



ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Constructing a prolonged field care echeloned system for interrupted casualty evacuation chains

Tao Yu¹, Bo Chen², Mengxia Li³, Keliang Song⁴, Junxiao Wang⁵, Huaping Li⁶

¹The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of Stomatology, Luoyang, Henan Province, China;

²The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of Orthopedics, Luoyang, Henan Province, China;

³The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of Orthopedics and Joint Surgery, Luoyang, Henan Province, China;

⁴The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of Emergency Medicine, Luoyang, Henan Province, China;

⁵The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of General Surgery, Luoyang, Henan Province, China;

⁶The 989th Hospital of the People's Liberation Army Joint Logistics Support Force, Department of Anesthesiology, Luoyang, Henan Province, China

SUMMARY

Introduction/Objective The aim was to analyze the evolution of modern combat casualty care from the Golden Hour and Tactical Combat Casualty Care (TCCC) to Prolonged Field Care (PFC) and Prolonged Casualty Care (PCC), and to construct an Echelon P model for situations in which casualty evacuation is delayed or interrupted.

Methods A structured literature analysis, conceptual differentiation, and model-construction approach was used. Foreign military guidelines, position statements, operational reports, and peer-reviewed studies on PCC were reviewed, with priority given to literature from 2022 to 2026. PFC and PCC were compared by origin, target users, operational scenario, capability requirements, time frame, and interface with traditional echelons of care.

Results The evidence indicates a shift from evacuation-dependent care toward sustained forward care under contested conditions. PFC is primarily a clinical continuation of TCCC by advanced-trained personnel, whereas PCC is a system-level framework for all Role 1 responders when timely evacuation is limited or denied. The proposed Echelon P model includes activation triggers, P0-P3 capability tiers, and medical, blood/resuscitation, data, and command interfaces.

Conclusion Institutionalizing prolonged care as an independent capability layer may improve medical resilience in future high-intensity operations. Implementation should focus on doctrine, training, equipment modularization, telemedicine-enabled support, documentation, and quality assessment.

Keywords: combat casualty care; golden hour; tactical combat casualty care; prolonged field care; prolonged casualty care; military medical resilience

INTRODUCTION

Traditional combat casualty care has been organized around echeloned care and the Golden Hour. In this model, life-threatening problems are controlled at or near the point of injury, the casualty is moved rapidly through Role 1 and Role 2 care, and progressively more specialized treatment is provided at rear facilities. The model achieved major success when tactical conditions, transport assets, air superiority, and medical infrastructure enabled rapid evacuation. Its hidden assumption, however, is that the evacuation chain remains available and predictable. Once this assumption fails, the clinical burden carried by forward providers expands from short stabilization to sustained monitoring, resuscitation, and decision-making [1, 2].

Tactical Combat Casualty Care (TCCC) was developed to reduce preventable deaths before hospital arrival by integrating medical interventions with tactical realities. Its emphasis on

massive hemorrhage control, airway support, respiration, circulation, hypothermia prevention, and documentation made forward care more executable under fire. The institutional mechanism of the Committee on TCCC also allowed the guidelines to be updated as battlefield evidence changed, including recent updates to casualty care and resuscitation recommendations [3–7]. Nevertheless, TCCC was designed primarily for the acute phase and cannot by itself define how to maintain a casualty for many hours or days when evacuation is delayed.

Future large-scale combat operations challenge the evacuation-dependent model. Long-range fires, contested airspace, drone surveillance, electronic warfare, difficult terrain, limited communications, and mass casualty surges can delay or deny movement to higher roles of care. Reports from the Russia–Ukraine conflict describe relocation of field hospitals farther from the front, delayed movement windows, severe fragmentation injuries, and

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Correspondence to:

Huaping Li
The 989th Hospital of the People's
Liberation Army Joint Logistics
Support Force
Department of Anesthesiology
No. 2, Huaxia West Road
Jianxi District
Luoyang
471031 Henan Province
China
lihuaping2026@126.com

rapid degradation of Role 2+ capabilities under sustained pressure [8, 9, 10]. These conditions create a practical gap between completing TCCC interventions and reaching definitive care.

This gap has both clinical and organizational consequences. Clinically, the casualty may require repeated assessment, blood or fluid decisions, analgesia adjustment, infection prevention, hypothermia control, respiratory monitoring, and preparation for deterioration rather than simple packaging for transport. Organizationally, the forward team must decide how long available supplies will last, how to divide personnel across casualties, when to request remote consultation, and how to communicate medical risk to commanders. Therefore, prolonged care should be regarded as a planned capability with defined boundaries rather than an accidental waiting period.

Prolonged Field Care (PFC) and Prolonged Casualty Care (PCC), emerged to address this gap, but the two terms are often used interchangeably, which can obscure the difference between a clinical practice package and a system capability. PFC was initially shaped by special operations and austere medicine experience, where small teams in remote areas expected delayed but eventual evacuation. PCC has evolved into a broader system-level concept for conventional forces operating when timely evacuation cannot be assumed. This distinction is important because the solution cannot be limited to teaching individual procedures; it must also define triggers, equipment, documentation, authority, consultation pathways, and quality assessment.

The present study restructures this topic as an original article using a literature-based model-construction approach. Its objectives are to distinguish PFC from PCC, identify the operational logic behind prolonged care, and propose an Echelon P model that can be inserted into traditional echeloned care without treating prolonged care as an improvised extension of TCCC alone. The intended contribution is not to replace the traditional Role system, but to make the prolonged interval between Role 1 and higher echelons visible, trainable, resourced, and assessable.

METHODS

This study used a structured narrative review and conceptual model-construction method. The source pool included military medical guidelines, position statements, clinical practice guidelines, operational reports, and peer-reviewed studies related to TCCC, PFC, PCC, delayed evacuation, far-forward resuscitation, austere wound care, prolonged monitoring, training, equipment configuration, documentation, and team resilience. Priority was given to sources published from 2022 to 2026, while foundational publications were retained when they introduced concepts that remain central to the development of the Golden Hour, TCCC, PFC, or PCC.

Documents were selected when they met at least one of the four criteria: they defined TCCC, PFC, or PCC; described delayed or disrupted evacuation in combat or austere environments; provided clinical or system

requirements for prolonged care; or offered evidence relevant to training, equipment, data capture, telemedicine, ethics, or resilience. Sources focused only on routine civilian trauma systems were excluded unless they informed the military prolonged-care problem. Serbian military medical literature was also checked, and a Serbian-authored source relevant to military medical evacuation and deployment stress was retained where appropriate [11].

Conceptual differentiation was performed by comparing PFC and PCC across six dimensions: origin, intended users, typical scenario, clinical and system capabilities, duration, and relationship to traditional echelons of care. This comparison was used to clarify whether prolonged care should be treated as a temporal delay, a clinical skill set, or a system layer. The Echelon P model was then developed by answering two implementation questions: when prolonged care should be activated, and how prolonged care should interface with higher medical, logistic, data, and command systems.

Data extraction focused on recurring operational and clinical requirements rather than on pooled statistical estimation. For each source, relevant information was grouped into the following categories: evacuation assumptions, care duration, provider level, resuscitation needs, wound and infection management, equipment burden, documentation, telemedicine, command decision support, and resilience or ethical concerns. This approach was selected because the available literature is heterogeneous, combining guidelines, reports, reviews, qualitative studies, and model papers. The goal was therefore to synthesize an implementable framework rather than to calculate a single effect size.

Model construction followed a pragmatic logic. First, operational triggers were identified from delayed evacuation, mission constraints, environmental limitations, and casualty-volume mismatch. Second, the minimum–better–best concept used in prolonged-care guidance was translated into a P0–P3 stratification that links time after injury with resource density and clinical complexity. Third, interface mechanisms were defined so that prolonged care would not become an open-ended responsibility isolated from the evacuation, resuscitation, documentation, and command chain. The resulting model was checked against recent guideline and operational evidence for conceptual consistency.

Ethics: An ethics statement was not required for this study type; no human or animal subjects or materials were used. The authors declare that the article was written in accordance with ethical standards of the Serbian Archives of Medicine as well as ethical standards of medical facilities for each author involved.

RESULTS

The first finding is that the evolution from the Golden Hour to TCCC and then to PFC/PCC reflects a shift in the dominant assumption of battlefield medicine. The Golden

Hour and traditional echeloned care assume that rapid movement to more capable facilities is normally available. TCCC improved survival within this framework by reducing preventable death during the immediate tactical phase. In contrast, PFC and PCC begin from the opposite premise: evacuation may be delayed, denied, or interrupted for reasons beyond the control of medical personnel. The problem is therefore not only how to perform early life-saving interventions, but how to sustain a casualty when the system that usually removes that casualty from the forward area is no longer reliable.

The second finding is that PFC and PCC have overlapping but distinct meanings. PFC originated in special operations and remote austere settings. It emphasizes advanced clinical tasks after TCCC has been completed, including serial reassessment, airway and respiratory support, circulation management, analgesia and sedation, infection prevention, hypothermia control, wound monitoring, nursing care, and preparation for delayed evacuation [1, 12]. PFC is usually delivered by advanced-trained personnel and is therefore close to a clinical module or practice set. PCC, by contrast, is broader. The recent Joint Trauma System and Committee on TCCC materials position PCC as a Role 1 system capability for all responders when timely or optimal medical care is limited by the tactical situation [13, 14, 15]. It includes clinical skills but also doctrine, training, equipment, capacity planning, telemedicine, documentation, ethical decision-making, and command integration.

The distinction between capability and capacity is central to PCC. Capability refers to what a team can do, such as start antibiotics, maintain an airway, monitor vital signs, perform wound care, or request teleconsultation. Capacity refers to how many casualties can be supported, for how long, and under what resource constraints. A team may have the capability to monitor one casualty for 24 hours but lack the capacity to care for several casualties during a mass casualty event. PCC therefore requires planners to connect clinical tasks with supply depth, manpower, rest cycles, communication reliability, and evacuation probability.

The third finding is that prolonged care is increasingly relevant to conventional operations, not only special operations. Evidence from Ukraine indicates that pre-hospital and forward care can be extended by battlefield geometry, drone threat, nighttime movement requirements, limited routes, damage to facilities, and attrition of Role 2+ capabilities [8, 9, 10]. In such circumstances, the forward echelon may face patients with severe blast or fragmentation injuries, ongoing hemorrhage risk, infection risk, hypothermia, pain, psychological distress, and delayed surgical access. The medical task therefore migrates from a short TCCC episode to a prolonged period of physiologic maintenance and resource management. This migration also increases the importance of blood availability, antibiotic timing, nursing tasks, communication, documentation, and triage decisions.

Based on these findings, this study proposes Echelon P as an independent capability layer rather than a new fixed facility. Echelon P is activated when specific triggers are met and then provides a structured pathway for sustained care until transfer to an appropriate level of care becomes

possible. The first category of triggers is evacuation delay beyond doctrinal or operational thresholds, for example more than two hours, more than six hours, or more than 24 hours. The second category is mission constraint, such as concealment requirements, ongoing contact, electronic suppression, inability to move during daylight, or lack of secure transport. The third category is capability or capacity mismatch, such as mass casualty events, extreme cold or altitude, depletion of blood or oxygen, limited communications, or simultaneous care for multiple unstable casualties.

The proposed P0-P3 stratification translates the time dimension into capability requirements. P0 – from injury to approximately two hours, remains the acute preventable-death phase. Its core is TCCC execution: hemorrhage control, airway positioning or adjuncts, chest injury management, circulation assessment, hypothermia prevention, analgesia when appropriate, and rapid documentation. The expected output of P0 is not definitive recovery but stabilization, prioritization, and transport readiness.

P1 – approximately 2–6 hours, is the sustained resuscitation and monitoring phase. At this point, the provider must repeat examinations, track vital signs, reassess tourniquets and dressings, continue hypothermia prevention, maintain analgesia and sedation safety, and determine whether the casualty is improving, deteriorating, or consuming resources faster than anticipated. P1 also requires an early estimate of available consumables, blood, oxygen, battery power, and personnel endurance. Failure at this level often occurs not because a single procedure is unknown, but because reassessment, documentation, and handover discipline decline under fatigue.

P2 – approximately 6–24 hours, is the multidimensional management phase. Infection prevention, wound care, sepsis awareness, pressure injury prevention, nutrition and hydration decisions, pain and anxiety control, urine output or perfusion monitoring, and communication with remote consultants become increasingly important [12, 14, 16]. If telemedicine is available, the forward team should transmit structured information rather than informal impressions. If evacuation remains uncertain, the team must also update triage categories and explain resource implications to commanders.

P3 – approximately 24–72 hours, is the systematic maintenance phase. It requires a more formal rhythm of care, including shift organization, medication and supply accounting, serial documentation, remote consultation, end-of-life decision preparation, and team resilience management. Prolonged Field Care Kit (PFAK) studies are particularly relevant at this level because they attempt to define a portable package capable of supporting prolonged objectives under weight and volume constraints [17, 18, 19]. The function of P3 is to prevent prolonged care from degrading into unmeasured improvisation; it turns sustained management into a documented, supervised, and logistically supported activity.

The P0-P3 structure should not be interpreted as rigid time compartments. A casualty can enter P2-level complexity before six hours if severe shock, sepsis concern, airway compromise, or environmental exposure develops

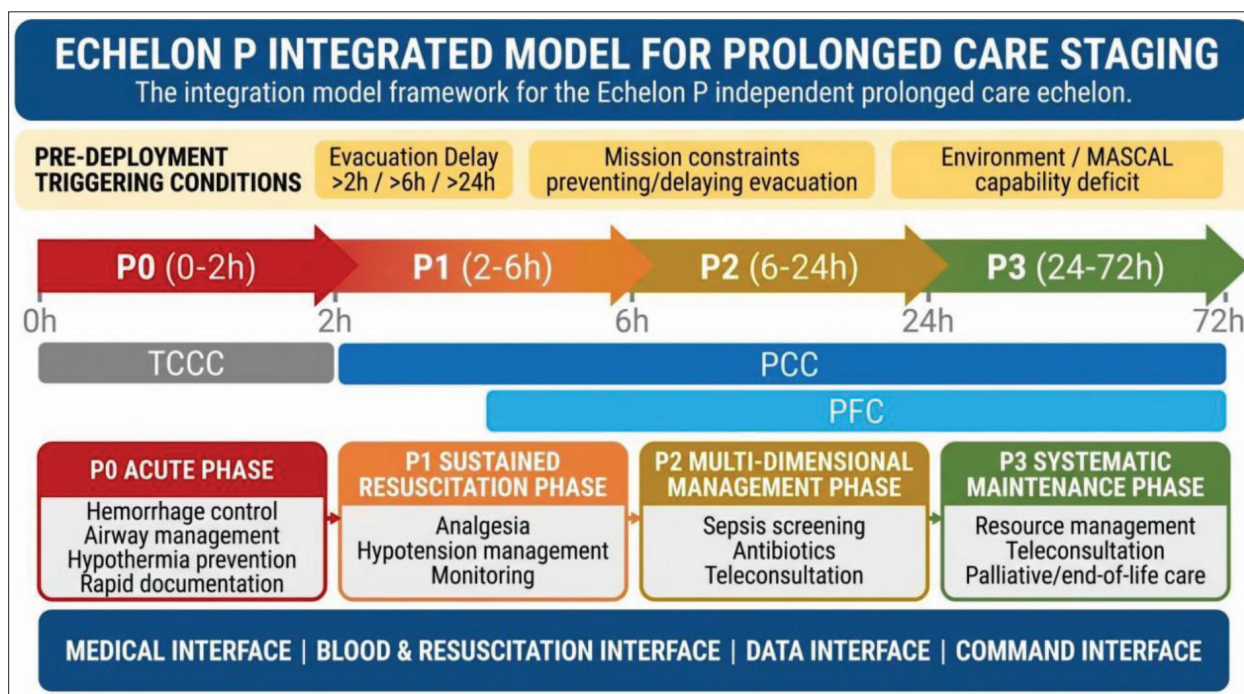


Figure 1. The Echelon P integrated model for prolonged care staging; the model links activation triggers, P0-P3 capability tiers, and four interface mechanisms; TCCC covers the immediate P0 phase, PCC covers the broader Role 1 prolonged-care framework, and PFC represents the continuation of PCC by advanced-trained personnel until transfer to an appropriate level of care becomes possible; MASCAL – mass casualty; h – hours; TCCC – tactical combat casualty care; PCC – prolonged casualty care; PFC – prolonged field care; P0 – acute phase (0–2 hours); P1 – sustained resuscitation phase (2–6 hours); P2 – multidimensional management phase (6–24 hours); P3 – systematic maintenance phase (24–72 hours)

early. Conversely, a stable casualty may remain within a lower capability demand for longer. The practical value of the stratification lies in its forcing function: as time passes, teams are reminded to reassess whether their clinical tasks, supplies, documentation, and consultation mechanisms have kept pace with the increasing risk profile.

Echelon P must also define interfaces. The medical interface determines which clinical findings require urgent evacuation or higher-level consultation, such as suspected sepsis, uncontrolled hemorrhage, airway failure, shock requiring blood products, or deterioration despite initial stabilization. The blood and resuscitation interface links forward providers to whole blood, component therapy, walking blood bank procedures, calcium replacement, and resuscitation priorities. The data interface uses TCCC cards, after-action review, registry-compatible documentation, and automated or simplified records to support quality improvement. The command interface translates medical risk into operational language, including expected resource consumption, likelihood of deterioration, evacuation priority, and ethical constraints. These interfaces are essential because prolonged care without defined boundaries can create unlimited expectations for forward teams.

Finally, the model highlights four support conditions. Equipment support should be modular, portable, environment-resistant, and aligned with P0-P3 needs. Training support should move beyond individual procedures toward scenario-based management, communication, team leadership, documentation, and resource allocation [20, 21]. Technical support should include remote consultation, decision prompts, and documentation tools that reduce

cognitive burden during long care intervals. Resilience support should address fatigue, moral injury, grief, team cohesion, and end-of-life care, because prolonged casualty holding may expose small teams to repeated loss and ethically difficult decisions [22, 23, 24]. The integrated relationships among activation triggers, P0-P3 capability tiers, prolonged-care concepts, and the four interface mechanisms are summarized in Figure 1.

DISCUSSION

This study makes three contributions. First, it separates PFC and PCC in a way that is useful for implementation. PFC should be understood as the advanced clinical continuation of care under austere conditions, whereas PCC should be understood as the broader capability framework that prepares the force for delayed or denied evacuation. This distinction matters because a military medical system can possess several PFC-trained providers and still lack a PCC capability if doctrine, equipment, blood supply, communication, documentation, and command interfaces are absent.

Second, the proposed Echelon P model converts prolonged care from a vague duration into an operational structure. The P0-P3 sequence shows that time itself changes the task. During the first minutes and hours, failure is dominated by preventable death and transport readiness. As the delay lengthens, the dominant risks shift toward physiologic deterioration, infection, hypothermia, pain, resource exhaustion, documentation loss, team fatigue, and ethical complexity. This view helps explain why

simply adding more supplies or teaching more procedures is not enough. A prolonged-care system must know when to activate, what capability to bring forward, what information to record, and when to request help.

Third, Echelon P offers a way to connect prolonged care with the traditional role system. It does not propose a separate hospital echelon or a replacement for evacuation. Instead, it formalizes the interval in which evacuation is not yet possible and prevents this interval from being invisible in planning. The model therefore supports resilience: it allows forward teams to continue care in a structured way, while still treating evacuation and definitive care as the final objective. This is especially important in high-intensity conflicts, where forward facilities may need to displace frequently and casualty movement may be governed by enemy fires rather than medical preference.

The model also has implications for training. TCCC training should remain the foundation, but prolonged-care training should start after TCCC mastery and should use longer scenarios that force teams to reassess, document, communicate, ration, hand over, and explain medical risk to commanders. Existing data on incomplete adherence to analgesia and tranexamic acid guidelines suggest that even relatively defined TCCC tasks are difficult to execute consistently [25, 26]. PCC tasks are more complex and therefore require repeated simulation, checklists, and objective assessment rather than lectures alone.

Equipment planning should also follow the P0-P3 logic. A first-line kit optimized for P0 cannot support P3 care by itself, while a full prolonged-care package may be too heavy for dismounted teams. PFAK development studies show the need to balance portability with meaningful capability, including medication, monitoring, wound care, documentation, and environmental protection [17, 18, 19]. The correct solution may be layered: individual TCCC equipment for P0, team-level modules for P1-P2, and mission-specific augmentation for P3 or extreme environments.

Implementation should be incremental. A practical starting point is to define activation thresholds and minimum documentation standards, because these two elements require relatively little equipment but immediately change behavior. The next step is to build modular equipment lists for likely missions and to train teams in prolonged scenarios that last long enough to expose fatigue, communication gaps, and supply depletion. Higher-level medical authorities should then review after-action data to refine triggers, revise kits, and identify training deficiencies. This cycle would turn Echelon P from a theoretical construct into a quality-improvement mechanism.

This study has limitations. It is primarily based on foreign military guidelines, published studies, and operational reports, especially from the US- and Ukraine-related sources. Applicability to another military medical system depends on differences in doctrine, equipment, evacuation assets, command relationships, personnel structure, and operating environment. The Echelon P model is also conceptual and has not yet been validated in field exercises or real operations. In addition, ethical issues such as end-of-life care, resource allocation, and communication

with commanders require local cultural and institutional adaptation.

Future research should test the model through tabletop exercises, simulation, and field training. Evaluation indicators could include time to activation, documentation completeness, appropriateness of evacuation requests, ability to maintain vital sign monitoring, blood and medication use, team fatigue, and casualty outcomes. Equipment studies should compare PFAK configurations under weight and volume constraints. Training studies should determine whether P0-P3 scenarios improve performance compared with TCCC-only instruction. Finally, registry-compatible documentation should be designed before implementation so that prolonged care can be measured and improved rather than remembered only through anecdote.

Local adaptation will be necessary before direct application. Different forces may have different evacuation platforms, blood-product policies, telemedicine access, and training pipelines. Therefore, the model should be used as a framework rather than a fixed checklist. Units can map their current assets against P0-P3 requirements, identify the point at which care becomes unsafe, and then decide whether the gap should be closed through additional supplies, training, communication support, or changes in evacuation planning. This mapping process may be the most immediate practical use of Echelon P.

CONCLUSION

Modern combat casualty care is entering a phase in which rapid evacuation can no longer be assumed. TCCC remains the foundation for preventable death control, but prolonged evacuation demands additional clinical, logistical, ethical, and command capabilities. PFC provides the clinical continuation of care by advanced-trained personnel, whereas PCC provides the broader system framework for all Role 1 responders when evacuation is delayed or denied.

The proposed Echelon P model translates prolonged care into an operational structure built on activation triggers, P0-P3 capability tiers, and medical, blood/resuscitation, data, and command interfaces. This model can help prevent prolonged care from being treated as an improvised exception and instead make it a planned, trainable, assessable, and resource-supported part of military medical resilience. Future implementation should proceed through doctrine refinement, modular equipment design, scenario-based training, telemedicine and documentation support, and standardized quality assessment.

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Изградња ешелонираног система продуженог збрињавања на терену за прекинуте ланце евакуације повређених

Тао Ју¹, Бо Чен², Менгсја Ли³, Келијанг Сунг⁴, Ђунсјао Ванг⁵, Хуапинг Ли⁶

¹989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за стоматологију, Луојанг, провинција Хенан, Кина;

²989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за ортопедију, Луојанг, провинција Хенан, Кина;

³989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за ортопедију и хирургију зглобова, Луојанг, провинција Хенан, Кина;

⁴989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за ургентну медицину, Луојанг, провинција Хенан, Кина;

⁵989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за општу хирургију, Луојанг, провинција Хенан, Кина;

⁶989. болница Здружених снага за логистичку подршку Народноослободилачке војске Кине, Одељење за анестезиологију, Луојанг, провинција Хенан, Кина

САЖЕТАК

Увод/Циљ Циљ рада је анализирати еволуцију савременог збрињавања повређених у борбеним условима – од концепта Златног сата и тактичког збрињавања повређених у борбеним условима (*Tactical Combat Casualty Care – TCCC*) до продуженог збрињавања на терену (*Prolonged Field Care – PFC*) и продуженог збрињавања повређених (*Prolonged Casualty Care – PCC*), као и конструисати модел „Echelon P” за ситуације у којима је евакуација повређених одложена или прекинута.

Методе Примењени су структурирана анализа литературе, концептуално разграничење и приступ конструкцији модела. Анализиране су иностране војномедицинске смернице, званични ставови, оперативни извештаји и рецензиране студије о продуженом збрињавању повређених, уз давање приоритета литератури објављеној у периоду од 2022. до 2026. године. Извршено је поређење концепата *PFC* и *PCC* према пореклу, циљним корисницима, оперативном сценарију, захтеваним способностима, временском оквиру и повезаности са традиционалним ешелонима медицинског збрињавања.

Резултати Докази указују на померање тежишта са збрињавања које зависи од брзе евакуације ка одрживом збри-

њавању на предњим положајима у оспораваним борбеним условима. Концепт *PFC* представља првенствено клинички наставак *TCCC*-а који спроводи додатно обучено медицинско особље, док *PCC* представља системски оквир за све пружаоце медицинске помоћи на првом нивоу (енгл. *Role 1*) у ситуацијама када је благовремена евакуација ограничена или онемогућена. Предложени модел „Echelon P” обухвата услове за активацију, нивое способности *P0–P3*, као и интерфејсе са медицинским, трансфузиолошким/ресусцитационим, информационим и командним системима.

Закључак Увођење продуженог збрињавања као независног нивоа способности може унапредити отпорност војномедицинске подршке у будућим операцијама високог интензитета. Примену овог концепта треба усмерити на развој доктрине, обуку, модуларизацију опреме, подршку путем телемедицине, документацију и процену квалитета.

Кључне речи: збрињавање повређених у борбеним условима; Златни сат; тактичко збрињавање повређених у борбеним условима; продужено збрињавање на терену; продужено збрињавање повређених; отпорност војномедицинске подршке