Blood Product Administration During Transport Throughout the US Africa Command Theater of Operation

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ABSTRACT

Background: United States Africa Command (US AFRICOM) is one of six US Defense Department's geographic combatant commands and is responsible to the Secretary of Defense for military relations with African nations, the African Union, and African regional security organizations. A full-spectrum combatant command, US AFRICOM is responsible for all US Department of Defense operations, exercises, and security cooperation on the African continent, its island nations, and surrounding waters. We seek to characterize blood product administration within AFRICOM using the in-transit visibility tracking tool known as TRAC2ES (TRANSCOM Regulating and Command & Control Evacuation System). **Methods:** We performed a retrospective review of TRAC2ES medical evacuations from the AFRICOM theater of operations conducted between 1 January 2008 and 31 December 2018. **Results:** During this time, there were 963 cases recorded in TRAC2ES originating within AFRICOM, of which 10 (1%) cases received blood products. All patients were males. One was a Department of State employee, one was a military working dog, and the remainder were military personnel. Of the ten humans, seven were the result of trauma, most by way of gunshot wound, and three were due to medical causes. Among human subjects receiving blood products for traumatic injuries, a total of 5 units of type O negative whole blood, 29 units of packed red blood cells (pRBCs), and 9 units of fresh frozen plasma (FFP) were transfused. No subjects underwent massive transfusion of blood products, and only one subject received pRBCs and FFP in 1:1 fashion. All subjects survived until evacuation. **Conclusions:** Within the TRAC2ES database, blood product administration within AFRICOM was infrequent, with some cases highlighting lack of access to adequate blood products. Furthermore, the limitations within this database highlight the need for systems designed to capture medical care performance improvement, as this database is not designed to support such analyses. A mandate for performance improvement within AFRICOM that is similar to that of the US Central Command would be beneficial if major improvements are to occur.

KEYWORDS: *prehospital; blood; Africa; prolonged field care; AFRICOM*

Introduction

During the recent wars in Iraq and Afghanistan, approximately 90% of US military Servicemembers' deaths occurred in the prehospital setting, and nearly 25% of deaths were secondary to potentially survivable injury, among which >90% was related to hemorrhage.[1–3] The deployed US military medical system implemented strategies for rapid casualty evacuation to surgical facilities and early hemostatic resuscitation of severely injured patients to optimize survival.[4–7] Published data demonstrate prehospital administration of blood products, and early surgical intervention improved combat casualty outcomes.[8–12] The "Golden Hour" evacuation policy and damage control resuscitation (DCR) paradigm, however, owes its success in part to a military trauma system supported by established medical and logistical infrastructure.[13,14]

The US Africa Command (AFRICOM) manages military operations across a continent that is 3 times larger than the continental United States with immature medical and logistical systems.[15,16] Increasing numbers of US military forces deploy to AFRICOM and published data demonstrate few battle injuries. However, such injuries are predominantly from penetrating trauma and require evacuation out of theater to the US military hospital in Landstuhl, Germany.[17,18] Adherence to the "Golden Hour" standard is not feasible throughout all of AFRICOM, which should prompt emphasis of remote DCR principles to optimize outcomes.[19–21] It is unclear if hemostatic resuscitation is possible given the sheer geography of AFRICOM and limited resources. However, freeze-dried plasma (FDP), warm fresh whole blood (WFWB), stored whole blood (SWB), and cold-stored low-titer group O whole blood (CS-LTOWB) may be potential options.[22–27] To date, there a little published data on hemostatic resuscitation of casualties within AFRICOM.

Goal of This Investigation

We are seeking to describe blood product administration throughout the AFRICOM theater of operations within the TRAC2ES data repository.

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Methods

Ethics

The US Air Force 59th Medical Wing regulatory office reviewed protocol FWH20180147E and determined it was exempt from Institutional Review Board oversight. We obtained only de-identified data.

Subjects and Setting

We conducted a retrospective review of prospectively entered in-transit records of patient care into TRAC2ES in the AFRICOM theater of operations from 1 January 2008 to 31 December 2018. We included all military and civilian patients that were tracked for transport by TRAC2ES during this timeframe. We sought all available evacuation data on the initial search to create the dataset. The overall dataset from which this analysis was derived is previously described with this analysis focusing on documented blood product administration or shortcomings.[18] Data were extracted by the primary author (SGS) with secondary review by another author (BMC) to ensure accurate capture of cases. If there was a discrepancy, the two authors extracting the data would compare findings until a decision was reached.

Database Description

Data were collected using TRAC2ES, an electronic platform that coordinates medical transport of all (DoD) patients worldwide.[18] Data entered in TRAC2ES include patient demographics, primary diagnosis, origin, destination, and evacuation priority level. There is also the ability to free text a patient's history, which can be used to provide relevant information about the patient's clinical course. Data were extracted from these free text entries, which are previously described.[28] Herein, we performed a subanalysis, with a focus on blood product administrations and limitations. We performed additional free text searches using the following terms: *packed, red, cells, blood, whole, freeze, dried, plasma,* and *platelets*.

Data Analysis

We performed all statistical analysis using Microsoft Excel (version 10, Redmond, WA). We used descriptive statistics, reporting categorical variables as numbers with percentages and ordinal variables as medians with interquartile ranges. We reported the case description data with brief summaries.

Results

Between 2008 and 2018, there were 963 cases recorded in TRAC2ES originating within AFRICOM, of which 10 (1%) cases received blood products. All patients were males (Tables 1 and 2). One was a Department of State (DoS) employee, one was a military working dog (MWD), and the remainder were all military personnel. Of the 10 humans, seven cases were the result of trauma, most by way of gunshot wound, and three were due to medical causes (gastrointestinal bleeding, symptomatic anemia). The MWD presented with a medical complaint (heat stroke). Based on the reports, all patients survived until transfer. We note three cases in which a blood transfusion was indicated by the local clinician. However, it appeared that US-screened blood products were not available and the local blood products were considered high risk relative to the potential benefit (Table 3). Based on review of the free text information, there were no apparent deaths in any of these cases before reaching their destination.

TABLE 1 *Demographics of Patients Who Received Blood*

Demographics	Age	30 (26–34)
	Male	100% (10)
Affiliation	Army	30% (3)
	Navy	50% (5)
	Air Force	10% (1)
	Civilian	10% (1)
Movement precedence	Urgent	40% (4)
	Priority	50% (5)
	Routine	10% (1)
Transport mode	Military Air	80% (8)
	Civilian Air	20% (2)

Among human subjects receiving blood products for traumatic injuries (n = 7), none underwent massive transfusion of blood products per documentation (Table 2). Of these seven, the documentation of only five listed the specific types and numbers of blood products transfused, which were comprised of 5 units of type O negative whole blood, 29 units of packed red blood cells (pRBCs), and 9 units of fresh frozen plasma (FFP). Of these five subjects, only one received pRBCs and FFP in 1:1 fashion. The only subject to receive whole blood did so while aboard a US Navy vessel with medical capabilities.

Discussion

In this subanalysis of patient movements throughout AFRICOM, we noted that approximately 1% sustained a blood product transfusion within the repository. Of note, one of these patients was an MWD that received a fresh whole blood transfusion of unknown origin. That aside, while limited to a small volume of occurrences, we must highlight several details that warrant discussion. First, the span of countries from which the patients originated was quite vast. Our dataset included one DoS employee from Libya, and military Servicemembers spanning from Mali to Kenya to Djibouti to areas off the coast and extending down toward the south. Furthermore, all patients except for the MWD went to Landstuhl, Germany, which highlights the distance travelled out of the theater. Moreover, we identified three cases in which blood products were documented as indicated but were not available to meet US-screening standards. This suggests there is still ongoing need for pathogen reduction and blood product alternative research and development to meet the needs of the end-user within this particular theater.

There are no data published to date on blood product administration within the AFRICOM theater of operation. This is in stark contrast to the extensive publications from the CENTCOM theater of operation.[13,14,25,26,29] CENTCOM has a relatively mature blood supply logistical chain that can fulfill cold storage requirements during and after shipment. However, during the initial years of the conflicts, combat support hospitals within CENTCOM received blood products older than 25 days and commonly transfused them when aged over 30 days. After refinements made to administrative processes and by 2009, blood products arrived in CENTCOM in an average age of 7.2 days.[13,14] AFRICOM, on the other hand, relies on blood products from Landstuhl without a unified method for movement across a vast continent without established logistical networks into small pockets of both diplomatic and military missions. Our data do not indicate

TABLE 2 *Description of Casualties Receiving Blood Products Within AFRICOM*

Age	Gender	Service	Origin Destination	Description
30 years	Male	USN/active	Djibouti Landstuhl	30-year-old man sustained a gunshot wound to the mandible. He was evacuated to a US Navy ship where he was immediately taken to the OR. They were unable to intubate so a cricothyrotomy was performed. He was hypotensive and received 5 units of type-O negative whole blood, 4 units of pRBCs, and 2 units of FFP. His estimated blood loss was 2L. His wound was surgically packed for hemostasis and he was transferred to Landstuhl.
24 years	Male	USAF/active	Djibouti Landstuhl	24-year-old man with ATV rollover with blunt force injury to the right groin. Initially he was hemodynamically stable, and his FAST was negative. He was taken to the OR for a right arterial bypass; he coded in surgery. He was given 7 units of pRBCs and 7 units of FFP. Bilateral chest tubes were placed and a thoracotomy were performed. He was diagnosed with a blunt cardiac injury.
Unknown	Male	DoS	Libya Landstuhl	Unknown age male involved in Libyan Embassy attack with undocumented mechanism of injury. Patient found to be in severe shock and received 6 units of pRBCs on the ground and 1 unit en route. Patient was intubated prior to transfer.
29 years	Male	USN/active	Kenya Landstuhl	29-year-old man with gunshot wound to the left hip and thigh. A tourniquet was applied, and patient was taken to surgery at a local hospital in Nairobi. Patient had multiple surgical explorations, followed by multiple compartment fasciotomy with significant hemorrhage, complicated by renal failure. Patient was transfused a total of 9 units of pRBCs.
31 years	Male	USA/active	Mali Landstuhl	31-year-old man injured by 40-mm grenade in Mali. A needle chest decompression was performed followed by a right-side chest tube. Patient transferred from Bamako, Mali to Ouagadougou for clinical intervention care. Patient was transfused 2 units of pRBCs prior to flight evacuation.
33 years	Male	USN/active	Kenya Landstuhl	33-year-old man with gunshot wound to the left thigh with femoral vessel laceration. Two tourniquets were applied, and he was transferred for vascular surgery intervention in Nairobi. Patient was transfused blood products that were not specified type or volume.
24 years	Male	USN/active	Kenya Landstuhl	24-year-old man with a gunshot wound to the high left thigh with femoral vessel injury. He was transfused 2 units of unspecified blood products prior to arrival the hospital in Nairobi where he underwent surgery. He was then transferred to Landstuhl.
34 years	Male	USA/active	Djibouti Landstuhl	34-year-old man with history of gastrointestinal bleeds that presented to the medical clinic in Djibouti with lightheadedness and melanotic stools. He was given 2 units of O-positive pRBCs and transferred to Landstuhl.
44 years	Male	USA/active	Djibouti Landstuhl	44-year-old man with melanotic stools found have a gastrointestinal bleed from an ulcer with presyncopal episodes. He was transfused 2 units of pRBCs. His pretransfusion hematocrit was 21.6. He was transferred to Landstuhl where he underwent esophagogastroduodenoscopy.
30 years	Male	USN/active	Djibouti Landstuhl	30-year-old man with rectal bleeding over 1 week with 2–3 stools with bright red blood. His hematocrit was 17.5. He was transfused 2 units of pRBCs and transferred to Landstuhl for colonoscopy. He was noted to have a febrile reaction to the blood but no other transfusion reaction symptoms.

OR = operating room, ATV = all-terrain vehicle, FAST = focused assessment of sonography for trauma, FFP = fresh frozen plasma, DoS = Department of State, pRBC = packed red blood cell, USA = US Army, USN = US Navy, USAF = US Air Force.

TABLE 3 *Case Data of Noting Challenges With Transfusions*

Age	Gender	Service	Origin Destination	Description
26 years	Male	USA/active	Unknown South Africa	26-year-old with suicide attempt by way of toxic ingestion and cutting of his arm. His arm was locally ligated to control the hemorrhage. He was found to have a hemoglobin of 5.4g/dL. However, it appeared no blood products were available, and the Tricare International service recommended against local blood transfusion in undocumented location. Due to his unstable nature, he was transferred to Johannesburg, South Africa.
31 years	Male	USN/active	Seychelles Landstuhl	31-year-old with duodenal ulcer with history of nonsteroidal anti-inflammatory drug use with syncopal episode. He had several episodes of maroon stools. His hemoglobin was 7g/dL. Tricare International service advised that that blood in the Republic of Seychelles is screened by the Ministry of Health Blood Bank and the incidence of HIV is low, however screening standards are not guaranteed. Due to underlying fears, the Servicemember declined the blood transfusion recommended.
48 years	Female	PHS/active	Zambia South Africa	44-year-old woman with presented with chest tightness, shortness of breath, and fatigue in Lusaka, Zambia. Her hemoglobin was 7.1g/dL. The etiology for her anemia was unclear but they noted concerns for malaria. Tricare International advised that local healthcare does not meet their standards and a blood transfusion was at high risk for HIV and hepatitis. She was evacuated to Pretoria, South Africa.

USA = US Army, USN = US Navy, PHS = Public Health Service, HIV = human immunodeficiency virus.

the age of administered blood products. However, given the initial experience within CENTCOM and current challenges within AFRICOM, it is possible these blood products were aged with short shelf lives. The resulting narrow time window for blood product transfusion coupled with continuous storing disruptions may partially explain the infrequent rate of blood product administration observed. Given the limitations in documentation within the entries, we are unable to characterize cases in which blood products were likely beneficial but not administered unless explicitly documented.

Given the challenges within AFRICOM, part of the medical support strategy for operational forces is to preposition small, surgical elements capable of delivering remote DCR and damage control surgery (DCS). These teams must be supplied with blood products to leverage their full capabilities, but understand local procurement of whole blood may be necessary in accordance with published military medical management guidelines.[21,30] Within our dataset, only one human subject received whole blood, and the type [warm fresh whole blood (WFWB), stored whole blood (SWB), cold stored low-titer type O whole blood (CS-LTOWB)] was not specified. This may indicate low utilization stemming from operational forces not engaged in kinetic armed conflict, which is consistent with a previous analysis of AFRICOM casualty statistics utilizing a different database.[17] However, none of our subjects were host nation forces or local national civilians for whom there are case reports and anecdotal evidence of blood product transfusion.[31] Consequently, this finding may be due to database limitations. This is likely due to the nature of the database which only tracks movements of US military personnel or non-US military that move through US military transport mediums. As such, we are unable to capture casualties that may have been moved from the point-of-injury to a local hospital system. We must also note that a high proportion of the military personnel in Africa are engaged in non-combat roles and thus likely do not have resuscitation teams positioned nearby (e.g., embassy personnel).

The Armed Services Blood Program (ASBP) is responsible for "blood products and services for all worldwide customers in peace and war."[32] The majority of blood products shipped by the ASBP meet US Food and Drug Administration (FDA) and American Association of Blood Banks (AABB) requirements. Because of these requirements, there are significant hurdles for storage, shipping, and inventory management. As technology has improved, management of blood products have become more flexible; however, there are still several obstacles before blood makes it to the ground forces. Our dataset highlights the need for further advancements with regards to storage, maintenance, and logistical movements.

European countries have a long history of expeditionary forces on the continent of Africa. Because of this, they have demonstrated the ability to successfully care for and evacuate casualties. The French often use freeze-dried plasma as the optimal resuscitation blood product.[33] It is immediately available and can be stored at room temperature for 2 years. The French use Role II military treatment facilities (MTFs) scattered strategically across the continent based on military operations. They also have a robust medical evacuation program that uses fixed and rotary-wing platforms.[34,35] Across the spectrum of care, blood transfusions are available. The use of air-drop for blood products is an option.[36] Delivering blood to austere locations either by manned or unmanned flying platforms may offer a solution for the US military as operations expand in the AFRICOM theater of operations. However, further refinement of the storage methods is needed before the blood products can withstand the stress of drone transportation. Militaries are not the only institutions challenged by the size and austerity of Africa. Civilian hospitals and providers also have trouble obtaining blood products. An innovative method of delivering blood that has even piqued the interest of the US military is the use of drone technology. Since 2014, Zipline (San Francisco, CA; www.flyzipline.com) has over 35,000 deliveries across the world.[37]

Our analysis is limited by several issues, namely the lack of case volume to analyze in a quantitative method combined with incomplete data entry into TRAC2ES. Personnel entering data into TRAC2ES may be nonmedical personnel, which introduces a possible source of error in data entry, specifically to the data that medical personnel may find useful in a retrospective review. We have no reference standard available for the data documented so we are unable to assess for missing variables or free text errors or omissions. Patient movement records are often produced during the early phases of care, leading to incomplete documentation of performed diagnostics and treatments. There is no consistent standard as to which data are included in the free form section detailing the patient history and course of care. This limits the ability to both document interventions consistently and to extract the data accurately during analysis. Of note, the TRAC2ES is designed for management of the patient movement throughout theater – it is not designed for research or performance improvement, which is a limiting factor. Expansion of the Joint Trauma System data collection mandate from CENTCOM into other theaters including AFRICOM would be highly beneficial for performance improvement.[38] Such a larger data collection mandate would allow for more advanced methods of analysis, allowing for uniform data capture and comparisons across groups. We must also note that TRAC2ES only tracks movements of living casualties, and thus if someone died before transport they would not be captured within this system. Perhaps, the authors likely missed many opportunities for blood resuscitation that we are not able to characterize. Last, previous studies found that battlefield documentation has largely been poor and inconsistent – this is likely amplified within AFRICOM given that the Joint Trauma System (JTS) does not have a data collection mandate within this theater of operations.[14,15]

Conclusions

Within the TRAC2ES database, blood product administration within AFRICOM was infrequent, with some cases highlighting lack of access to adequate blood products. Furthermore, the limitations within this database highlight the need for systems designed to capture medical care performance improvement, as this database is not designed to support such analyses. A mandate for performance improvement within AFRICOM similar to that of the US Central Command would be beneficial if major improvements are to occur.

Acknowledgments

We would like to thank Mark R. Barnes from TRANSCOM for providing us with this dataset.

Ethics

The US Air Force 59th Medical Wing regulatory office reviewed protocol FWH20180147E and determined it was

exempt from institutional review board oversight. We obtained only deidentified data.

Disclaimer

Opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Air Force, the Department of the Army, or the Department of Defense.

Authorship Statement

SGS is the overall principal investigator (PI) for the database from which these data were drawn. SGS performed the data analysis and drafted the manuscript. JFN, ADF, DGH, and BMC have extensive operational experience at a Role 1 and provided data interpretation and critical revisions. MAE and CDL performed data extraction from the original database including identification of the cases presented here. HM is an Armed Services Blood Program officer who provided critical revisions. APC and JB are blood and coagulation capability area managers at the US Army Institute of Surgical Research and provided data interpretation and critical revisions. All authors participated in revising the manuscript and accept responsibility for the final manuscript.

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