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Tactical Combat Casualty Care (TCCC): Historical Evolution, Evidence-Based Development, And Contemporary Applications In Modern Warfare

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Abstract

Background: Armed conflict has historically driven advances in trauma surgery and emergency medicine. However, prehospital combat casualty care developed more slowly, contributing to preventable deaths before casualties reached definitive medical treatment. Tactical Combat Casualty Care (TCCC) was developed to integrate evidence-based trauma interventions with tactical and operational realities. This review aimed to describe the historical evolution of TCCC, summarize the scientific evidence supporting its development, and examine its implementation and adaptation in contemporary armed conflicts.

Methods: A narrative literature review was conducted using landmark publications, military trauma registries, clinical practice guidelines, authoritative official documents, and peer-reviewed literature indexed in PubMed, Scopus, and military medical databases. Evidence was organized by historical development, core intervention, and operational application. Study design, population, denominator, setting, and risk of bias were considered when interpreting findings. Because of heterogeneity in study designs and outcomes, evidence was synthesized descriptively rather than pooled statistically.

Conclusion: TCCC is an adaptive trauma-care framework whose strongest support derives from military registries, observational cohorts, and selected randomized civilian trauma evidence. Its application should remain context-specific, data-driven, and explicit about uncertainty, particularly in ongoing armed conflicts and in diverse ASEAN operational environments.

Keywords: *Tactical combat casualty care; Battlefield medicine; Combat trauma, Haemorrhage control; Damage control resuscitation*

Background

Tactical Combat Casualty Care (TCCC) was developed to reconcile trauma priorities with active threat, limited personnel and equipment, and delayed evacuation. Its central contribution was not a single device or drug, but a context-dependent system linking immediate actions at the point of injury with tactical conditions and the subsequent chain of care.[2,4–7] Claims about TCCC effectiveness require careful qualification. Much of the evidence derives from retrospective registries, before-and-after comparisons, and highly selected military units. These designs are operationally informative but cannot fully separate the effect of TCCC from concurrent improvements in body armor, evacuation, surgical capability, blood-product availability, training, and command support. This review therefore distinguishes evidence for individual interventions from evidence concerning implementation of the complete TCCC system.[3–5,15]

Methods

Study design

This study was conducted as a narrative literature review to describe the historical evolution of Tactical Combat Casualty Care (TCCC), synthesize the scientific evidence supporting its principal interventions and doctrinal development, and critically evaluate its application in contemporary armed conflicts. A narrative approach was selected because the evidence base comprises heterogeneous sources—including historical analyses, military trauma-registry studies, observational cohorts, clinical practice guidelines, consensus recommendations, official surveillance documents, and operational reports—whose populations, outcomes, and designs were not sufficiently comparable for quantitative meta-analysis.

Literature search strategy

A structured literature search was conducted from April through July 2026. PubMed, Scopus, and Google Scholar were searched, together with targeted searches of Military Medicine, the Journal of Special Operations Medicine (JSOM), the Joint Trauma System website and guideline repository, and relevant official military and multilateral sources. The primary publication window was January 2016 through July 2026; this was supplemented by purposive retrieval of seminal pre-2016 publications required to explain the origins and historical evolution of TCCC. Search strings combined controlled vocabulary, where available, with free-text terms, including "Tactical Combat Casualty Care," "battlefield trauma," "combat casualty care," "tourniquet," "haemorrhage control," "Joint Trauma System," "damage-control resuscitation," "tactical evacuation," and "prolonged casualty care." Reference lists of eligible and landmark articles were also screened to identify additional relevant sources.

Eligibility criteria

Inclusion criteria. Sources were included when they addressed one or more prespecified review domains: landmark or historical publications describing the development of TCCC; battlefield mortality or preventable-death classification; haemorrhage control, tourniquet effectiveness, haemostatic dressings, tranexamic acid, damage-control resuscitation, tactical evacuation, or prolonged casualty care; TCCC implementation in military casualties or combat-related trauma; or contemporary operational constraints relevant to TCCC. Eligible evidence comprised peer-reviewed full-text studies, military trauma-registry analyses, clinical practice guidelines, evidence-supported consensus recommendations, landmark historical publications, and authoritative official documents.

Exclusion criteria. Duplicate publications; editorials or opinion articles without supporting evidence; studies unrelated to combat trauma; and civilian trauma studies without a clear rationale for military applicability were excluded. Civilian randomized evidence was retained only when it directly informed a core TCCC intervention, and its limitations of transferability to military settings were explicitly considered.

Study selection and evidence synthesis

Titles and abstracts identified through the searches were screened for relevance, followed by full-text assessment of potentially eligible sources. Because this was a narrative rather than a systematic review, screening and extraction were performed by the author and were not independently duplicated. For each principal source, the review extracted the publication or data-collection period, population, sample size, operational setting, study design, principal findings, and major limitations. Evidence was synthesized thematically under historical evolution, core TCCC interventions, contemporary applications, and implications for ASEAN military medicine. Guideline or policy recommendations were distinguished from clinical and operational outcome evidence, and empirical findings were separated from expert opinion or operational inference. No pooled effect estimate was calculated. The study-selection process is summarized in Figure 1.

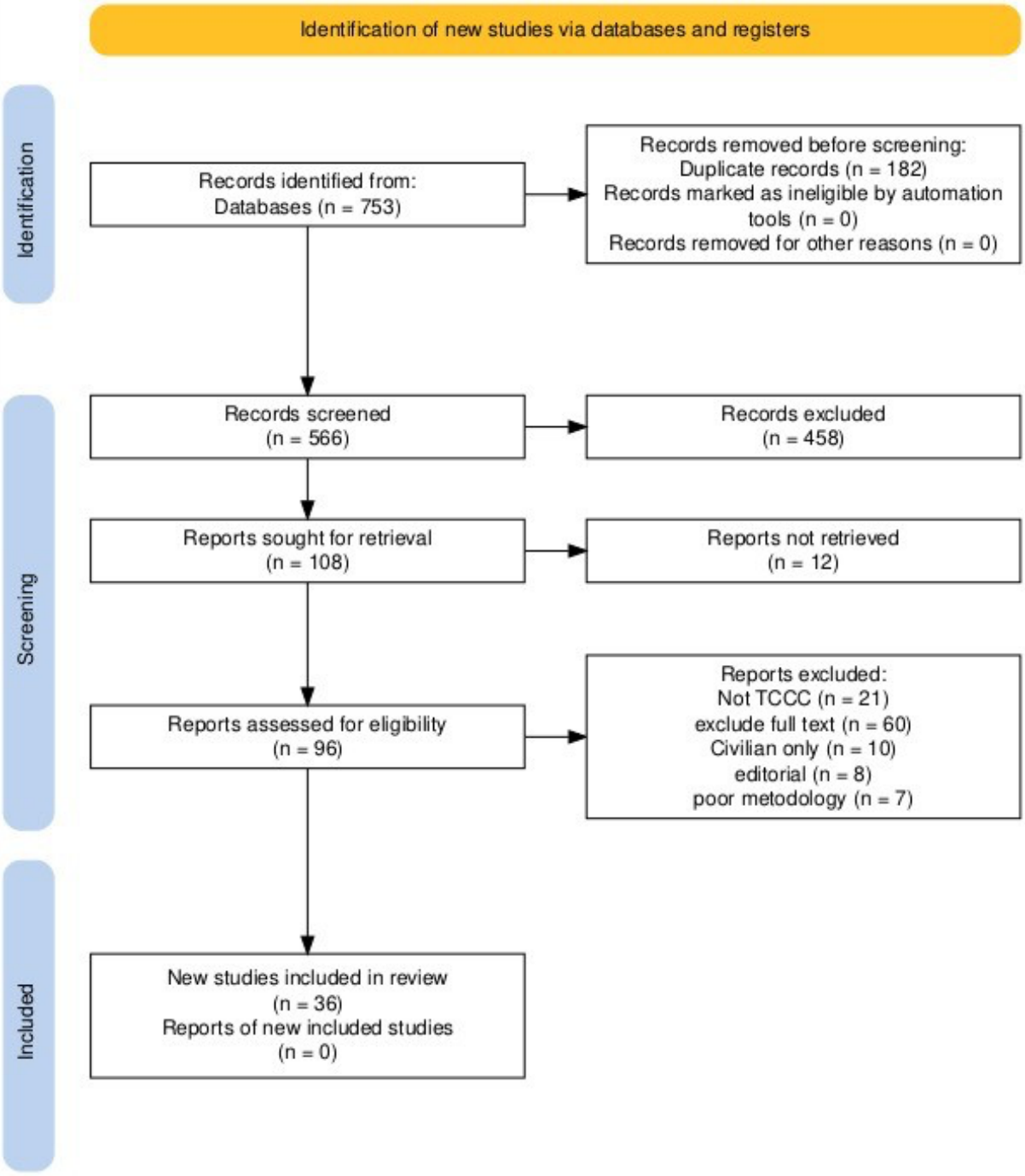

Figure 1. Flow diagram of study identification, screening, eligibility assessment, and inclusion in the narrative review.

Quality and reporting framework

The manuscript was developed and critically reviewed against the six domains of the Scale for the Assessment of Narrative Review Articles (SANRA) (Table 1): justification of the review's importance, statement of concrete aims, description of the literature search, referencing, scientific reasoning, and appropriate presentation of data.28 The author-completed SANRA self-assessment documents reporting completeness; it is not an independent quality judgment or a substitute for external peer review or formal risk-of-bias assessment. To strengthen transparent presentation, the principal sources and developments were summarized in an evidence-synthesis table reporting study design, population or setting, findings, limitations or level of evidence, and implications for TCCC practice.

Table 1. SANRA author self-assessment for the revised narrative review

SANRA component	Author assessment of the revised manuscript	Score
1. Justification of the article's importance for the readership	The Background explains the relevance of TCCC, the burden of potentially preventable prehospital death, and the need for a critical review applicable to contemporary and ASEAN settings.	**2/2**
2. Statement of concrete aims or formulation of questions	The Abstract and Background explicitly state the aims: to describe historical evolution, synthesize the evidence, and evaluate contemporary implementation and adaptation.	**2/2**
3. Description of the literature search	The Methods report the April–July 2026 search period, databases and targeted sources, publication window, search concepts, eligibility criteria, selection process, and synthesis approach.	**2/2**
4. Referencing	Seminal and contemporary sources, military registries, guidelines, peer-reviewed studies, and authoritative official documents support the principal statements.	**2/2**
5. Scientific reasoning	The review distinguishes guideline recommendations from outcome evidence, considers alternative explanations and bias, and relates the strength and limitations of evidence to practice implications.	**2/2**
6. Appropriate presentation of data	Evidence is presented through structured narrative synthesis, a study-selection flow diagram, and an evidence-synthesis table reporting design, population, findings, limitations, and implications.	**2/2**
Total author self-assessment		**12/12**

Historical Evolution

Pre-TCCC Foundations: World War I through the Vietnam War. World War I demonstrated the mismatch between industrialized weapons and the limited organization of evacuation, transfusion, antimicrobial therapy, and forward surgery. World War II expanded blood transfusion, penicillin use, and forward surgical capability. These developments improved treatment after evacuation but did not yet constitute a standardized point-of-injury doctrine.[1,10]

The Korean War brought mobile surgical hospitals and more extensive helicopter evacuation, while the Vietnam War further shortened access to surgery. Historical comparisons suggest lower case-fatality rates across these conflicts, but attribution to evacuation alone is not possible because injury patterns, casualty ascertainment, protective equipment, transfusion practice, and hospital capability also changed.[11–13]

The 1996 TCCC publication challenged direct transfer of civilian Advanced Trauma Life Support priorities to an environment in which ongoing fire, limited visibility, tactical movement, and delayed evacuation alter both risk and feasibility. It proposed that medical actions be sequenced according to the tactical situation and the most time-sensitive preventable causes of death.[2,14]

The subsequent MARCH sequence—Massive Hemorrhage, Airway, Respiration, Circulation, and Hypothermia/Head Injury—represented an important change in battlefield trauma priorities. Its rationale is supported by mortality analyses showing that hemorrhage accounts for a large share of potentially survivable prehospital deaths. The

evidence supports prioritizing rapid hemorrhage control; it does not establish that every element of the sequence independently improves survival.[1–4]

Theater-Based Operational Development. In Iraq, the Joint Theater Trauma System and expanding registry infrastructure enabled systematic review of injury mechanisms, prehospital interventions, and outcomes. Observational tourniquet studies and command-directed training programs were influential because they linked treatment timing and implementation practices with measurable outcomes. Their nonrandomized design, however, leaves residual confounding by injury severity, evacuation time, provider skill, and broader trauma-system maturation.[3,9,15–17]

In Afghanistan, blast injury, traumatic amputation, junctional hemorrhage, and dispersed operations increased the importance of hemostatic dressings, junctional-control strategies, blood-based resuscitation, and preparation for delayed evacuation. These developments should be understood as theater-driven doctrinal adaptation rather than as a separate chronological phase that overlaps with Iraq.[4,5,9,19,20]

Experience across both theaters also illustrates that TCCC is a socio-technical system. Protocols were implemented alongside training of nonmedical personnel, trauma-registry feedback, command ownership, rapid evacuation, and progressively capable surgical and critical-care networks. Outcomes observed in mature United States military systems therefore should not be assumed to transfer unchanged to forces with different logistics, training, or evacuation capacity.[3–5,15]

Three Operational Phases of TCCC. Care Under Fire is delivered while the casualty and responder remain exposed to an effective or imminent threat. Priorities are suppression or avoidance of the threat, movement to cover when feasible, prevention of additional casualties, and rapid control of immediately life-threatening external hemorrhage, typically with a limb tourniquet. Other assessments and procedures are deliberately limited when they would increase tactical risk.[2,4,7]

Tactical Field Care begins when the immediate threat has been reduced sufficiently to permit a structured assessment. Care expands to the MARCH sequence, including reassessment of hemorrhage control, airway and respiratory management, circulatory support, prevention of hypothermia, analgesia, antibiotics when indicated, documentation, and preparation for evacuation. The available time and intervention set remain dependent on threat, personnel, equipment, and anticipated evacuation delay.[2,4,7]

Tactical Evacuation Care covers treatment during movement from the point of injury to a higher level of care. Depending on platform and staffing, it may add monitoring, oxygen, blood products, advanced airway or ventilatory support, warming, and repeated resuscitation assessment. Its effectiveness depends not only on clinical procedures but also on platform availability, communication, handover quality, route security, and time to definitive care.[4,7,20]

The phases describe changing tactical conditions rather than fixed clock times or locations. A casualty may move between them as the threat changes, and the same intervention may be appropriate in one phase but unsafe or infeasible in another. This conditional structure is central to TCCC and distinguishes it from a purely hospital-based algorithm.[2,4,7]

Evidence Supporting Core TCCC Interventions
Preventable Death and Hemorrhage Control
Eastridge et al. reviewed 4,596 United States battlefield fatalities from October 2001 through June 2011. Of all injury deaths, 87.3% occurred before arrival at a medical treatment facility. Among pre-facility deaths, 3,040 (75.7%) were classified as nonsurvivable and 976 (24.3%) as potentially survivable; hemorrhage accounted for 90.9% of the potentially survivable acute deaths. These findings provide a defined denominator for prioritizing hemorrhage control, but survivability classification involved expert review and does not by itself measure the effect of a specific TCCC intervention.[3]

Tourniquets
In a prospective observational study of 232 patients with major limb trauma in Iraq, Kragh et al. reported 11% mortality among 194 patients who

received prehospital tourniquets compared with 24% among 38 patients first treated in the emergency department. Survival was also higher when the tourniquet was applied before shock. The direction and magnitude of these associations support early use for life-threatening extremity hemorrhage, although treatment was not randomized and timing was linked to clinical condition and evacuation circumstances.[16]

A separate 75th Ranger Regiment cohort included 419 battle-injured casualties accumulated during seven years of combat in Iraq and 8.5 years in Afghanistan. Lower killed-in-action and died-of-wounds rates than the wider United States military population were observed in a command-directed system combining TCCC training, rapid response, and continuous performance review. This institutional experience supports the value of integrated implementation but cannot isolate the effect of tourniquets or any other single component.[15]

Hemostatic Dressings

Hemostatic dressings extend external hemorrhage control to wounds not amenable to conventional limb tourniquets. Their inclusion in TCCC reflects laboratory evaluation, case series, and operational experience rather than large randomized battlefield trials. The evidence supports their role as an adjunct to direct pressure and wound packing, while comparisons among products remain sensitive to wound model, application technique, provider training, and concurrent resuscitation.[4,9,17]

Tranexamic Acid and Damage-Control Resuscitation

The CRASH-2 randomized trial enrolled 20,211 adult trauma patients with or at risk of significant bleeding at 274 hospitals in 40 countries. Tranexamic acid reduced death due to bleeding when administered early, with later analyses emphasizing treatment within three hours of injury. This is higher-level evidence than most battlefield studies, but it was generated predominantly in civilian hospital settings; application to prehospital military care requires consideration of injury pattern, transport delay, dosing logistics, and selection criteria.[18]

Damage-control resuscitation combines restricted crystalloid use, early blood-component or whole-blood strategies, permissive hypotension when appropriate, and prevention of hypothermia and coagulopathy. Observational military data and physiologic rationale support this integrated approach, but the components are difficult to evaluate independently because they are delivered as part of an evolving trauma system and are modified for traumatic brain injury, resource scarcity, and evacuation delay.[19,20]

Critical Appraisal of the Evidence Base

The evidence is strongest for early control of life-threatening extremity hemorrhage and for early tranexamic acid in appropriately selected bleeding trauma patients. Evidence for a complete TCCC implementation package is necessarily more indirect. Registry studies offer large operationally relevant populations, but missing prehospital data, changing case mix, immortal-time effects, and concurrent system improvements constrain causal interpretation. Institutional reports demonstrate feasibility and potential benefit but have limited external validity.[3,15,16,18]

Contemporary Applications

Armed Conflict in Ukraine (2022–Present): Injury Patterns and Trauma-System Constraints. Published evidence from the armed conflict in Ukraine remains predominantly retrospective, facility-based, or qualitative. Prysiazhniuk et al. reviewed 415 military personnel and civilians with gunshot or blast-related maxillofacial injuries admitted from February 24, 2022, to February 24, 2024, to six specialized military and civilian institutions in Kyiv and surrounding regions. The cohort was 96.9% male, had a military-to-civilian ratio of 12:1, and included 87.2% blast-related injuries. These data characterize a referred maxillofacial cohort, not all casualties in the conflict.[21]

Lawry et al. conducted virtual semi-structured interviews from January 10 to March 6, 2023, with 26 United States and Canadian health-care or logistics volunteers who had worked in western or central Ukraine between February 2022 and February 2023. Respondents described variable prehospital care, inconsistent handoffs, evacuation constraints, and limited rehabilitation capacity.

These are purposively sampled perceptions rather than patient-level outcomes and exclude eastern frontline and Ukrainian provider perspectives.[22]

World Health Organization surveillance documented 1,940 attacks on health care from February 24, 2022, through August 19, 2024; during the first 7.5 months of 2024, it recorded 229 injuries and 34 deaths among health workers and patients. The data establish threats to health services but do not constitute a combat casualty registry. Any link between damaged infrastructure, contested evacuation, and the performance of specific TCCC interventions remains an operational inference.[23]

Armed Conflict in Israel and the Gaza Strip (2023–Present): Hospital-Based Evidence. Goldman et al. extracted casualties with injury dates of October 7–8, 2023, from the Israel National Trauma Registry. Among 630 hospitalized patients, 277 were civilians and 353 were military personnel; 90% had gunshot injuries, 19% explosion-related injuries, and 16% multiple mechanisms, with non-mutually exclusive categories. This defined hospital denominator excludes prehospital deaths, nonadmitted patients, and later phases of the conflict.[24]

In the Gaza Strip, Wajahath et al. conducted a cross-sectional study during a 16-day international medical mission at European Gaza Hospital in Khan Yunis in April 2024. More than 500 patients were examined, but the analytic sample comprised 80 surgical cases treated by the mission team; 53% were classified as directly conflict-related, 14% indirectly conflict-related, and 33% unrelated. This single-hospital, surgically selected cohort preceded ground operations in Rafah and cannot be generalized to the wider population.[25]

Jamaluddine et al. used capture–recapture analysis of three partially overlapping death lists for traumatic injury from October 7, 2023, through June 30, 2024. The analysis estimated approximately 64,260 traumatic deaths and suggested that 41% were absent from the official Ministry of Health count. This statistical reconstruction addresses under-ascertainment but is not a clinical registry and cannot identify prehospital interventions, preventability, or TCCC exposure.[26]

Across these contemporary settings, hospital and registry studies can describe treated injury patterns and resource requirements, while qualitative and surveillance reports can identify system constraints. They do not presently permit population-wide causal comparisons of TCCC effectiveness. Empirical findings should therefore remain separate from expert opinion about drones, contested evacuation, prolonged casualty care, or future doctrine.[21–26]

Implications for ASEAN Military Medicine

For ASEAN armed forces, the principal implication is adaptation rather than direct replication. Archipelagic geography, remote border areas, variable evacuation platforms, tropical exposure, civilian–military coordination, and differences in blood-product and surgical capacity may prolong the interval between injury and definitive care. National TCCC programs should therefore align training and equipment with a realistic evacuation concept and with the competencies available at successive levels of care.

Priority capabilities include standardized competency-based training for combatants and medics, reliable hemorrhage-control equipment, hypothermia prevention despite tropical climates, blood-delivery planning, interoperable casualty documentation, and exercises that test communications and handover during maritime, air, and land evacuation. These are strategic recommendations inferred from TCCC principles and regional operating conditions; they should be evaluated through prospective training metrics, registry completeness, treatment timing, adverse events, and patient outcomes.[4,7,19,20]

Existing regional mechanisms can support common terminology, instructor development, simulation, registry standards, and multinational medical exercises. Official ASEAN policy identifies the ADMM-Plus Experts' Working Group on Military Medicine and the ASEAN Center of Military Medicine as platforms for exchanging lessons and coordinating military medical cooperation. Regional standardization

should define minimum interoperable capabilities while allowing national adaptation to force structure, law, resources, and threat.[27]

This review has methodological limitations. It is a narrative rather than systematic review; the search was not preregistered, study selection was not independently duplicated, and a formal risk-of-bias instrument was not applied. Publication and reporting bias are likely because successful interventions, mature trauma systems, and favorable operational experiences may be more likely to enter the published literature than unsuccessful implementation, protocol deviations, adverse events, or incomplete missions. Language and database restrictions may also have reduced the representation of evidence produced outside English-language military medical systems.

The available evidence is dominated by United States military experience, particularly operations in Iraq and Afghanistan, and by observational, registry-based, and institution-specific studies. These designs provide operationally relevant data but remain vulnerable to missing prehospital variables, selection bias, survivorship bias, temporal changes in trauma systems, and confounding by evacuation, body armor, training, blood-product availability, command support, and surgical capability. Definitions of preventable death and potentially survivable death are also heterogeneous: studies differ in the injuries included, the information available to expert reviewers, the assumed treatment and evacuation capability, and whether prehospital and in-hospital deaths are assessed together. Reported proportions therefore should not be compared without examining their denominators and classification methods.[3,15,16]

Data from ongoing armed conflicts are limited, preliminary, and potentially unstable as case ascertainment and access change over time. Operational-security restrictions, damaged records, disrupted health systems, loss to follow-up, shifting front lines, and changes between phases of hostilities can produce reporting, selection, referral, and survivorship bias. Published hospital cohorts exclude casualties who die before arrival or cannot access care, while qualitative reports and individual institutional experiences do not provide population denominators. Findings from these sources should not be generalized to an entire conflict or used alone to infer the causal effectiveness of TCCC.[21–26]

External validity across military settings is limited by differences in injury mechanisms, protective equipment, evacuation time and platform, provider training, command structure, documentation, blood logistics, surgical access, and material resources. Evidence generated in a mature United States military trauma system cannot be transferred directly to ASEAN military health systems, which encompass diverse force structures, legal frameworks, archipelagic and remote geography, civilian–military interfaces, and variable evacuation and definitive-care capacity. ASEAN adoption should therefore be treated as context-specific implementation requiring local needs assessment, competency evaluation, registry development, prospective monitoring of treatment timing and adverse events, and validation against locally relevant patient outcomes.[3–7,15,27]

Conclusion

TCCC evolved from historical lessons in evacuation and forward care into a threat-adapted system organized around Care Under Fire, Tactical Field Care, and Tactical Evacuation Care. Evidence is most persuasive for timely control of life-threatening extremity hemorrhage and for early tranexamic acid in selected bleeding trauma patients. Evidence for the complete TCCC package is largely observational and should be interpreted as the effect of an integrated trauma system rather than a single protocol.[2–4,16,18]

Contemporary conflicts reinforce the importance of evacuation resilience, documentation, and prolonged casualty-care capability, but current evidence is not sufficient for broad causal claims. For ASEAN military medicine, progress should be measured through interoperable training, credible registries, context-specific logistics, and transparent outcome evaluation.[21–27]

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Author Contributions

The sole author was responsible for the conceptualization, methodology, literature search, evidence selection, analysis and interpretation, manuscript drafting, critical revision, and approval of the final manuscript. The author accepts full responsibility for the accuracy and integrity of the work.

Conflict of Interest

The author declares no financial, professional, institutional, or personal conflicts of interest related to this manuscript. The views expressed in this article are solely those of the author and do not necessarily represent the official policies or positions of the author's affiliated institution, military organization, or governmental authority.

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