included initiation of bleeding control interventions. The primary outcome was mortality at 3, 6, and 24 hr after trauma bay arrival. Secondary outcome measures included hemorrhagic shock, the need for bleeding control interventions, utilization of blood products, and ICU length of stay.

Statistics

Note that this is a descriptive study comparing nonindependent groups: Study subjects could meet criteria for more than one group, and groups were widely overlapping. Categorical variables are conveyed as frequencies and percentages. Continuous variables are presented as medians and interquartile ranges, except age, which is presented as mean and standard deviation. All descriptive statistics, frequencies, and relative frequencies were computed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

During the 6-year study period, an emergency uncross-matched blood cooler was requested, or the MT protocol was activated for 485 patients following trauma bay presentation. The study enrollment flowchart is displayed in Figure 1. Following exclusions, 250 subjects were initially identified for data collection. An additional 63 subjects who did not meet any of the major bleeding definitions being studied were removed. Data collection and analysis were completed for a total of 187 subjects.

Admission demographics for the major bleeding definitions are shown in Table 1. Resuscitation Intensity captured the largest portion of the cohort (n = 148; 79%), followed by Modified Sharpe (n = 134; 72%). Mean (SD) patient age was 47 (19) years. Males comprised at least three fourths of the subjects in all categories. Blunt mechanism predominated in all groups versus penetrating mechanism. Penetrating mechanism was highest in the Resuscitation Intensity and Modified Sharpe groups. Median transfusion values for all groups met the traditional MT definition during the first 3 hr after hospital arrival, except for Resuscitation Intensity, which did not meet the traditional MT definition at 3, 6, or 24 hr.

In Table 2, the definitions are compared on markers of injury severity. Resuscitation Intensity had a lower proportion of patients with Injury Severity Score of

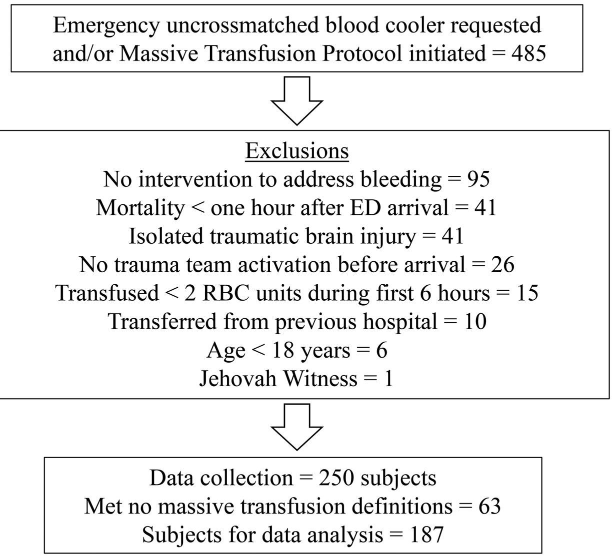

Figure 1. Study enrollment flowchart.

16 or more, hemoglobin level of 11 g/dl or less, and coagulopathy in contrast to the Modified Sharpe, Sharpe, and traditional MT definitions. Sharpe and traditional MT definitions had higher proportions of patients with acidosis (base excess < -5 mmol/L) and hypotension in patients 65 years or older. Missing data for this table ranged from 1% for heart rate, systolic blood pressure, and base excess to 8% for temperature and were considered to be missing randomly.

Interventions and outcomes for the major bleeding definitions are shown in Table 3. Higher percentages of surgery and ED thoracotomy or REBOA were noted for the Sharpe definition. Resuscitation Intensity had the lowest proportions for all interventions except for tourniquet placement, with the highest proportion for this intervention. The traditional MT definition had the highest proportion for patients undergoing angioembolization and pelvic binder application. Overall mortality percentages for all three time periods were lowest for Resuscitation Intensity and highest for Sharpe. For the total cohort, 39 patients died during the first 24 hr following trauma bay arrival. Of these patients, more than half died during the first 3 hr and nearly three fourths were dead by the first 6 hr. All but one who died by the first 3 hr or by the first 6 hr, and all but two who died during the first 24 hr, met the Modified Sharpe major bleeding definition. The Modified Sharpe definition captured the largest proportion of 3-hr (95%, 20/21), 6-hr (96%, 27/28), and 24-hr (95%, 37/39) mortalities.

The two most inclusive definitions, Resuscitation Intensity and Modified Sharpe, focus on all blood products rather than solely RBCs. A subgroup comparison of Resuscitation Intensity and Modified Sharpe is presented in Table 4. This table displays the two groups with inclusive data (both definitions positive) in the first

Table 1. Comparison of Major Bleeding Descriptions for Admission Demographics and Blood Product Utilization

Variable	Cohort	Resuscitation Intensity	Modified Sharpe	Traditional Definition	Sharpe
n (%)	187	148 (79.1)	134 (71.7)	105 (56.2)	83 (44.4)
Age, mean (SD), years	46.6 (19.3)	45.1 (19.1)	47.3 (19.0)	50 (20.2)	50.4 (18.9)
Gender, n (%)					
Male	142 (75.9)	116 (78.4)	101 (75.4)	82 (78.1)	67 (80.7)
Female	45 (24.1)	32 (21.6)	33 (24.6)	23 (21.9)	16 (19.3)
Mechanism, n (%)					
Blunt	120 (64.2)	90 (60.8)	94 (70.2)	81 (77.1)	61 (73.5)
Penetrating	67 (35.8)	58 (39.2)	40 (29.9)	24 (22.9)	22 (26.5)
Transfusions, Mdn (IQR)					
RBCs, units					
3 hr	6 (4–12)	6 (4–12)	10 (6–13)	11 (7–15)	12 (10–17)
6 hr	7.5 (4–12)	7 (4–12)	10 (7–15)	12 (10–17)	14 (12–26)
Interval hem control	8 (4–14)	6.5 (4–14)	12 (7–17)	13 (10–20)	15.5 (12–26)
24 hr	10 (5–14)	9 (4–14)	12 (8–17)	14 (12–20)	16 (13–25)
Plasma, units					
3 hr	6 (2–10)	6 (2–10)	8 (6–12)	10 (6–14)	11 (9–18)
6 hr	6 (4–11)	6 (2–10)	9 (6–14)	11 (7–16)	13 (10–24)
Interval hem control	6 (4–12)	6 (3–12)	9.5 (6–16)	11 (7–20)	13.5 (10–25)
24 hr	7 (4–12)	6 (2–12)	10 (6–16)	12 (9–20)	16 (10–24)
Platelets, bags[a]					
3 hr	1 (0–2)	1 (0–2)	1 (1–2)	2 (1–2)	2 (1–3)
6 hr	1 (0–2)	1 (0–2)	1 (1–2)	2 (1–3)	3 (2–3)
Interval hem control	1 (0–2)	1 (0–2)	1.5 (1–2)	2 (1–3)	2 (2–4)
24 hr	1 (0–3)	1 (0–2)	2 (1–3)	3 (2–4)	3 (2–5)

Note. Interval hem control = the interval of hemorrhage control.

[a]One bag of platelets = 6–8 apheresis units.

column and as exclusive data (only one definition positive) in columns 2 and 3 to compare cases missed by either definition. Both groups had similar proportions of patients requiring surgery, but more than twice as many patients in the Modified Sharpe positive/Resuscitation Intensity negative group required interventional radiology than in the Resuscitation Intensity positive/Modified Sharpe negative group. For Injury Severity Score, approximately half of the Resuscitation Intensity positive/Modified Sharpe negative group was in the moderate injury category, whereas approximately half of the Modified Sharpe positive/Resuscitation Intensity negative group was in the critical injury category. Mortality was also different between the two groups. Only one death and two deaths occurred during the 6- and 24-hr time periods, respectively, for the Resuscitation Intensity positive/Modified Sharpe negative group. For the Modified Sharpe positive/Resuscitation Intensity negative group, there were eight and 10 deaths for the same periods, respectively.

DISCUSSION

Approximately 10% of blood products dispensed by transfusion support services are in the context of MT (McQuilten et al., 2021). Three definitions of MT in the trauma literature are the traditional MT definition, Resuscitation Intensity, and the Sharpe interval of hemorrhage control. The traditional MT definition originated with cardiac surgeons in the 1950s (Meyer et al., 2018) and was later used during the Vietnam war to reference the approximate total blood volume of a 70-kg male (Gauss et al., 2022; Hu et al., 2021). The Resuscitation Intensity definition evolved from study results showing more than two times higher 6-hr mortality for patients who received 4 units of any resuscitation fluid given within the first 30 min following trauma bay arrival than for those who received less than 4 units (14.5% vs. 4.5%; Rahbar et al. 2013). The Sharpe et al. (2012) research emphasizing the "interval of hemorrhage control" found 24-hr mortality more than three times higher for patients who received 10 RBC units before

Table 2. Comparison of Major Bleeding Description Categories by Markers of Severe Injury

Variable	Cohort	Resuscitation Intensity	Modified Sharpe	Traditional Definition	Sharpe
n (%)	187	148	134	105	83
ISS ≥ 16	137 (73.3)	106 (71.6)	111 (82.8)	89 (84.8)	68 (84.0)
BE < −5 mmol/L[a]	102 (54.8)	84 (57.1)	78 (58.7)	68 (64.8)	58 (69.9)
Hb ≤ 11 g/dl	76 (40.6)	61 (41.2)	63 (47.0)	60 (57.1)	48 (57.8)
Platelet < 100 × 10^3/μl[b]	9 (4.9)	8 (5.5)	7 (5.3)	7 (6.8)	6 (7.4)
PT ≥ 18 sec and INR > 1.4[b]	39 (21.2)	33 (22.6)	34 (25.4)	31 (30.4)	26 (32.5)
Temperature < 36.0 °C[c]	77 (44.8)	66 (48.9)	57 (46.3)	42 (43.8)	35 (46.1)
Heart rate ≥ 120 bpm[a]	73 (39.3)	61 (41.5)	57 (42.9)	45 (43.1)	37 (45.1)
SBP < 90 mmHg, age 18–64 years[a]	58 (31.2)	52 (35.4)	44 (33.1)	39 (37.1)	29 (35.4)
SBP < 110 mmHg, age ≥65 years[d]	24 (12.9)	19 (12.9)	18 (13.4)	20 (19.0)	16 (19.3)
Shock index ≥1[e]	121 (67.2)	104 (73.2)	95 (73.6)	80 (80.0)	64 (82.1)
ICU LOS, mean (IQR)	5 (2–11)	5 (3–11)	6 (2–14)	7 (2–16)	6 (2–16)

Note. BE = base excess; bpm = beats per minute; Hb = hemoglobin; ISS = Injury Severity Score; INR = international normalized ratio; LOS = length of stay; PT = prothrombin time; SBP = systolic blood pressure.

[a]One data point missing.

[b]Three data points missing.

[c]Fifteen data points missing.

[d]Total number of patients 65 years or older = 36.

[e]One data point missing and six unable to calculate the shock index due to unobtainable SBP.

ICU admission than those meeting the 10-unit threshold after ICU admission (33% vs. 9%).

For the current study, we modified the Sharpe MT definition to include transfusion of all blood products versus only RBCs during the interval of hemorrhage control. We performed a retrospective analysis to compare this definition to the three definitions noted earlier. This research shows Modified Sharpe to be the most clinically relevant definition of MT for capturing the largest proportion of deaths at the 3-, 6-, and 24-hr time periods. Modified Sharpe missed only one death at 3 and 6 hr and two deaths at 24 hr.

The Resuscitation Intensity definition captured subjects at the earliest time point following trauma bay arrival compared with the other definitions. Early identification can be helpful as an alert for MT protocol activation. Meeting the Resuscitation Intensity definition may signal potential mortality risk, prompting reassessment of hemorrhage control interventions by the trauma team (Meyer et al., 2018). Although Resuscitation Intensity included the most patients (nearly 80%), we observed that 24 patients (16%) in this group received no further blood products following the initial amount meeting the Resuscitation Intensity definition. This could be explained by timely hemorrhage control requiring no further blood products or a less severely injured cohort. The current study noted a higher use of tourniquets for the Resuscitation Intensity group (25%), possibly accounting for early hemorrhage control. Conversely, the Resuscitation Intensity group experienced less treatment with interventional radiology, ED thoracotomy or REBOA, and pelvic binder than the rest of the groups, less surgery than Modified Sharpe or Sharpe, and a larger proportion of the Injury Severity Score corresponding with moderate injury in subgroup analysis (Table 4). This may suggest a less severely injured cohort. The Resuscitation Intensity group had lower mortality at every time point than the other three groups.

The Sharpe group captured less than half of the entire cohort, but this group had higher mortality at all time points. The Sharpe group received the most RBCs, plasma, and platelets across all time periods, despite the Sharpe definition itself not accounting for the use of plasma and platelets. Early administration of plasma and platelets in balanced ratios with RBCs is current best practice (Cannon et al., 2017). The Sharpe definition missed 23% of deaths occurring by 24 hr compared with only 5% for Modified Sharpe. Fox et al. (2017) notes that "primary endpoints should be congruent with the … timing of the disease process" (p. 572). The benefit of the "interval of hemorrhage control" used in the Sharpe and Modified Sharpe definitions is that this reflects the period of highest mortality from hemorrhage and the period of definitive bleeding control when MT to support the patient occurs.

A Delphi study of international trauma experts with the goal of achieving consensus for an MT definition for research purposes was published in 2020. The proposed consensus definition was 4 units of any blood product within 2 hr following injury (Wong et al., 2020).

Table 3. Comparison of Major Bleeding Description Categories by Interventions and Outcome

Variable	Cohort	Resuscitation Intensity	Modified Sharpe	Traditional Definition	Sharpe
n (%)	187	148	134	105	83
Interventions					
Surgery	152 (81.3)	122 (82.4)	115 (85.8)	86 (81.9)	74 (89.2)
IR	43 (23.0)	28 (18.9)	34 (26.1)	31 (29.5)	23 (27.7)
EDT/REBOA	20 (10.7)	15 (10.0)	17 (13.0)	14 (11.0)	13 (16.0)
Tourniquet	39 (20.9)	37 (25.0)	24 (17.9)	20 (19.1)	17 (20.5)
Pelvic binder	31 (16.6)	25 (16.9)	23 (17.2)	23 (21.9)	16 (19.3)
Mortality					
At 3 hr	21 (11.2)	15 (10.1)	20 (14.9)	17 (16.2)	17 (20.5)
At 6 hr	28 (15.0)	20 (13.5)	27 (20.2)	22 (21.0)	22 (26.5)
At 24 hr	39 (20.9)	29 (19.6)	37 (27.6)	33 (31.4)	30 (36.1)

Note. EDT = emergency department thoracotomy; IR = interventional radiology; REBOA = resuscitative endovascular balloon occlusion of the aorta.

Although this definition may capture a large cohort, it may also include less injured subjects. We did not include this definition for the current study, but it may be important for future work. In addition, the inclusion of whole blood (WB) in MT protocols is becoming more commonplace at trauma centers. WB contains coagulation factors, platelets, and RBCs, providing a "balanced resuscitation" in each unit (Yazer et al., 2018). The use of WB may mean less component units are required during MT. Limited data is currently available to inform how the transfusion of WB may impact the definition of MT. In a retrospective study, Hu et al. (2021) defined the WB MT score as each WB unit multiplied by 3 (to account for the extra volume of plasma and platelets) plus each RBC unit transfused. A WB MT score of 7 or more was considered positive for MT, and these patients had higher mortality during the first 3 hr after injury (28.9% WB MT positive vs. 3.1% WB MT negative, $p < .01$). More research on MT comprising WB transfusion needs to be done.

LIMITATIONS

This study has limitations. Mortality of less than 1 hr was an exclusion criterion. Subjects may have

Table 4. Subgroup Comparison: Resuscitation Intensity and Modified Sharpe

Variable	RI Positive/MS Positive[a]	RI Positive/MS Negative[b]	MS Positive/RI Negative[c]
n (%)	98 (52.4)	50 (26.7)	36 (19.3)
Interventions			
Surgery	87 (88.8)	35 (70.0)	28 (77.8)
IR	21 (21.4)	7 (14.0)	14 (38.9)
Injury severity indicators			
Base excess < -5	63 (65.0)	21 (42.0)	16 (43.2)
Shock index ≥ 1	79 (84.0)	25 (52.1)	16 (45.7)
Injury Severity Score			
Moderate 9–15	14 (14.3)	19 (38.0)	6 (16.7)
Severe 16–24	28 (28.6)	12 (24.0)	12 (32.4)
Critical ≥25	54 (55.1)	12 (24.0)	17 (47.2)
Mortality			
First 6 hr	19 (19.4)	1 (2.0)	8 (22.2)
First 24 hr	27 (27.6)	2 (4.0)	10 (27.8)

Note. IR = interventional radiology; MS = Modified Sharpe definition; RI = Resuscitation Intensity definition.

[a]For this category: missing one base excess and one shock index data point; unable to calculate shock index for three patients due to unobtainable systolic blood pressure.

[b]For this category: unable to calculate shock index for two patients due to unobtainable systolic blood pressure.

[c]For this category: unable to calculate shock index for one patient due to unobtainable systolic blood pressure.

met the Resuscitation Intensity definition but then have been excluded because they died at less than 1 hr after arrival. The 1-hr mortality cutoff was chosen to attempt to control for survivor bias for the other three definitions. The 1-hr mortality exclusion cutoff is consistent with the Pragmatic Randomized Optimal Platelet and Plasma Ratios (PROPPR) clinical trial (Holcomb et al., 2015). The current research only considers the initial period of hemorrhage control. It does not include an additional bleeding event during the first 24 hr, such as a patient admitted to the ICU who must return to the operating room for further bleeding control, which the traditional MT definition would capture. Missing data are another limitation of this study. Crystalloids documented as liters hung but with no infused volume recorded were noted for 18 patients. Eleven of these still met the Resuscitation Intensity score through transfusion of blood products, six would not have met Resuscitation Intensity regardless, and one Resuscitation Intensity score would have changed to positive if the liter had been documented as infused. Other missing data for markers of injury severity are noted in the footnotes for Tables 2 and 4. This is a small single-center retrospective study conducted over a 6-year period. Changes in practice may have occurred both during and after the study, which could influence the results. Finally, the results may not be applicable to other centers where mechanisms of trauma or demographics differ.

CONCLUSION

Among four definitions of major traumatic bleeding examined in this research, Modified Sharpe is the most clinically relevant definition. It identified critically injured patients and captured the most mortalities in this study. More research is needed to determine an optimal definition to represent major bleeding during the period when bleeding trauma patients die.

The findings of this research do not necessarily represent the viewpoint of The Queen's Medical Center.

Orcid iDs

Darcy L. Day https//orcid.org/0000-0002-1552-5921

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