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RESEARCH

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A comparison of clinical prediction scores for massive traumatic hemorrhage

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Abstract

Background Accurate early identification of bleeding trauma patients remains challenging. Several clinical prediction tools—including the Assessment of Blood Consumption (ABC) score, Trauma-Associated Severe Hemorrhage (TASH) score, and shock index (SI)—have been developed to guide transfusion decisions, but their performance across clinically meaningful outcomes remains uncertain.

Methods We conducted a retrospective cohort study of trauma patients with massive hemorrhage protocol (MHP) activation at a university-affiliated, regional referral trauma center in Ontario, Canada, from July 2019 to September 2022. We included patients aged ≥ 16 years who presented within 3 h of injury. We evaluated the ABC score, TASH score, and SI for predicting massive transfusion (≥ 10 PRBCs in 24 h or ≥ 5 PRBCs in 4 h), the critical administration threshold (CAT; ≥3 PRBCs in 1 h), need for hemostatic intervention, and hemorrhage-related mortality. Score performance was assessed using area under the ROC curve (AUC), sensitivity, and specificity.

Results Among 331 patients, 10.6% received ≥ 10 PRBCs, 20.8% met the 5-unit threshold, 30.8% met CAT, 27.8% required hemostatic intervention, and 4.2% died from hemorrhage during the index admission. The TASH score had the highest AUCs (0.72–0.82) but poor sensitivity. The ABC score showed moderate, threshold-dependent performance (AUCs 0.66–0.76). The shock index (≥ 1.0) showed fair discrimination for major transfusion thresholds (AUC ~ 0.74) but was less predictive for hemostatic intervention (AUC 0.60).

Conclusion The ABC, TASH, and SI scores performed poorly to moderately across key bleeding outcomes. These findings highlight the need for improved tools aligned with real-time, clinically actionable endpoints in trauma resuscitation.

Keywords Trauma, Hemorrhage, Massive transfusion, Prediction scores

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Background

Trauma remains a major global health burden and is the leading cause of death among young adults worldwide [1]. Hemorrhage is the most common preventable cause of trauma related mortality, a trend noted in both civilian and military settings [2]. Despite increased emphasis on early resuscitation and activation of massive hemorrhage protocols (MHPs) [3, 4] -typically including predefined transfusion ratios, rapid availability of blood components, and early use of adjuncts such as tranexamic acid—translating early physiologic indicators of bleeding into timely hemorrhage control remains a major challenge [5, 6]. MHPs are structured, multidisciplinary approaches designed to deliver coordinated resuscitation in the setting of life-threatening hemorrhage, and have been associated with improved survival and reduced blood product wastage when implemented effectively [7]. Early recognition and timely hemostatic intervention are critical but often challenged by clinical uncertainty in the initial assessment [7–10]. For these reasons, there has been significant research interest in clinical decision aids to support early identification of bleeding patients [11–15] and guide activation of MHP [16–18].

The Assessment of Blood Consumption (ABC) [16] and Trauma-Associated Severe Hemorrhage (TASH) [17] scores have been previously developed and validated for the prediction of massive transfusion – a quantitative outcome typically defined by the volume of blood products administered, distinct from the clinical decision to activate a massive hemorrhage protocol (MHP). In addition to these multivariable tools, the shock index (SI)—calculated as heart rate divided by systolic blood pressure—is a simple bedside measure of hemodynamic instability and is commonly used in trauma settings to support bleeding risk assessment [19]. However, reliance on massive transfusion as the sole outcome is increasingly recognized as problematic due to competing risk and survivorship bias, particularly in patients who die early before meeting transfusion thresholds [20–23]. Despite numerous scoring systems, their accuracy remains variable and few have been evaluated across multiple, time-sensitive outcomes beyond massive transfusion [24]. A clearer understanding of their real-world performance is essential to guide early clinical decision-making.

In this study, we evaluated the performance of the ABC and TASH scores, as well as the shock index, for predicting a range of clinically relevant bleeding outcomes in trauma patients. We hypothesized that existing scores would demonstrate reasonable accuracy for traditional massive transfusion outcomes, but would underperform for the critical administration threshold and for hemostatic interventions, as they were originally derived to predict massive transfusion alone.

Methods

Design and setting

We conducted a retrospective cohort study at The Ottawa Hospital Civic Campus in Ontario, Canada, from July 1, 2019, to September 1, 2022. The Ottawa Hospital is the designated lead trauma center, university-affiliated hospital, and regional referral center for the Champlain Local Health Integration Network in Ontario, Canada. The Ottawa Hospital serves a regional catchment of approximately 1.5 million people and cares for 1,000 trauma admissions annually.

Eligibility criteria

Patients were eligible if they were aged ≥ 16 years and presented directly from the scene or via transfer within 3 h of injury, had a MHP activation (out-of-hospital or in-hospital), and required activation of the trauma team. At our institution, MHP activation is driven primarily by clinician judgment (clinical gestalt) rather than score-based triggers. This decision can be made at the discretion of either the trauma team leader or the initial responding emergency physician. We excluded patients with traumatic out-of-hospital cardiac arrest. This group is characterized by case-mix heterogeneity (including exsanguination, severe traumatic brain injury, tamponade, and pneumothorax), distinct resuscitation pathways (e.g., ongoing CPR, resuscitative thoracotomy, REBOA), and, importantly, frequent unavailability of key score inputs (e.g., FAST results, laboratory values, ISS). This design choice is consistent with the original derivation cohorts of ABC and TASH, which likewise required complete physiologic and laboratory variables to calculate the scores. Patients with non-hemorrhagic injury mechanisms (e.g., burns, drowning, electrocution, strangulation) were also excluded.

Data extraction

A list of patients with trauma team activation during the study period was obtained and screened for eligibility. Trained abstractors reviewed electronic medical records to extract data using a standardized form. A quality audit was performed by our study investigators and research coordinator on the first 100 cases and 10% of subsequent records. Data were cross-referenced with the institutional trauma registry to validate injury severity scores. The registry was maintained by a dedicated data analyst with a standardized input form and routine quality assurance audits consistent with all trauma centers across the province of Ontario [11, 25–28]. We collected variables to describe patient demographics, injury mechanism and severity, clinical exam and physiologic status, MHP activation and delivery of blood products, as well as clinical outcomes. We extracted the necessary variables to calculate the ABC score [16], TASH score [17],

and SI [19]. Our primary clinical outcome of interest was requiring massive transfusion, which we defined as transfusing 10 units of packed red blood cells (PRBCs) in 24 h or as receiving 5 units of PRBCs in any consecutive 4-hour period during the first 24 h of arrival to hospital [4]. Secondary outcomes of interest included the critical administration threshold (CAT) which was defined as transfusing 3 units of PRBCs in any consecutive 1 h period during the first 24 h of arrival to hospital [20, 21], and the need for hemostatic intervention that was defined as angioembolization or surgical intervention for hemostasis. For surgical cases, only procedures with documented hemostatic intent (e.g., laparotomy, thoracotomy, pelvic fixation, vascular repair) were included. Similarly, only angiographic studies with embolization were included. Exploratory procedures or angiography without intervention were classified as non-events. Death from hemorrhage was defined as mortality directly attributable to the acute physiologic consequences of massive blood loss from the index injury during the index hospitalization. Each case was reviewed by a staff trauma surgeon, and when classification was uncertain, a second staff physician independently reviewed the chart. Patients with death from secondary complications (including infection or venous thromboembolism) were classified as not meeting the outcome.

Data analysis

We used descriptive statistics to summarize baseline characteristics. We assessed score performance using receiver operating characteristic (ROC) curves, calculating the area under the curve (AUC) with 95% confidence intervals. We evaluated calibration with Hosmer–Lemeshow tests. Sensitivity, specificity, predictive values, and likelihood ratios were reported for thresholds based on prior derivation and validation studies. A cutoff of ABC ≥ 2 was originally proposed by Nunez et al. [16] and has been widely adopted in subsequent research. TASH ≥ 16 corresponds to a high predicted probability of requiring massive transfusion, as established in the original derivation by Yucel et al. [17]. A shock index threshold of ≥ 1.0 is commonly used to identify shock in trauma patients and has been associated with increased risk of mortality and resource-intensive interventions such as massive transfusion [29].

To explore potential spectrum effects, we performed post hoc sensitivity analyses by (a) mechanism of injury (penetrating vs. blunt), (b) activation context (prehospital vs. in-hospital MHP activation), and (c) injury severity (ISS ≤ 15, 16–24, ≥ 25). For each subgroup we recalculated discrimination (AUC) and operating characteristics for ABC (≥ 2), TASH (≥ 16), and SI (≥ 1.0) across all outcomes. Finally, to assess the impact of component definitions, we repeated performance analyses after counting PRBC, FFP, and platelets equally. We constructed composite thresholds for MT ≥ 10 units in 24 h, MT ≥ 5 units in any 4 h, and CAT ≥ 3 units in any 1 h. Pairwise AUC comparisons used DeLong's test. Analyses were conducted using SAS 9.4.

Ethics & funding

Ethics approval was obtained from the Ottawa Health Science Network Research Ethics Board. The study was supported by an operating grant from the Physician Services Incorporated Foundation.

Results

Study population

Figure 1 shows patient flow through the study. Of 1,143 trauma team activations between July 1, 2019 and September 30, 2022, 488 had MHP activation. After exclusions (< 16 years, > 3 h from injury, isolated non-torso injuries, non-hemorrhagic mechanism, VSA on arrival, or unavailable/mismatched charts), 331 patients were included for analysis. The median age among participants was 37 years (interquartile range [IQR] 25–55), with the majority being male ($n = 259/331$, 78.3%). Penetrating injury accounted for 34.1% ($n = 113/331$) of cases. The median Injury Severity Score was 17 (IQR 9–29.5). Common high-risk bleeding features included pelvic instability ($n = 30/331$, 9.1%), femur fracture ($n = 55/331$, 16.6%), and active bleeding on imaging or exam ($n = 71/331$, 21.5%). Initial median hemoglobin was 137 g/L, base excess − 0.9 mmol/L, and lactate 3.3 mmol/L (Table 1).

Transfusion and intervention outcomes

There were 122 out-of-hospital and 209 in-hospital MHP activations. Among those with in-hospital activation, 62.7% were transfused at least one unit of PRBCs. The median time from hospital arrival to in-hospital MHP activation was 20 min (IQR 13–42), while the median time from hospital arrival to initiation of first PRBC transfusion was 19 min (IQR 11–37). Median transfusion times were shorter for patients receiving MHP activation (18 min) compared to those without activation (380 min) (Table 2). In total, 10.6% ($n = 35/331$) of patients received ≥ 10 PRBC units in the first 24 h, 20.8% ($n = 69/331$) met the 5 units in 4 h transfusion threshold, and 30.8% ($n = 102/331$) met the CAT (≥ 3 units in 1 h). Hemostatic interventions were performed in 27.8% ($n = 92/331$) of patients, including surgery ($n = 81/331$, 24.5%) and angioembolization ($n = 16/331$, 4.8%). Hemorrhage-related mortality occurred in 4.2% ($n = 14/331$) during the index admission, while the overall in-hospital mortality was 11.5% ($n = 38/331$). Clinical outcomes (ICU admission, ICU and hospital LOS, in-hospital, 30-day, and hemorrhage-related mortality) stratified by

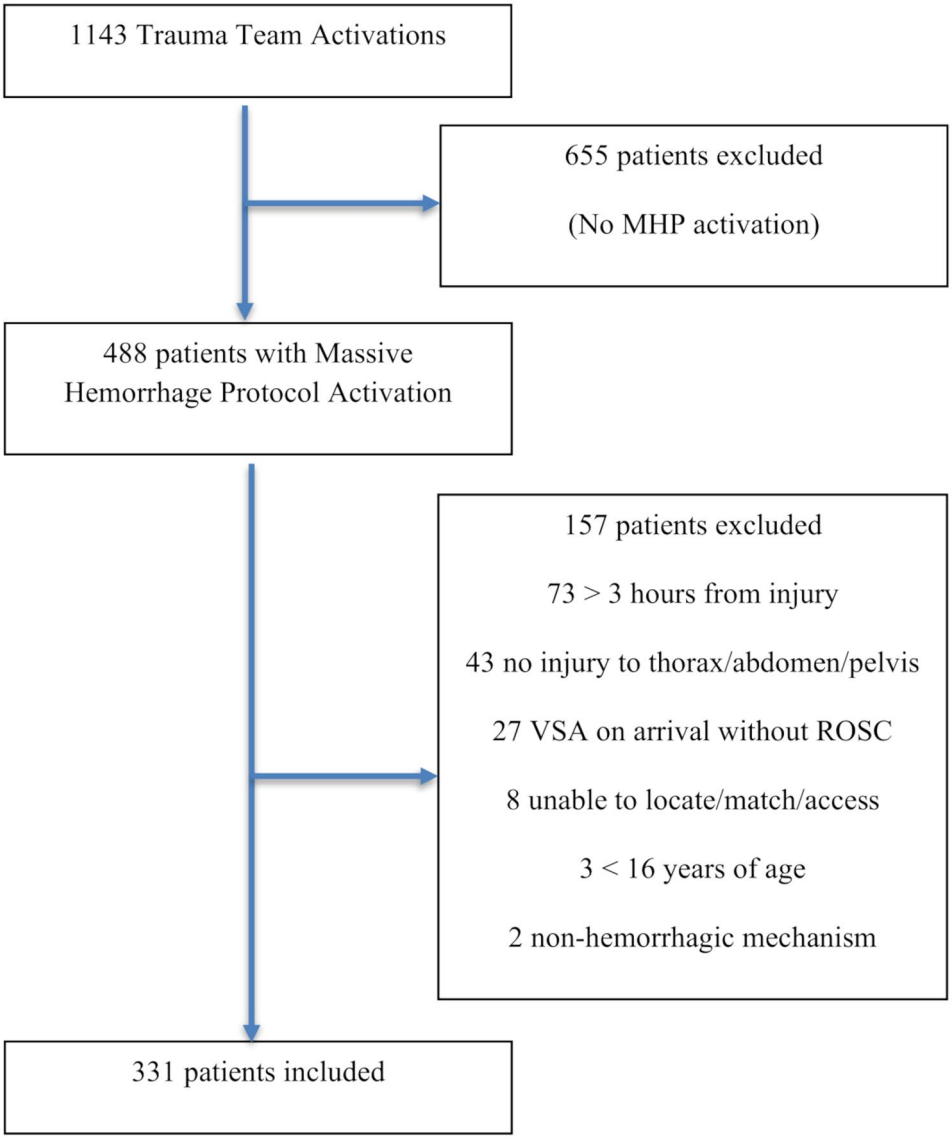

Fig. 1 Flowchart of patient inclusion and exclusions

each massive transfusion definition are reported in the Supplement.

Performance of clinical prediction scores

Across outcomes, TASH was highly specific (>98%) but with very low sensitivity at the ≥16 cut-point, consistent with a rule-in profile. ABC showed more balanced sensitivity and specificity and achieved its best performance for hemostatic intervention (AUC ~ 0.76). Shock index demonstrated only modest discrimination overall, with values similar to ABC for transfusion thresholds and somewhat higher for hemorrhage-related mortality. Detailed operating characteristics for all outcomes are provided in Table 3. ROC curves for ABC, TASH, and shock index are provided in the Supplement, with conventional operating points (ABC ≥ 2, TASH ≥ 16, SI ≥ 1.0) indicated.

Sensitivity analyses

Because score performance can vary with patient spectrum and activation context, we conducted post hoc sensitivity analyses stratified by mechanism of injury, activation setting, and injury severity (Supplement). In these analyses, the qualitative pattern of performance was unchanged. For all transfusion thresholds, TASH consistently had the highest AUC but low sensitivity at the ≥16 threshold, while SI and ABC demonstrated modest discrimination. For hemostatic intervention, ABC remained the best performer across all subgroups. By mechanism, AUCs were slightly higher for penetrating injuries but the rank-order was preserved. Among in-hospital MHP

Table 1 Population characteristics

Characteristic	*N* = 331
Age (years), median (IQR)	37.0 (25.0–55.0)
Male, N (%)	259 (78.3%)
Pre-existing Medical Bleeding Disorder, n (%)	2 (1.0%)
Pre-existing use of Anticoagulation, N (%)	15 (4.5%)
Penetrating Mechanism of Injury, N (%)	113 (34.1%)
Baseline Clinical Characteristics, median (IQR)	
Initial Systolic Blood Pressure (mmHg)	119.0 (96.5–136.0)
Initial Heart Rate (Beats/minute)	98.5 (81.0–112.8)
Glasgow Coma Scale Score	15.0 (13.0–15.0)
Injury Severity Score, median (IQR)	17.0 (9.0–29.5)
Pelvic Instability, N (%)	30 (9.1%)
Open or Dislocated Femur Fracture, N (%)	55 (16.6%)
Visualization of Active Bleeding, N (%)	71 (21.5%)
FAST performed, N (%)	303 (91.5%)
FAST positive	80 (26.4%)
Hemoglobin (g/L), median (IQR)	137.0 (124.0–149.0)
pH, median (IQR)	7.3 (7.3–7.4)
Base Excess (mmol/L), median (IQR)	-0.9, (-5.1, 1.6)
Lactate Level (mmol/L), median (IQR)	3.3 (2.2–4.9)
CT Imaging Performed, N (%)	292 (88.2%)
Free Fluid or Contrast Extravasation on CT	136 (46.6%)
Hemostatic Interventions, n (%)	
Any Hemostatic Intervention	92 (27.8%)
Surgery	81 (24.5%)
Embolization	16 (4.8%)
ICU Admission, N (%)	150 (45.3%)
Overall Mortality, N (%)	38 (11.5%)
In-Hospital	38 (11.5%)
30-day	
Hemorrhage-Related Mortality, n (%)	14 (4.2%)

IQR = interquartile range; FAST = Focused abdominal sonography for trauma; CT = computed tomography, *N* = number, ICU = intensive care unit

Table 2 Transfusion outcomes

Characteristic	*N* = 331
Massive Hemorrhage Protocol Activation, *n* (%)	
Out-of-hospital Activation with no PRBC provided	13 (3.9)
Out-of-hospital Activation with PRBC provided	109 (32.9)
In-hospital Activation with no PRBC provided	78 (23.6)
In-hospital Activation with PRBC provided	131 (39.6)
Time to In-hospital MHP Activation (minutes), median (IQR)	20 (13–42)
Time to First PRBC Transfusion (minutes), median (IQR)	
Overall	19 (11–37)
MHP Activation	18 (11–33)
Non-MHP Activation	380 (342–517)
Time to First FFP Transfusion (minutes), median (IQR)	
Overall *(n = 114)*	41 (27–94)
MHP Activation *(n = 109)*	40 (27–93)
Non-MHP Activation *(n = 4)*	574 (347–828)
Time to First PLT Transfusion (minutes), median (IQR)	
Overall *(n = 54)*	114 (56–192)
MHP Activation *(n = 54)*	114 (56–192)
Non-MHP Activation *(n = 0)*	
Large Volume Transfusion, N (%)	
10 units PRBC in first 24 hours (MT+)	35 (10.6)
5 units PRBC in any 4 hours in first 24 hours (MT+)	69 (20.8)
3 units PRBC in any 1 hour over first 24 hours (CAT+)	102 (30.8)

N = number, IQR = interquartile range, MHP = massive hemorrhage protocol, PRBC = packed red blood cells, FFP = fresh frozen plasma, PLT = platelets, MT = massive transfusion, CAT = critical administration threshold

Table 3 Performance of bleeding risk scores among 331 trauma patients

Outcome	Model	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
10 units PRBC in first 24 h (MT+)	ABC Score ≥ 2	54.3% (38.2–69.5)	77.0% (71.9–81.5)	21.8% (14.5–31.6)	93.4% (89.6–95.9)	0.68 (0.59–0.77)
	TASH Score ≥ 16	14.3% (6.3–29.4)	98.3% (96.1–99.3)	50.0% (23.7–76.3)	90.7% (87.0–93.4)	0.82 (0.82–0.85)
	Shock Index ≥ 1	68.2% (51.6–83.3)	74.4% (69.3–79.3)	24.1% (16.0-32.7)	95.3% (92.4–97.8)	0.74 (0.63–0.84)
5 units PRBC in any 4 h in first 24 h (MT+)	ABC Score ≥ 2	48.4% (36.6–60.4)	79.0% (73.7–83.5)	35.6% (26.4–46.1)	86.5% (81.6–90.2)	0.66 (0.66–0.68)
	TASH Score ≥ 16	9.4% (4.4–19.0)	98.5% (96.2–99.4)	60.0% (31.3–83.2)	81.9% (77.4–85.8)	0.79 (0.80–0.83)
	Shock Index ≥ 1	63.4% (50.9–75.4)	77.6% (72.6–82.5)	40.0% (30.3–50.0)	90.0% (86.0–93.6)	0.74 (0.66–0.81)
3 units PRBC in any 1 h in first 24 h (CAT+)	ABC Score ≥ 2	50.0% (40.4–59.6)	84.0% (78.7–88.2)	57.5% (47.0–67.3)	79.5% (74.0–84.1)	0.71 (0.68–0.73)
	TASH Score ≥ 16	9.0% (4.8–16.2)	99.6% (97.6–99.9)	90.0% (59.6–98.2)	71.7% (66.5–76.3)	0.79 (0.78–0.79)
	Shock Index ≥ 1	57.0% (47.3–66.7)	81.4% (76.2–86.3)	57.0% (47.2–67.0)	81.3% (76.1–86.3)	0.74 (0.68–0.80)
Need for Hemostatic Intervention (Any)	ABC Score ≥ 2	55.9% (45.8–65.6)	85.3% (80.2–89.2)	59.8% (49.3–69.4)	83.2% (78.0–87.4)	0.76 (0.73–0.79)
	TASH Score ≥ 16	5.4% (2.3–12.0)	97.9% (95.2–99.1)	50.0% (23.7–76.3)	72.6% (67.5–77.2)	0.68 (0.66–0.69)
	Shock Index ≥ 1	40.5% (31.1–50.0)	74.7% (68.6–80.4)	43.0% (33.0–52.9)	72.7% (66.8–78.4)	0.60 (0.53–0.66)
Hemorrhage-Related Mortality	ABC Score ≥ 2	50.0% (26.8–73.2)	74.8% (69.7–79.2)	8.0% (4.0–15.7)	97.1% (94.2–98.6)	0.68 (0.55–0.80)
	TASH Score ≥ 16	21.4% (7.6–47.6)	97.8% (95.5–98.9)	30.0% (10.8–60.3)	96.6% (94.0–98.1)	0.74 (0.59–0.88)
	Shock Index ≥ 1	71.4% (45.4–88.3)	71.6% (66.4–76.3)	10.0% (5.5–17.4)	98.3% (95.6–99.3)	0.72 (0.53–0.88)

CI = confidence interval, TASH = Trauma Associated Hemorrhage, ABC = Assessment of Blood Consumption, PRBC = packed red blood cells, AUC = area under the curve, PPV = positive predictive value, NPV = negative predictive value

activations, results mirrored the main cohort; prehospital activations were underpowered for transfusion outcomes but again showed ABC best for hemostatic intervention. By injury severity, TASH discrimination improved in higher ISS groups, but overall conclusions remained consistent. When components were counted equally (PRBC + FFP + PLT), event prevalence increased (e.g., MT-10 from 10.6% to 19.6%), but the performance pattern was preserved: TASH had the highest discrimination with very high specificity and low sensitivity; SI and ABC showed more balanced sensitivity/specificity with lower AUCs.

Discussion

In this study, we evaluated the performance of three commonly used clinical prediction tools – the ABC score, the TASH score, and the shock index across a range of bleeding-related outcomes in trauma. While none of the three tools demonstrated strong overall discrimination – particularly for time-sensitive endpoints such as the CAT, the need for hemostatic intervention, and hemorrhage-related mortality, their limitations varied. The TASH score offered the highest specificity, especially for massive transfusion thresholds, but consistently showed poor sensitivity. The ABC score provided only modest, threshold-dependent discrimination. The shock index (≥ 1.0), while commonly used at the bedside, demonstrated fair discrimination for major transfusion thresholds (AUC ~ 0.74) but remained limited for predicting hemostatic intervention (AUC 0.60).

An important consideration is the potential for spectrum bias, whereby test performance may vary across different patient subgroups or case-mixes [30, 31]. Because our primary analysis was restricted to MHP activations, the observed operating characteristics could differ in broader trauma populations. To explore this, we performed post hoc sensitivity analyses by mechanism, activation context, and injury severity. The subgroup results echoed the main analysis – TASH discriminated best for transfusion thresholds but missed many cases, ABC was most useful for identifying those requiring hemostatic intervention, and SI provided only limited value. This stability across case-mix supports the robustness of our conclusions despite the potential for spectrum bias.

These findings underscore the well-established limitations of existing bleeding scores. The ABC and SI rely on a narrow set of clinical parameters and omit key data that influence early bleeding management, such as imaging and laboratory values. While the TASH score is more comprehensive [17], it includes variables that may not be available during the early phases of resuscitation (such as injury severity score) and may be poorly aligned with modern trauma workflows. Critically, all three scores were originally derived and validated using massive transfusion as the primary outcome — a surrogate now recognized to suffer from treatment-based misclassification, survivorship bias, and poor correlation with the actual need for intervention [20–23, 32, 33].

In clinical practice, these limitations may contribute to meaningful delays in care. Clinical gestalt alone has limited sensitivity in identifying patients requiring hemostatic intervention [32], and previous work has shown that prolonged delays are common among bleeding trauma patients [11, 14]. Our international survey of trauma care providers similarly identified clinical uncertainty and lack of reliable early tools as major barriers to timely hemorrhage control [6]. The present study confirms that existing scores do not sufficiently address these challenges and may contribute to both under-triage and overuse of blood products.

In our cohort, the median time from hospital arrival to in-hospital MHP activation was 20 min (IQR 13–42), and the median time to first PRBC transfusion was 19 min overall; among those with MHP activation, the median time to first PRBC was 18 min. While this approximates the delivery benchmarks observed in the PROPPR trial sub-analysis by Meyer et al., delays of even a few minutes may be clinically meaningful. In that study, the median time from MTP activation to cooler arrival was 8 min, and each additional minute of delay was independently associated with a 5% increase in the odds of mortality at both 24 h and 30 days (OR 1.05; $p = 0.035$ and 0.016, respectively) [34]. These findings underscore how institutional logistics—such as differences in blood bank location, protocol activation procedures, and transport processes —can prolong access to transfusion and compound early clinical uncertainty. Prediction tools must be interpreted within these system constraints, which may contribute to their real-world performance limitations.

Strengths and limitations

This study has several notable strengths. It includes a well-defined cohort from a lead regional trauma center with comprehensive clinical, physiologic, and transfusion data. Outcomes were rigorously defined, capturing a range of bleeding endpoints beyond massive transfusion alone, including time-sensitive metrics such as the CAT and hemorrhage-related mortality. In addition, we assessed score performance using both discrimination and calibration, providing a more complete picture of clinical utility.

However, some limitations must be acknowledged. First, our cohort was restricted to patients with MHP activation, which increases the prevalence of major hemorrhage and introduces important selection bias relative to the broader trauma population. At our institution, MHP activation is based primarily on clinical gestalt at the discretion of the trauma team leader or the initial

responding emergency physician. This case-mix enrichment raises the potential for spectrum bias, whereby test performance may vary across different patient subgroups. To address this, we conducted post hoc sensitivity analyses stratified by mechanism, activation context, and injury severity, which showed that the overall pattern of score performance was preserved across subgroups. Nevertheless, these analyses were exploratory and should be interpreted cautiously. Excluding traumatic OHCA may omit a subset of severely bleeding patients; however, as with the original ABC and TASH derivations, complete physiologic and laboratory inputs are rarely available in this group. This remains a potential limitation. In addition, the single-center retrospective design may limit generalizability. While we attempted to align outcomes with clinical practice definitions, adjudication of hemorrhage-related mortality required subjective judgment and is vulnerable to misclassification bias. Finally, although we evaluated widely validated thresholds, alternate cut-points or recalibrated versions might yield different performance, and the tools' original derivation for massive transfusion prediction may inherently limit validity when applied to broader outcomes.

Clinical implications

Our findings, which demonstrate poor-to-moderate performance of the ABC score, TASH score, and SI for predicting actionable bleeding outcomes, are consistent with limitations identified in the trauma literature. Our findings align with Motameni et al., who demonstrated that while the ABC criteria prompt earlier massive transfusion protocol activation, only one-third of activations were associated with actual high-volume transfusion (defined as >5 PRBC units in 24 h), and frequent product wastage occurred when compared with clinician judgment [35]. Similarly, Wangoo et al. found that in an Australian trauma setting, commonly used prediction tools (including the ABC score) had suboptimal performance and should "be applied cautiously and used only in combination with on-going clinical judgement" to avoid misallocation of resources [36]. Tools such as the ABC score and the SI are easy to calculate at the bedside but lack sufficient accuracy, while the TASH score, though more predictive for massive transfusion, is much more comprehensive and less practical to implement at the bedside in acute settings.

Importantly, score performance varied across different outcome definitions, reinforcing that predictive tools must be aligned with clinically actionable endpoints [34]. Outcomes such as the CAT and hemostatic intervention offer more immediate relevance for decision-making. Prediction tools should be prospectively validated using these outcomes and designed for integration into trauma workflows. This shift is supported by trauma system benchmarking initiatives such as the Trauma Quality Improvement Program, which now emphasize timely hemorrhage control, time-to-blood-product delivery, and early procedural intervention over aggregate transfusion volume as performance indicators [37].

Conclusion

Existing bleeding scores demonstrate suboptimal performance across a range of clinically relevant outcomes in trauma. These findings challenge the continued reliance on massive transfusion as a surrogate for intervention needs and highlight the importance of developing new tools aligned with real-time clinical decisions. Future efforts should focus on developing and validating decision tools that support timely, evidence-based activation of hemorrhage protocols and improve outcomes for bleeding trauma patients.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13049-025-01499-9.

Supplementary Material 1

Author contributions

AT, TL, MC and CV conceived the study. AT, MC, CL and CV supervised the conduct of the study and data collection. AT and MC conducted data cleaning and analysis. AT drafted the manuscript and all authors contributed substantially to its revision. AT takes responsibility for the paper as a whole.

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Data availability

Partial or complete datasets and data dictionary are available upon reasonable request to Dr. Alexandre Tran (aletran@toh.ca).

Declarations

Competing interests

The authors declare no competing interests.

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