Getting out of the bay faster: Assessing trauma team performance using trauma video review

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BACKGROUND: Minutes matter for trauma patients in hemorrhagic shock. How trauma team function impacts time to the next phase of care has not been rigorously evaluated. We hypothesized better team performance scores to be associated with decreased time to the next phase of trauma care.

METHODS: This retrospective secondary analysis of a prospective multicenter observational study included hypotensive trauma patients at 19 centers. Using trauma video review, we analyzed team performance with the validated Non-Technical Skills for Trauma scale: leadership, cooperation and resource management, communication, assessment/decision making, and situational awareness. The primary outcome was minutes from patient arrival to next phase of care; deaths in the bay were excluded. Secondary outcomes included time to initiation and completion of first unit of blood and inpatient mortality. Associations between team dynamics and outcomes were assessed with a linear mixed-effects model adjusting for Injury Severity Score, mechanism, initial blood pressure and heart rate, number of team members, and trauma team lead training level and sex.

RESULTS: A total of 441 patients were included. The median Injury Severity Score was 22 (interquartile range, 10–34), and most (61%) sustained blunt trauma. The median time to next phase of care was 23.5 minutes (interquartile range, 17–35 minutes). Better leadership, communication, assessment/decision making, and situational awareness scores were associated with faster times to next phase of care (all $p < 0.05$). Each 1-point worsening in the Non-Technical Skills for Trauma scale score (scale, 5–15) was associated with 1.6 minutes more in the bay. The median resuscitation team size was 12 (interquartile range, 10–15), and larger teams were slower ($p < 0.05$). Better situational awareness was associated with faster completion of first unit of blood by 4 to 5 minutes ($p < 0.05$).

CONCLUSION: Better team performance is associated with faster transitions to next phase of care in hypotensive trauma patients, and larger teams are slower. Trauma team training should focus on optimizing team performance to facilitate faster hemorrhage control. (*J Trauma Acute Care Surg.* 2024;96: 76–84. Copyright © 2023 American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCE: Therapeutic/Care Management; Level III.

KEY WORDS: Trauma video review; teamwork; nontechnical skills; resuscitation; hemorrhagic shock.

Time to hemorrhage control is a key benchmark for trauma patients presenting in hemorrhagic shock.[1,2] Trauma team performance has been shown to impact patient outcomes and has been evaluated in prior work using the modified Non-Technical Skills for Trauma (T-NOTECHS) instrument, a validated tool analyzing five domains: leadership, cooperation and resource management, communication, assessment and decision making, and situation awareness.[3–6] However, how team performance impacts the time required to move to the next phase of care and resuscitation efficiency has not yet been rigorously evaluated.

Trauma video review (TVR) has been used for quality improvement since the 1960s, and it has been found to be more effective than verbal feedback when used as an educational and performance improvement tool.[7–9] Trauma video review is a powerful technology with a rapidly expanding role in improving communication, medical decision making, and team leadership. Trauma video review has been recently shown to be superior to real-time prospective data collection.[10]

Using a retrospective secondary analysis of a prospective multicenter TVR database, we aimed to analyze the association of elements of trauma team performance as measured by T-NOTECHS with resuscitation efficiency in patients presenting in hemorrhagic shock, controlling for patient instability and severity of injury. We hypothesized that better performance scores would be associated with decreased time to the next phase of care.

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PATIENTS AND METHODS

Study Procedures

Nineteen trauma centers participated in a multicenter, prospective observational study sponsored by the Eastern Association for the Surgery of Trauma, as previously described.[11] Each included institution had an established, functional TVR program before the start of the study to permit real-time audiovisual recording of trauma resuscitations and granular data capture.[9] Video capture and management were per institutional protocol at each included trauma center. Recorded videos were evaluated between May 2021 and May 2022 by one to three trained individuals from each center, as previously described.[11] The EQUATOR STrengthening the Reporting of OBservational studies in Epidemiology reporting guidelines were followed (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/D314).[12] Institutional review board approval was obtained from each participating center. Before study initiation, two comprehensive training sessions occurred with all trauma centers to standardize definitions and to ensure accurate and consistent data capture.

Data were electronically submitted from study sites using REDCap, a secure web application for building and managing online surveys and databases. Using abstractions of audiovisual recordings of trauma resuscitations, we collected patient level resuscitation metrics and team dynamics. We also collected provider-level variables including provider discipline (e.g., physician, nurse) as well as training level (resident, fellow, or attending) and sex for physician providers. Additional injury-specific variables including Injury Severity Score (ISS), demographic information (age, sex, race), outcome variables, and other information not available on video review were obtained from the electronic medical record.

Study Population

Inclusion criteria were adult (16 years or older) trauma patients with an initial systolic blood pressure (SBP) <90 mm Hg or any episode of SBP <90 mm Hg within the first 5 minutes of emergency department presentation. We excluded patients who died in the trauma bay and patients with incomplete recording of any T-NOTECHS team performance variables.

Definitions

We analyzed team performance using the modified T-NOTECHS scale in five domains: leadership, cooperation and resource management, communication, assessment/decision making, and situational awareness (Fig. 1). Each domain ranged from 1 to 3 with "1" representing the best score. The primary independent variable of interest was the T-NOTECHS overall score (range, 5–15; 5 represents the best possible resuscitation) and individual five subdomains of team skills. The primary outcome was the time in minutes from patient arrival in the trauma bay to patient transition to next phase of care (e.g., operating room, interventional radiology, computed tomography scanner), defined on video review as "wheels in" to "wheels out." More specifically, this was defined as visualization of the emergency medical services stretcher entering the room to last visualization of the ED gurney on camera exiting the room.

Secondary outcomes included time to initiation of the first unit of blood (as defined by time from "wheels in" to time that blood was visualized in the tubing), time to completion of the first unit of blood (as defined by "wheels in" to time of verbal report of transfusion complete and/or disconnection of the blood tubing), and inpatient mortality. Additional factors considered in multivariable analyses included the number of team members involved in the trauma resuscitation, the trauma team lead (TTL) training level, TTL sex, study site, patient ISS, patient initial SBP, patient initial heart rate (HR), and mechanism of injury (blunt vs. penetrating).

Statistical Analysis

The unadjusted association between the total T-NOTECHS score and time to next phase of care was assessed with Spearman's correlation. Wilcoxon rank-sum tests were used to compare time to next phase of care and number of trauma team members between those with a total T-NOTECHS score equal to 5 versus those with a higher score. Next, associations between team dynamics and outcomes were assessed with a linear mixed-effects model adjusting for ISS, injury mechanism, initial SBP and HR,

Leadership	**1-** team leader clearly recognizable at all times, "birds eye" view with delegation, transitions of leadership clear, assigns roles, excellent team management
	2- team leader defined but does not fill all functions or does procedures meant for others or transitions unclear
	3- team leader not clear
Cooperation and resource management	**1-** all team members clearly identified, speak up if help needed, no team members are idle
	2- role identity of all members not clear, some team members idle some of the time
	3- role identity of most members not clear, most team members idle most of the time
Communication	**1-** team leader is the hub, all critical communication through the team leader, all orders to team leader, EMS provides handoff, closed loop communication, orders directed to specific people
	2- communication not always through team leader, orders not always acknowledged
	3- communication frequently inaudible or incoherent, on many levels or simultaneous
Assessment	**1-** primary and secondary survey done in order and without omissions, findings summarized, goals and plan communicated to the team
	2- assessment somewhat out of order, some elements of secondary survey incomplete
	3- elements of the primary survey incomplete, multiple team members unclear about the next step
Situational awareness	**1-** untoward findings, distractions or change in patient condition did not disrupt systematic and orderly evaluation and treatment, team is calm, teams plan ahead, awareness of team members emotional condition (anxiety/stress)
	2- untoward findings cause minor delay but did not preclude task completion
	3- unforeseen events disrupt patient assessment and treatment, team members stressed or panicky, lack of anticipation of next steps

Figure 1. Modified T-NOTECHS scale. Modified T-NOTECHS score, ranges from 5 to 15. EMS, emergency medical services.

number of resuscitation team members, and TTL training level and sex. Study site was treated as a random-effect factor to account for any correlation in patient outcomes within individual trauma centers.

We modeled T-NOTECHS as a continuous variable[5–15] and T-NOTECHS scores for each component as categorical variables (i.e., 1, 2, 3). For our primary analysis, we conducted a complete case analysis because of being unable to meet the assumption that the missing covariate data were missing at random. To validate our results, a sensitivity analysis was performed by excluding SBP and HR as covariates from the models, as these variables had considerable percentages of missingness. In addition, a priori subset analyses limited to patients with penetrating thoracoabdominal injuries and patients who went directly from the trauma bay to the operating room (OR) or interventional radiology was conducted. We defined statistical significance as $p < 0.05$. p Values were not corrected for multiple testing. R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) was used for all statistical analyses.

RESULTS

Unadjusted Analyses

Of the n = 581 patients in the original study, n = 127 were excluded because of death in the trauma bay, and n = 13 were excluded because of missing T-NOTECHS variables. A total of 441 patients met the inclusion criteria for this secondary analysis. The patients included had a median age of 42.4 years (interquartile range Q1/Q3, 29/61 years), and 71.9% were male. Mechanism was penetrating in 39.0% of patients and penetrating to the torso in 26.3%. Virtually, all patients presented in shock with an initial median SBP of 78 mm Hg (interquartile range Q1/Q3, 68/85 mm Hg), a median HR of 96 beats per minute (interquartile range Q1/Q3, 78/121 beats per minute), and a median ISS of 22 (interquartile range Q1/Q3, 10/34). Overall inpatient mortality was 29.3% (patients who died in the trauma bay were excluded from this study). A minority of patients (117 [26.5%]) went directly from the trauma bay to the OR for hemorrhage control, and three patients went directly to interventional radiology. Patient characteristics and presenting hemodynamics did not differ in a clinically meaningful way between groups of different levels of trauma team performance as measured by T-NOTECHS (Table 1).

Trauma team performance was excellent (T-NOTECHS, 5) in 47.4% of cases, good (T-NOTECHS, 6–10) in 43.1% of cases, and poor (T-NOTECHS, 11–15) in 9.5% of cases (Table 2). Resuscitation team size varied largely by institution, with a median of 12 (interquartile range Q1/Q3, 10/15) team members across all sites. Patient resuscitations with the best team performance had fewer team members at a median of 10 (interquartile range Q1/Q3, 9/13). The number of team members did not differ between the "good" and "poor" teams, but the number was significantly lower in the "best" category based on the Kruskal-Wallis test ($p < 0.0001$). The TTL was male in 57.1% of cases, and most frequently, this role was assumed by an attending (43.1%) or resident (40.8%), less commonly a fellow (12%) or advanced practice provider (0.5%). Female TTLs were more likely to be trainees (residents or fellows) than male TTLs (64.8% vs. 48.4% of male TTLs, $p = 0.0035$).

The median time in the trauma bay prior to transfer to next phrase of care was 23.5 minutes (interquartile range Q1/Q3, 17/35 minutes); for this study, we did not collect data on the number of type of procedures done in the bay during that time (Table 3). The unadjusted time to next phase of care was fastest in the best performing teams at 20.7 minutes (interquartile range Q1/Q3, 16.0/28.7 minutes). The median time to transfusion initiation was 6.5 minutes (interquartile range Q1/Q3, 4.9/8.5 minutes) and that to transfusion completion was 12.5 minutes (interquartile range Q1/Q3, 9.6/16.0 minutes). These unadjusted measures did not differ in clinically meaningful ways by T-NOTECHS team performance scores. The correlation between resuscitation times and team performance scores was weak at 0.21 (Fig. 2).

Adjusted Analyses: Time to Next Phase of Care

After multivariable adjustment, the better T-NOTECHS team performance scores were independently associated with faster time to the next phase of care (Fig. 3). Each 1-point worsening in the T-NOTECHS score (scale, 5–15) was associated with 1.6 minutes more in the bay ($p = 0.0384$). Better leadership, communication, assessment/decision making, and situational awareness subset scores were also all independently associated with faster times to next phase of care (all $p < 0.05$). Larger trauma teams were also slower ($p < 0.05$). Blunt resuscitations were more than 8 minutes longer.

Adjusted Analyses: Inpatient Mortality

The study group had an overall inpatient mortality of 29.3%. Neither the overall T-NOTECHS team performance score nor any of the individual T-NOTECHS subset scores were found to be associated with inpatient mortality. Only ISS and initial HR showed significant associations with inpatient

TABLE 1. Patient Characteristics

Variable	Best Team Performance T-NOTECHS 5 (n = 209)	Good Team Performance T-NOTECHS 6–10 (n = 190)	Poor Team Performance T-NOTECHS 11–15 (n = 42)	Overall Population (N = 441)
Age	44 [29–60]	42 [28.8–63.2]	42 [30–54]	42.4 [29–61]
Male sex, n (%)	147 (70.3)	141 (74.2)	29 (69)	317 (71.9)
ISS	22 [10–34]	20 [10–33]	22 [10–34]	22 [10–34]
Initial SBP	78 [70–85.8]	79 [67–85]	76.5 [59.8–83.2]	78 [68–85]
Initial HR	100 [80–122]	91 [74–121]	91 [77.5–115]	96 [78–121]
Penetrating mechanism, n (%)	84 (40.2)	70 (36.8)	18 (42.9)	172 (39)
Penetrating injury thoracoabdominal, n (%)	60 (28.7)	43 (22.5)	13 (31.0)	116 (26.3)

Data are median [interquartile range] unless otherwise noted.

TABLE 2. Trauma Team Characteristics and T-NOTECHS Team Performance Scores

Variable	Best Team Performance T-NOTECHS 5 (n = 209)	Good Team Performance T-NOTECHS 6–10 (n = 190)	Poor Team Performance T-NOTECHS 11–15 (n = 42)	Overall Population (N = 441)
Total T-NOTECHS, median [IQR]	5 [5–5]	7 [6–9]	12 [11–13]	6 [5–8]
Leadership				
1	209 (100)	91 (47.9)	2 (4.8)	302 (68.5)
2	0 (0)	93 (48.9)	17 (40.5)	110 (24.9)
3	0 (0)	6 (3.2)	23 (54.8)	29 (6.6)
Cooperation and resource management				
1	209 (100)	74 (38.9)	1 (2.4)	284 (64.4)
2	0 (0)	116 (61.1)	21 (50)	137 (31.1)
3	0 (0)	0 (0)	20 (47.6)	20 (4.5)
Communication				
1	209 (100)	70 (36.8)	0 (0)	279 (63.3)
2	0 (0)	112 (58.9)	16 (38.1)	128 (29.0)
3	0 (0)	8 (4.2)	26 (61.9)	34 (7.7)
Assessment				
1	209 (100)	111 (58.4)	6 (14.3)	326 (73.9)
2	0 (0)	78 (41.1)	22 (52.4)	100 (22.7)
3	0 (0)	1 (0.5)	14 (33.3)	15 (3.4)
Situational awareness				
1	209 (100)	122 (64.2)	2 (4.8)	333 (75.5)
2	0 (0)	66 (34.7)	21 (50.0)	87 (19.7)
3	0 (0)	2 (1.1)	19 (45.2)	21 (4.8)
Number of trauma team members, median [IQR]	10 [9–13]	13 [10–16]	13.5 [11–16]	12 [10–15]
TTL training level				
Resident	74 (35.4)	89 (46.8)	17 (40.5)	180 (40.8)
Fellow	38 (18.2)	13 (6.8)	2 (4.8)	53 (12.0)
Attending	86 (41.1)	83 (43.7)	21 (50.0)	190 (43.1)
APP/other	2 (1.0)	1 (0.5)	2 (4.8)	5 (1.2)
TTL sex male	122 (58.4)	103 (54.2)	27 (64.3)	252 (57.1)

Date are n (%) unless otherwise stated.
Lower indicates better performance.
IQR, interquartile range.

mortality (Supplemental Digital Content, Supplementary Fig. 1, http://links.lww.com/TA/D335).

Adjusted Analyses: Time to Transfusion Initiation and Completion

Neither the overall T-NOTECHS team performance score nor any of the individual T-NOTECHS subset scores predicted time to transfusion initiation. A better situational awareness score was associated with faster completion of the first unit of blood product by 4 to 5 minutes on multivariate modeling ($p = 0.0007$). A better communication score was also marginally associated with faster completion of transfusion of the first unit ($p = 0.0650$ for communication score of 2:1 and 0.0349 for communication score 3:1).

Female TTL sex was associated with a slower time to transfusion initiation (Supplemental Digital Content, Supplementary Fig. 2, http://links.lww.com/TA/D335), but no difference in time to completion of transfusion of the first unit of

TABLE 3. Unadjusted Outcome Measures by T-NOTECHS Team Performance Scores

Variable	Best Team Performance T-NOTECHS 5 (n = 209)	Good Team Performance T-NOTECHS 6–10 (n = 190)	Poor Team Performance T-NOTECHS 11–15 (n = 42)	Overall Population (N = 441)
Time to next phase of care	20.7 [16.0–28.7]	26.5 [19.0–38.3]	27.8 [17.5–43.7]	23.5 [17.0–35.0]
Inpatient death, n (%)	57 (27.3)	58 (30.5)	14 (33.3)	129 (29.3)
Time to transfusion initiation	7.0 [5.0–8.5]	6.2 [4.6–8.6]	7.0 [5.0–8.6]	6.5 [4.9–8.5]
Time to transfusion completion*	12.4 [10.0–15.5]	13.0 [9.1–16.8]	12.0 [9.4–23.1]	12.5 [9.6–16.0]

*Completion of first unit of blood product transfusion.
All times are median [interquartile range] in minutes.
Lower score indicates better team performance.

blood product was detected. As mentioned previously, female TTLs were more likely to be trainees. Although numbers were small, having an advanced practice provider in the TTL role was associated with faster time to transfusion completion.

All findings were consistent in the sensitivity analyses without SBP and HR as covariates and in the subset analysis limited to patients with penetrating torso injuries. In the subset analysis of patients who went directly from the trauma bay to the OR or interventional radiology (n = 82), each 1-point worsening in the T-NOTECHS score was associated with 2.0 minutes more in the bay, although this did not reach statistical significance ($p = 0.0516$) with the smaller sample size.

DISCUSSION

This retrospective subanalysis of a 19-center, prospective, observational Eastern Association for the Surgery of Trauma–sponsored study examined the association of trauma team performance and resuscitation efficiency in hemorrhaging trauma patients using TVR. We found better team performance to be independently associated with faster transitions to the next phase of care in hypotensive trauma patients; each 1-point worsening in the T-NOTECHS team performance score (scale, 5–15) was associated with 1.6 minutes more spent in the trauma bay. Better situational awareness in particular was associated with faster completion of the first unit of blood product by 4 to 5 minutes.

Faster resuscitation and hemorrhage control are intimately linked to improved patient outcomes, particularly for penetrating trauma patients going to the OR.[13–18] In these circumstances, minutes matter. Recent data from trials demonstrate that every minute counts in hemorrhaging trauma patients.[18] Trauma team dynamics and nontechnical abilities, including social, cognitive, and interpersonal skills, are linked to improved efficiency and play a central role in the prevention of critical errors that may lead to morbidity or mortality in trauma team resuscitations.[19–25] This is particularly important given that inpatient mortality in this patient population remains high at nearly 30% despite excluding patients who died in the trauma bay.

Video recordings of trauma resuscitations have been used to teach trauma leadership skills since at least the 1980s.[26] In 2012, the nontechnical skills scale for trauma, T-NOTECHS, was developed to teach and assess teamwork skills of multidisciplinary trauma resuscitation teams by Steinemann et al.[3] This pilot study evaluated the use of T-NOTECHS to determine its reliability and correlation with clinical performance. The T-NOTECHS ratings were completed real time for simulation and live resuscitations as well as via TVR. Reliability was highest (intraclass correlation coefficient, 0.71) for TVR of

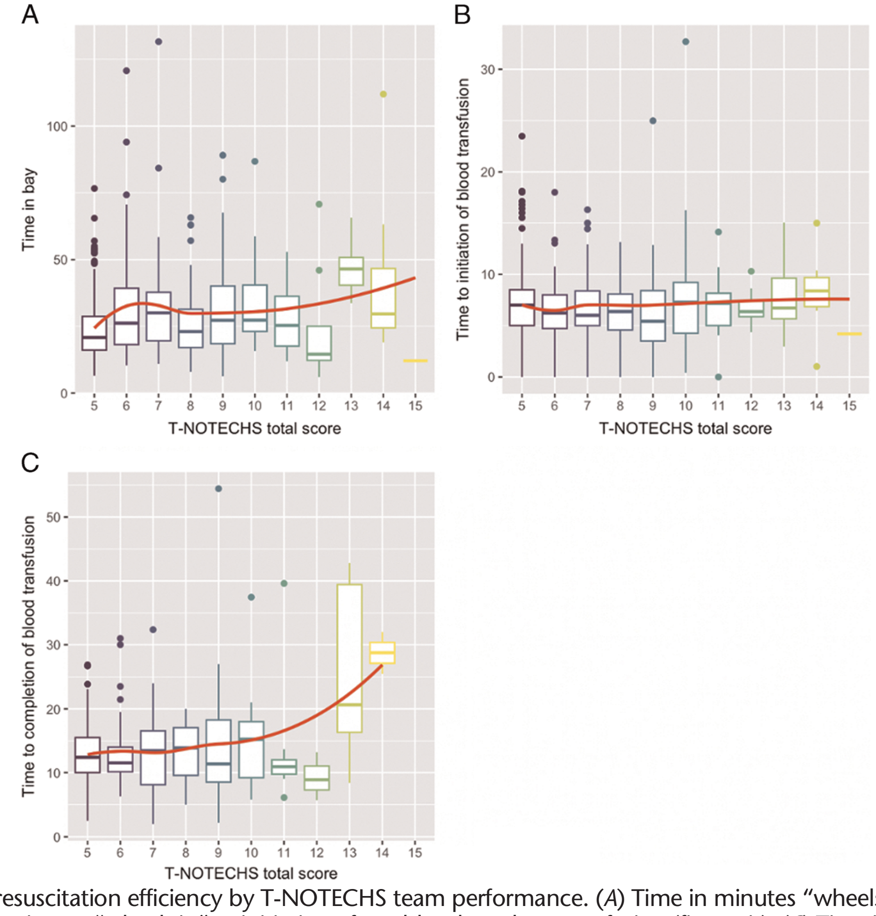

Figure 2. Unadjusted resuscitation efficiency by T-NOTECHS team performance. (*A*) Time in minutes "wheels in" to "wheels out" in trauma bay. (*B*) Time in minutes "wheels in" to initiation of any blood product transfusion (first unit). (*C*) Time in minutes "wheels in" to completion of any blood product transfusion (first unit). Lower indicates better performance.

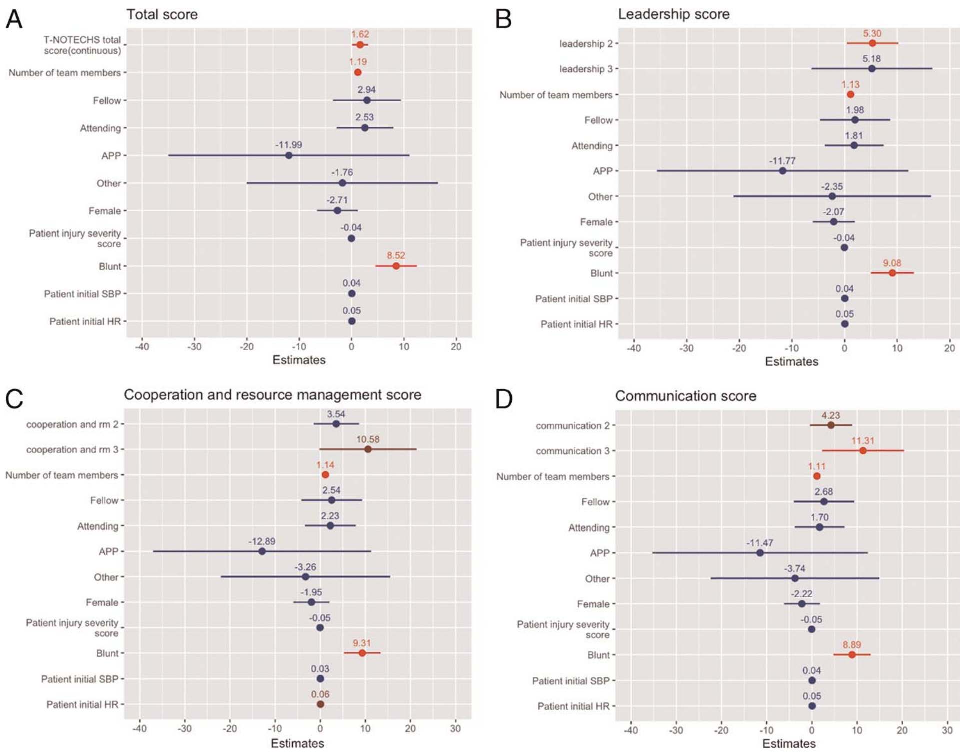

Figure 3. Factors associated with slower time to next phase of care. (*A*) Total T-NOTECHS score. (*B*) Leadership score subset of T-NOTECHS, 1 (best) versus 2 or 3. (*C*) Cooperation and resource management score subset of T-NOTECHS, 1 (best) versus 2 or 3. (*D*) Communication score subset of T-NOTECHS, 1 (best) versus 2 or 3. Red points indicate statistical significance ($p < 0.05$), and dark red points indicate marginal statistical significance ($p < 0.1$) for factors predictive of slower time to next phase of care. Estimates are odds ratios. The Assessment and Situational Awareness score subsets are not shown because of space constraints, but findings were consistent with the others.

resuscitations, and higher T-NOTECHS scores correlated with better clinical performance as defined by faster resuscitations and fewer unreported tasks (both $p < 0.05$).[3] In the first study demonstrating a significant link between trauma team performance and improved clinical resuscitation outcomes, better assessment and decision making scores correlated with improved return of spontaneous circulation rates in patients arriving in cardiac arrest who underwent resuscitative thoracotomy.[6]

Previous studies have similarly found better teamwork and nontechnical performance as measured by T-NOTECHS scores to be associated with more efficient trauma resuscitations.[3,27] In one study, T-NOTECHS scores worse than the median were associated with longer times to patient disposition from the trauma bay (35 vs. 20 minutes) and delays in care regardless of injury severity.[28] Nontechnical skills are challenging during trauma resuscitations; however, they are critical to patient safety and medical care, as demonstrated by quicker transition to the next phase of care. Addressing team and nontechnical skills has the potential to improve patient assessment, treatment, and outcomes.

Trauma team training works.[29–31] In particular, team simulation training focusing on nontechnical skills appears to translate to faster times to actual patient disposition from the trauma bay.[32] In the current study, the first, to our knowledge, to use video review to correlate trauma team dynamics in real resuscitations of hypotensive trauma patients to efficiency in the trauma bay, we found that better team performance was correlated with improved efficiency, similar to prior studies. Given that trauma team training and simulation have been associated with better team performance, there exists a direct link between trauma team training and improved efficiency. If we assume that improved efficiency in the trauma bay is correlated with faster hemorrhage control (not measured in the current study), then trauma team training may ultimately lead to faster hemorrhage control and ultimately improved patient outcomes.

Another key finding of our study was that larger trauma teams were slower. The presence of too many team members can lead to a chaotic environment and impede the efficiency of communication and key tasks in trauma resuscitations.[33,34] Larger teams in the operating room, the prehospital setting, and in other nonmedical disciplines have been shown to negatively affect team performance.[35–38] Our findings contrast with those of a single-center trauma hospital that reported increased efficiency with larger team size (also using TVR), but their maximum team size was nine, whereas our sample included much larger teams, with a median of 12 members.[34]

Our unexpected finding that female team leaders had slower times to transfusion initiation can be explained in a couple of different ways. First, it is possible that female leaders are indeed slower to pull the trigger to order blood products in the trauma bay. The female TTLs in our study were more likely to be trainees, so it is possible that trainee TTLs are slower to initiate an order for transfusion. Because we collected the time of actual transfusion initiation (i.e., blood visualized in the tubing) rather than the time that the blood was ordered by the TTL, we are not able to determine whether there was a differential delay in time to ordering blood product. Second, it is possible that there is a delayed team response to an order to give blood products that originates from a female leader, particularly a female resident or fellow. We have previously demonstrated that communication bias is common in the trauma bay and particularly affects female team leaders.[39,40] More work remains to be done in this area.

It is also important to note that the median time in the trauma bay for all centers was 23.5 minutes. While the optimal trauma bay dwell time is unknown, previous work has evaluated the association between time to hemorrhage control and outcomes. In a study using the American College of Surgeons Trauma Quality Improvement Program data of patients in hemorrhagic shock requiring laparotomy for gunshot wounds, the overall 75th percentile median time to OR (which includes time in the trauma bay) was 48 minutes.[17] Interestingly, there was no association between fast centers, defined as median time to the OR shorter than lower limit of 95th percentile for all centers, and major outcomes including mortality. Harvin et al.[14] evaluated mortality rates of patients undergoing emergent trauma laparotomy and found that the median time in the emergency department was 24 minutes, with an overall 21% mortality, similar to our findings. Other studies have shown that mortality in hypotensive trauma patients increases with time spent in the emergency department, with one group finding increased mortality in patients with penetrating torso injuries with delays to the operating room of more than 10 minutes.[15,16] This cutoff is above the median time spent in the emergency department in the many studies, including ours (albeit with slightly different patient populations), suggesting that there may be ongoing room for improvement in trauma bay efficiency even in high-volume, high-performing centers. Further work is required to better define these optimal times.

This study does have several limitations. This was a secondary analysis without an a priori power analysis, and we were likely underpowered for the secondary outcome of mortality. We measured time to the next phase of care but did not incorporate the number and type of procedures done in the trauma bay that could have delayed disposition, including temporary hemorrhage control procedures. We collected information on the sex and training level of the trauma team leader but not on the presence of a trauma attending in the trainee-led resuscitations. We did not collect information on surgery versus emergency medicine TTLs. Our conclusions assume that faster disposition from the bay leads to faster hemorrhage control, which we did not measure directly. As it was an observational study, by nature, it cannot determine causality or make definitive conclusions. As with all observational studies, residual or unmeasured confounding cannot be fully excluded. There is the possibility of confounding by indication, meaning that teams preparing for sicker patients may be more likely to have done a prearrival timeout, to function better and to move through the resuscitation quicker. It is also possible that, when trauma resuscitations are slower because of other factors, this impacts trauma team dynamics in a reverse causality direction. In addition, video reviewers were not blinded to the study site, trauma team composition, or patient outcomes, which may have introduced bias. Variability between sites and reviewers may have also affected our findings, despite training sessions to ensure accurate and consistent data capture across sites. Because trauma centers with TVR capabilities may differ from trauma centers without TVR in important ways, the generalizability of our findings to trauma centers without active TVR programs is unknown at present.

In conclusion, we found better trauma team performance to be associated with faster transitions to the next phase of care in hypotensive trauma patients, and larger teams were slower. This is the first study, to our knowledge, looking specifically at team dynamics and time to care in unstable patients requiring hemorrhage control. Trauma team training should focus on optimizing team performance toward more efficient resuscitations by training skills as measured by T-NOTECHS.

AUTHORSHIP

A.W.M., M.A.V., R.D.A., and R.P.D. designed the study. A.W.M., M.A.V., R.P.D., and the TVRC investigators did the data collection. R.I. and F.Y. did the data analysis. A.W.M., M.A.V., and R.D.A. did the writing. All authors participated in data interpretation and critical revision of the manuscript.

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DISCLOSURE

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