A Survey of Tranexamic Acid Use by US Tactical Emergency Medical Support Providers

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ABSTRACT

Background: Tactical Emergency Medical Support (TEMS) providers may encounter severe traumatic injuries, with associated hemorrhagic shock, coagulopathy, and hyperfibrinolysis. Tranexamic acid (TXA) administration represents a potential intervention in this operational environment. This study evaluated TXA availability and use among US tactical medical personnel supporting law enforcement tactical teams. **Methods:** An anonymous on-line survey of the American College of Emergency Physicians (ACEP) Tactical Emergency Medicine (TEM) section was administered. **Results:** Fifty respondents were included in the final study. Fifty-four percent reported TXA availability, with 14% reporting its use at least once in the past year. Additional available resuscitative products included crystalloids (88%) and packed red blood cells (6%). Twenty-five respondents reported managing ≥ 1 patient(s) with hemorrhagic shock in the past year. Resuscitative measures included crystalloids (96%), TXA (68%), and blood products (16%). Overall, 88% of respondents were supportive of TXA use. Full-time teams, those with ≥ 3 monthly callouts, and teams that carried blood products were more likely to have TXA. **Conclusions:** Half of respondents reported managing a patient with hemorrhagic shock in the past year. Although 88% were supportive of TXA use, only 54% reported availability. Tactical teams with higher call volume and more resources were more likely to carry TXA. Further studies evaluating TEMS patient wounding patterns and barriers to TXA utilization are required.

KEYWORDS: *TXA; TEMS; Tactical EMS; tranexamic acid; operational medicine; trauma-induced coagulopathy*

Introduction

Traumatic injuries are commonly encountered during tactical law enforcement operations. Hemorrhagic shock is a leading cause of early, potentially preventable death after trauma. Although civilian and military high-threat environments may have different wounding patterns, military data suggest that more than 90% of potentially survivable casualties die from hemorrhage.[1] Beyond the capabilities of both conventional emergency medical services (EMS) assets staged in the cold zone and law enforcement tactical first aid, integrated tactical medicine operational programs containing TEMS personnel may provide rapid advanced life-saving interventions in the high-threat environment.[2–7]

Trauma-induced coagulopathy (TIC) and hyperfibrinolysis are critical components of hemorrhagic shock that require careful management during resuscitation.[8,9] Existing evidence suggests that up to 15% of trauma patients may be in a state of hyperfibrinolysis at the scene of injury and that more than half may be in a state of moderate to severe fibrinolysis upon arrival to the hospital.[10] TXA, a powerful antifibrinolytic that inhibits plasmin breakdown of fibrin and saturates lysine-binding sites on plasminogen, prevents the conversion of plasminogen to plasmin, and can maintain stable fibrin clot formation by protecting fibrinogen stores.[8,11] Prior literature in military and civilian settings demonstrates both that TXA is most efficacious when given early after injury in patients for whom TXA is indicated and that early treatment of acute coagulopathies and hemorrhagic shock considerably minimizes posttraumatic deaths.[9,10,12–14]

Current military Committee on Tactical Combat Casualty Care (CoTCCC) and civilian Committee on Tactical Emergency Casualty Care (C-TECC) guidelines include the use of TXA within 3 hours of traumatic injury in patients in whom a blood transfusion is anticipated.[15,16] Despite this recommendation, military data suggest low administration rates among eligible patients in combat.[17,18] Although prior research has demonstrated benefits in civilian prehospital and combat settings, there is a paucity of literature examining adherence to C-TECC guidelines and TXA use in the civilian TEMS operational setting. The purpose of the current study was to evaluate TXA availability among US tactical medicine operational programs containing integrated tactical medical personnel.

Methods

Study Design and Setting

An anonymous online survey was administered to the ACEP TEM section.

Study data were collected and managed using REDCap electronic data capture tools hosted at Mayo Clinic.[19,20] REDCap (https://www.project-redcap.org/) is a secure, web-based software platform designed to support data capture for research

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studies, providing (1) an intuitive interface for validated data capture, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for data integration and interoperability with external sources.

An initial survey email was sent on 1 May 2020, with two reminder emails sent prior to survey conclusion on 30 June 2020. The study was reviewed by the Mayo Clinic Institutional Review Board and deemed exempt.

Survey

The survey was developed de novo by the authors, based on current operational guidelines for TXA and blood product administration, with some demographic categories adapted from the Federal Bureau of Investigations Law Enforcement Officers Killed and Assaulted (LEOKA) program.[21] It consisted of 19 multiple-choice items and one Likert-type question. Risk for hemorrhagic shock was defined as a patient demonstrating significant hemorrhage or considered at risk for significant hemorrhage (hypotension: systolic blood pressure [SBP] < 90 mmHg, or tachycardia: heart rate [HR] >110 bpm). Resuscitative products include crystalloids, colloids, packed red blood cells (pRBCs), plasma products, platelets, or whole blood. Administration of products specifically involved use during a tactical operation, as opposed to during training. A 1–5 Likert scale ("not supportive" to "extremely supportive") was used to measure participants' overall level of support for the use of TXA in the prehospital setting.

Demographic measures were collected, including geographic region, primary tactical team setting and agency type, full-time/part-time tactical team status, average number of TEMS calls/responses per month (excluding training), anticipated time from wounding to arrival at a trauma center, and highest level of TEMS provider attached to the team during operations.

Data Analysis

Survey responses were summarized as frequency counts and percentages. Comparisons of survey responses between groups were performed using Fisher exact tests. All tests were two-sided, with p-values < .05 considered significant. Analysis was performed using R version 3.6.2. (R Core Team, https://www.r-project.org/).[22]

Results

Characteristics of Study Subjects

A total of 51 completed surveys were received. One respondent was from outside the United States and was not included in the final analyses. Table 1 provides a summary of the geographic location of TEMS personnel represented by the survey respondents. Half of respondents (50%) reported a mixed operational setting, while 22% reported urban, 20% suburban, and 8% rural. Reported operational agency types were county (42%), municipal (20%), state (12%), regional (10%), and federal (6%); no respondents indicated military agency. The majority of respondents (74%) indicated a physician as the highest level of medical personnel on their respective TEMS team.

TABLE 1 *Tactical Medicine Operational Program Respondent Demographics*

	Overall (N=50)
Program location	
Midwest USA	17 (34%)
Northeast USA	11 (22%)
South USA	14 (28%)
West USA	8 (16%)
Operational setting	
Rural	4 (8%)
Urban	11 (22%)
Suburban	10 (20%)
Mixed	25 (50%)
Agency type	
Municipal	10 (20%)
County	21 (42%)
Regional	10 (20%)
State	6 (12%)
Federal	3 (6%)
Level of employment	
Part-time	36 (72%)
Full-time	14 (28%)
Highest level of provider	
N-Miss	2
Nurse/flight nurse	2 (4%)
Physician	37 (74%)
Paramedic	9 (18%)
Advanced/critical care paramedic	0 (0%)
Average monthly team calls	
0–2	27 (54%)
3–5	14 (28%)
6–10	5 (10%)
11–20	3 (6%)
>20	1 (2%)
Anticipated time to closest trauma center	
<5 minutes	3 (6%)
6–10 minutes	10 (20%)
11–15 minutes	10 (20%)
16–30 minutes	18 (36%)
31–60 minutes	5 (10%)
>61 minutes	4 (8%)
Support for use of TXA in prehospital setting	
Slightly supportive	3 (6%)
Moderately supportive	3 (6%)
Very supportive	13 (26%)
Extremely supportive	31 (62%)

TXA and Resuscitative Product Availability

Table 2 summarizes availability and utilization of TXA and resuscitative products (e.g., crystalloids, colloids, pRBCs, plasma products, platelets, or whole blood) during tactical operations over the previous year reported by all respondents. Overall, 54% of respondents reported TXA availability, with 8% reporting TXA being used once and 6% reporting its use 2–5 times during the past year. Available resuscitative fluids included crystalloids (88%), pRBCs (6%), colloids (4%), plasma products (4%), and whole blood (4%). Crystalloids were the most frequently reported IV resuscitative measure administered (44%), followed by TXA (14%) and pRBCs (2%).

Twenty-five respondents reported managing ≥1 patient(s) with hemorrhagic shock in the past year. Table 3 summarizes availability and utilization of TXA and resuscitative products

TABLE 2 *Summary of TXA and Resuscitative Product Availability and Utilization (Overall; N = 50)*

	Product Availability		Frequency of Use in Previous Year during Tactical Operations				
	Yes	No	None	Once	2–5 Times	>5 Times	No Response
Crystalloids	44 (88%)	6 (12%)	27 (54%)	13 (26%)	6 (12%)	3 (6%)	1 (2%)
Colloids	2 (4%)	48 (94%)	44 (88%)	0 (0%)	0 (0%)	0 (0%)	6 (12%)
TXA	27 (54%)	23 (45%)	40 (80%)	4 (8%)	3 (6%)	0 (0%)	3 (6%)
pRBCs	3 (6%)	47 (94%)	44 (88%)	0 (0%)	1 (2%)	0 (0%)	5 (10%)
Plasma products	2 (4%)	48 (96%)	45 (90%)	0 (0%)	0 (0%)	0 (0%)	5 (10%)
Platelets	0 (0%)	50 (100%)	45 (90%)	0 (0%)	0 (0%)	0 (0%)	5 (10%)
Whole blood	2 (4%)	48 (96%)	45 (90%)	0 (0%)	0 (0%)	0 (0%)	5 (10%)

TXA = tranexamic acid; pRBC = packed red blood cell.

TABLE 3 *Summary of TXA and Resuscitative Product Availability and Use Among Tactical Medical Operational Programs That Have Managed a Patient With Hemorrhagic Shock* in the Past Year (N=25)*

	Product Availability on TEMS Team		Frequency of Use in Previous Year During Tactical Operations				
	Yes	No	None	Once	2–5 Times	>5 Times	No Response
Crystalloids	24 (96%)	1 (4%)	6 (24%)	11 (44%)	6 (24%)	1 (4%)	1 (4%)
Colloids	2 (8%)	23 (92%)	20 (80%)	0 (0%)	0 (0%)	0 (0%)	5 (20%)
TXA	17 (68%)	8 (32%)	17 (68%)	4 (16%)	2 (8%)	0 (0%)	2 (8%)
pRBCs	3 (12%)	22 (88%)	20 (80%)	0 (0%)	1 (4%)	0 (0%)	4 (16%)
Plasma products	2 (8%)	23 (92%)	21 (84%)	0 (0%)	0 (0%)	0 (0%)	4 (16%)
Platelets	0 (0%)	25 (100%)	21 (84%)	0 (0%)	0 (0%)	0 (0%)	4 (16%)
Whole blood	1 (4%)	24 (96%)	21 (84%)	0 (0%)	0 (0%)	0 (0%)	4 (16%)

*Hemorrhagic shock defined as: significant hemorrhage or considered at risk for significant hemorrhage, hypotension (SBP < 90 mmHg), or tachycardia (HR >110 bpm).
TXA = tranexamic acid; pRBC = packed red blood cell; SBP = systolic blood pressure; HR = heart rate.

among teams managing these patients. Overall, 68% of this cohort reported TXA availability, with 16% reporting TXA being used once and 8% reporting its use 2–5 times during the past year. Additional available resuscitative fluids included crystalloids (96%), pRBCs (12%), colloids (8%), plasma products (8%), and whole blood (4%). Crystalloids were the most frequently reported IV resuscitative measure administered (72%), followed by TXA (24%) and pRBCs (4%).

Table 4 demonstrates TXA availability based on respondent demographics. There was no difference in availability of TXA across geographic location within the United States (p = .99), TEMS operational setting (p = .37), or TEMS jurisdiction (p = .53). Respondents who indicated their tactical medicine personnel served as the primary transporting service for individuals injured during tactical operations had a higher proportion of TXA availability (70% primary transporting service versus 41% nonprimary transporting service, p = .042). Full-time tactical teams were more likely to have TXA compared with part-time teams (72% versus 47%, p = .123), as were teams with ≥ 3 monthly callouts compared to those with ≥ 2 calls per month (74% versus 37%, p = .020). There was no difference in availability of TXA based upon the highest skilled member of the TEMS team (p = .97). Tactical medical providers who carried resuscitative products (crystalloids, colloids, or blood products) were significantly more likely to have TXA compared to those that did not (61% versus 0%, p = .005).

No difference in TXA availability was noted based on average time from point of wounding to the nearest trauma center (Table 5; p = .76). Similarly, no difference was noted between teams within 10 minutes to the nearest trauma center compared with teams ≥ 10 minutes from the nearest trauma center (46% versus 57%, p = .74).

Although not statistically significant, TXA availability was greater in respondents reporting support for use (59%) compared with those not supportive of use (17%, p = .209; Table 6).

Discussion

Members of tactical teams are at high risk for injury, sustaining an injury rate of 33 per 1000 officer missions.[5] Between 1996 and 2014, felonious assaults upon US law enforcement officers while on duty resulted in the deaths of 1,012 officers, representing 53.5 deaths per year.[21] Tactical units are specifically tasked with the resolution of high-threat operations, which carry with them a risk for traumatic injuries and hemorrhagic shock, during which TEMS providers may be responsible for providing medical care to tactical officers, hostages, suspects, and bystanders. The current study identified that half of all respondents had rendered care to at least one patient with hemorrhagic shock in the last year, indicating the life-saving potential of tactical medical operational programs in law enforcement operations.

Several large studies have demonstrated survival benefit for patients who receive TXA early in traumatic and non-traumatic hemorrhage.[10,12,14,23] Additional benefits of TXA include its relative inexpensiveness and logistical efficiency.[24] TXA is shelf stable, allowing it to be stored at room temperature, which provides a benefit over other intravenous resuscitative products, such as plasma and blood products, that require refrigeration capability.

Since 2011, US military Tactical Combat Casualty Care (TCCC) guidelines have included the use of TXA within 3 hours of traumatic injury in patients in whom a blood transfusion was anticipated (e.g., presents with hemorrhagic shock,

TABLE 4 *TXA Availability Based on Tactical Medicine Operational Program Demographics*

		TXA Availability	
		Yes	No
Transport for injured individuals during tactical Operations $p = .042$	Primary	16 (70%)	7 (30%)
	Not primary	11 (41%)	16 (59%)
Geographic location $p = .990$	Midwest USA	9 (53%)	8 (47%)
	Northeast USA	6 (54%)	5 (46%)
	South USA	8 (57%)	6 (43%)
	West USA	4 (50%)	4 (50%)
TEMS operational setting $p = .369$	Rural	1 (25%)	3 (75%)
	Urban	6 (54%)	5 (46%)
	Suburban	4 (40%)	6 (60%)
	Mixed	16 (64%)	9 (36%)
Agency type $p = .0533$	Municipal	4 (40%)	6 (60%)
	County	11 (52%)	10 (48%)
	Regional	5 (50%)	5 (50%)
	State	5 (83%)	1 (17%)
	Federal	2 (66%)	1 (33%)
Team employment $p = .123$	Part-time	17 (47%)	19 (53%)
	Full-time	10 (72%)	4 (28%)
Highest skill level $p = .973$	Physician	19 (51%)	18 (49%)
	Nurse/flight nurse	1 (50%)	1 (50%)
	Paramedic	5 (56%)	4 (44%)
Average monthly calls $p = .035$	0–2 Calls	10 (37%)	17 (63%)
	3–5 Calls	11 (79%)	3 (21%)
	6–10 Calls	3 (60%)	2 (40%)
	11–20 Calls	3 (100%)	0 (0%)
	> 20 Calls	0 (0%)	1 (100%)
Availability of any resuscitative product* $p = .005$	Products available	27 (61%)	17 (39%)
	No products available	0 (0%)	6 (100%)

*Crystalloids (e.g., normal saline, lactated Ringer's), colloids (e.g., Hextend), packed red blood cells (pRBCs), plasma products (e.g., fresh-frozen plasma or freeze-dried plasma), platelets, or whole blood. TXA = tranexamic acid; TEMS = Tactical Emergency Medical Support.

one or more major amputations, penetrating torso trauma, or evidence of severe bleeding).[15] Military tactical trauma protocols have been adapted by civilian TEMS programs for use in the high-threat environment. The C-TECC advocates for early use of TXA for patients with evidence of or at risk for hemorrhagic shock and need for blood transfusion.[16]

Despite evidence of survival benefit in patients with traumatic injuries for whom TXA is indicated, TXA remains underutilized in both military and civilian prehospital settings.[11,17,18] There have been several hypotheses to explain this gap, including the prioritization and increased familiarity of other interventions (e.g., hemorrhage control and evacuation) before TXA administration, complicated medication administration (requiring reconstitution and timed administration over 10 minutes), and bias contributing to lower administration rates in patients with minimal external hemorrhage visualized by the medical provider.[11,17] The most recent CoTCCC simplified its guidelines to recommend administration of 2 g TXA via slow IV push as soon as possible within 3 hours after injury.[25]

Our survey found that just over half of our overall respondent cohort had TXA available to them in the operational setting. TXA availability was greater among teams who reported managing a patient with hemorrhagic shock. Even though 17 of these 25 teams had access to TXA and reported treating a patient with hemorrhagic shock, only six reported its use (Table 3). Additionally, although crystalloids were available to nearly all teams managing a patient with hemorrhagic shock, only 72% reported their use during resuscitations. This may indicate a subset of TEMS teams in our cohort who prioritize evacuation of their wounded to a medical facility over immediate intravenous resuscitative treatment of hemorrhage in the field. Alternatively, it may reflect increased awareness of damage control resuscitation concepts and concerns about crystalloid administration.[26–28] Teams with higher call volumes and more resources (e.g., already carrying other resuscitative products) were more likely to carry TXA. Given the logistical constraints of blood product administration, smaller teams may be most able to benefit from access to TXA and future studies should evaluate barriers to these smaller teams utilizing TXA.

Controversy exists regarding the risk of vascular occlusive events with TXA administration, with some studies showing no significant risk, and others showing statistically significant increased risk. [8,10,12,14,23] Concern has also been voiced regarding the validity of the CRASH-2 study.[29] Institutional and provider preference may factor into support toward availability and administration of the product. Although not statistically significant, our study found that TXA availability was greater among teams whose survey respondent was supportive of use than in those not supportive of use. Future studies examining barriers to TXA use should further evaluate support of TXA among healthcare institutions affiliated with tactical medical operational programs.

TABLE 5 *Average Time to Trauma Center and TXA Availability*

	0–5 min	6–10 min	11–15 min	16–30 min	31–60 min	> 60 min	*p* Value
TXA Available for Use							.757
No	1 (33%)	6 (60%)	4 (40%)	9 (50%)	1 (20%)	2 (50%)	
Yes	2 (67%)	4 (40%)	6 (60%)	9 (50%)	4 (80%)	2 (50%)	

TXA = tranexamic acid.

TABLE 6 *Support for TXA and Availability*

	Slightly Supportive	Moderately Supportive	Very Supportive	Extremely Supportive	*p* value
TXA Available for Use					0.209
No	3 (100%)	2 (60%)	5 (39%)	13 (42%)	
Yes	0 (0%)	1 (33%)	8 (62%)	18 (58%)	

TXA = tranexamic acid.

This study has several important limitations. This survey was sent to a single US-based emergency medicine physician section. As such, it is not comprehensive of all current tactical medicine teams and is biased toward teams with EM physician involvement. Critically, although 51 individuals completed the survey, the response rate is unclear. The section currently contains 512 members. However, the section is open to any member with an interest in tactical medicine. When last surveyed, only 36 of 470 members reported current TEMS involvement. Based on the nature of the survey questions in terms of operational details, we presume that only those with active TEMS involvement provided responses. The majority of respondents (74%) indicated a physician as the highest level of provider on their respective TEMS team. However, this cohort of respondents also likely includes medical directors, who have significant influence on medication protocols, further highlighting the gap in TXA availability and use. Future research should attempt to include additional tactical medical operational programs representing more nonphysician personnel. Last, the study is subject to recall and reporting bias in terms of past operational calls and blood product/TXA use over a 12-month time period.

Conclusions

Half of respondents reported managing at least one patient with hemorrhagic shock in the past year. Although 88% were supportive of TXA use, only 54% reported availability. Teams with higher call volume and more resources were more likely to carry TXA. Further studies evaluating TEMS patient wounding patterns and outcomes, as well as barriers to TXA use, are required.

Presentations

Portions of this paper will be presented at the National Association of EMS Physicians Annual Meeting (Virtual), 2021.

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The authors have indicated they have no financial relationships relevant to this article to disclose.

Author Contributions

SM, AK, and MS conceived the study concept. SM collected the data, and AM analyzed the data. SM wrote the first draft, and all authors read and approved the final manuscript.

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