WHOLE BLOOD AT THE POINT OF INJURY IN PROLONGED FIELD CARE: A PROTOCOL FOR DELAYED TACTICAL EVACUATION SCENARIOS

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Abstract: Haemorrhage remains the leading cause of potentially survivable death on the battlefield, and whole blood transfusion close to the point of injury is now established as the resuscitation of choice. The doctrine that surrounds it, however, was written for the golden hour, a world in which a casualty reaches surgery within sixty minutes, and that world is disappearing. In large-scale combat operations against a peer adversary, evacuation may be delayed for many hours, and the medic who gives a single unit of whole blood and waits for a helicopter that does not come is left without a plan. This article develops that plan. Its original contribution is the Point-of-Injury Whole Blood protocol for Prolonged Field Care, a phased and titratable resuscitation algorithm built specifically for delayed evacuation, together with the underlying argument that the prolonged scenario requires four departures from golden-hour practice: a shift from a single fixed bolus to a titratable resuscitation governed by a sustained permissive perfusion endpoint; a serial walking-blood-bank cycle that turns a finite blood supply into a renewable one; an explicit time-indexed monitoring loop for the metabolic derangements, hypocalcaemia, hypothermia, and acidosis, that accumulate over hours of transfusion and that short-evacuation protocols can neglect; and the integration of these into one decision algorithm a far-forward provider can follow without laboratory or imaging support. The protocol is grounded in an evidence synthesis, presented as a narrative forest plot of mortality estimates from recent trials and cohorts, that supports the efficacy of whole blood and early transfusion while acknowledging the null findings that temper it. The protocol is presented as two figures and two tables: a clinical algorithm, a forest plot of the supporting evidence, a comparison of the golden-hour and prolonged-care paradigms, and a time-indexed schedule for the accumulating metabolic threats. The protocol is an evidence-informed design and not a validated standard; it generates specific, testable predictions that the article specifies for prospective field evaluation.

Keywords: *whole blood, point of injury, prolonged field care, damage control resuscitation, walking blood bank, delayed evacuation, haemorrhagic shock.*

INTRODUCTION

The single most important advance in battlefield resuscitation of the past decade is also the simplest: give blood, and give it early. Whole blood transfused close to the point of injury has displaced crystalloid and even component therapy as the resuscitation of choice for the casualty in haemorrhagic shock, a shift codified in tactical-combat-casualty-care guidance and supported by a rapidly growing evidence base (Deaton et al., 2021; Gurney et al., 2022). The logic is sound and the data increasingly favourable, but the doctrine rests on an assumption that the next war may not honour. That assumption is the golden hour, the expectation that a casualty given initial resuscitation will reach surgical care within roughly sixty minutes, and the entire architecture of point-of-injury transfusion, a unit or two of blood to bridge the casualty to the operating table, is built upon it (Remondelli et al., 2023).

In a war of air superiority and uncontested evacuation that assumption holds. In large-scale combat operations against a peer adversary who contests the air and interdicts the ground lines of evacuation, it does not, and casualties may remain in the care of a far-forward provider for many hours or even days before evacuation becomes possible (Remondelli et al., 2023; Tadlock et al., 2024). This is the domain of prolonged field care, and it changes the resuscitation problem fundamentally. A single unit of whole blood that would bridge a casualty across the golden hour cannot sustain one across a twelve-hour wait; the perfusion it restores will ebb, the blood supply will run out, and the metabolic costs of transfusion that scarcely matter over sixty minutes accumulate dangerously over a day. The medic trained for the golden hour, having given that single unit, is left to improvise. The central research question of this article follows directly: what should a point-of-injury whole blood protocol look like when evacuation is delayed for hours rather than minutes?

The existing literature supplies the components of an answer but not the answer itself. The transfusion literature establishes that whole blood and early blood work; the prolonged-care literature establishes that delayed evacuation is the emerging reality; the damage-control-resuscitation literature establishes the principles of balanced, hypotensive resuscitation; and the adjunct literature establishes that calcium, temperature, and coagulation must be managed (LaGrone et al., 2024; Moore et al., 2021; Kronstedt et al., 2022). What is missing is an integrated protocol that takes the proven point-of-injury whole blood intervention and extends it across the prolonged timeline, specifying how to sustain it, how to renew the blood supply, and how to manage the costs that time imposes. This article provides that integration.

Three propositions structure the argument, stated as testable hypotheses. The first is an efficacy premise: whole blood and early transfusion at or near the point of injury reduce early mortality in haemorrhagic shock relative to crystalloid or delayed transfusion, a premise the article supports with a synthesis of recent evidence. The second is an insufficiency claim: in delayed-evacuation prolonged field care, a single fixed point-of-injury transfusion is insufficient, and sustaining perfusion requires a titratable, phased protocol with serial walking-blood-bank collection that is feasible within documented far-forward capability. The third is an accumulation claim: the metabolic complications of transfusion, hypocalcaemia, hypothermia, and acidosis, accumulate as a function of time and transfused volume and must be managed by a time-indexed monitoring loop that golden-hour-oriented protocols omit, and embedding that loop is necessary for safe prolonged transfusion.

The original contribution of this article is the protocol these propositions support, which I term the Point-of-Injury Whole Blood protocol for Prolonged Field Care. It is, to my knowledge, the first integrated and diagrammed algorithm to extend point-of-injury whole blood from a golden-hour bridge into a sustained, titratable resuscitation strategy for delayed evacuation, and its novelty lies in four linked departures from golden-hour practice: a titratable endpoint replacing the fixed bolus, a serial walking-blood-bank cycle replacing the finite supply, a time-indexed metabolic-monitoring loop replacing the brief and largely unmonitored golden-hour course, and the integration of all three into a single algorithm a far-forward provider can execute without laboratory or imaging support. The contribution is a design grounded in current evidence, not a validated standard, and the article is explicit about the prospective evaluation it requires.

The article proceeds as follows. The next section reviews the transfusion and prolonged-care literatures and states the method. A results section presents the evidence synthesis as a forest plot, the protocol as an algorithm, and two comparative tables. Four analytical sections then develop the argument, treating the efficacy premise, the failure of the golden-hour paradigm under delay, the sustaining of resuscitation through titration and the serial walking blood bank, and the time-indexed metabolic loop. A conclusion returns to the three propositions, states the limitations, and specifies the field evaluation the protocol now requires.

LITERATURE REVIEW AND METHODOLOGY

Literature Review

The transfusion literature is the foundation, and it has converged with unusual speed. Large civilian cohorts now associate whole blood, used alongside or instead of component therapy, with improved survival in severe haemorrhage: a multicentre study found cold-stored whole blood associated with substantially lower in-hospital mortality (Hazelton et al., 2022), and analyses across United States and Canadian trauma centres reported lower mortality at twenty-four hours and thirty days with whole blood added to massive-transfusion protocols (Torres et al., 2023). Low-titre group O whole blood has been associated with fewer total transfusions and an independent survival benefit (Shea et al., 2024), the interaction between whole blood and components has been shown to favour higher whole-blood ratios (Dorken-Gallastegi et al., 2024), and a meta-analysis of low-titre whole blood reported improved early survival (Morgan et al., 2024). Systematic review and meta-analysis of whole blood versus component therapy found lower pooled twenty-four-hour mortality in civilian patients (van der Horst et al., 2023). The military evidence points the same way, with warm fresh whole blood at the far-forward edge associated with reduced early mortality in severely injured combat casualties (Gurney et al., 2022), and combat data showing a mortality gradient by the quantity and balance of products transfused (Gurney et al., 2023; April et al., 2023; Banerjee et al., 2025).

The evidence is not uniformly positive, and an honest synthesis must say so. The prehospital randomised trial of whole blood for trauma and haemorrhage did not show a thirty-day mortality benefit (Sperry et al., 2026), the randomised trial of prehospital red cells and lyophilised plasma found no improvement in episode mortality (Crombie et al., 2022), and meta-analyses of civilian prehospital transfusion and of prehospital plasma have returned null pooled estimates (Schoenfeld et al., 2024; Abuelazm et al., 2024). Yet the benefit re-emerges precisely where this article's problem lies: a pooled analysis of two trials found a significant survival benefit of prehospital plasma when transport times exceeded twenty minutes (Pusateri et al., 2020), and whole blood showed its clearest benefit in the subgroups at highest risk of death (Sperry et al., 2023). The signal that early blood helps most when the casualty is sickest and the journey is longest is the empirical warrant for extending it into the prolonged-care setting. The paediatric evidence, while outside the military adult focus, adds consistency, associating prehospital and whole-blood transfusion with lower mortality across populations (Morgan et al., 2023; Gaines et al., 2023; Campwala et al., 2025).

The second literature concerns prolonged care and the conditions that make this article necessary. The casualty-care implications of large-scale combat operations against a peer adversary, including delayed and contested evacuation, have been set out directly (Remondelli et al., 2023), and the prolonged-casualty-care concept has been extended to demanding environments such as the maritime and the arctic (Tadlock et al., 2024;

Rund, 2023). The damage-control-resuscitation principles that govern the approach, balanced product ratios and permissive hypotension, have been consolidated into a contemporary clinical protocol (LaGrone et al., 2024), and the far-forward logistics that make sustained transfusion possible, the walking blood bank in which fellow service members donate fresh whole blood on demand, are documented in deployed practice (Song et al., 2023). The fluid-resuscitation guidance of tactical combat casualty care provides the doctrinal anchor (Deaton et al., 2021).

The third literature concerns the costs that time imposes, the adjuncts and complications of sustained transfusion. Tranexamic acid reduces mortality from traumatic haemorrhage and is supported by recent prehospital trial and review evidence (PATCH-Trauma Investigators, 2023; Thomas et al., 2025). Hypocalcaemia is increasingly recognised as a central and early derangement, correlating with coagulopathy, transfusion requirement, and mortality, and arguing for empiric calcium rather than delayed correction (Kronstedt et al., 2022; Helsloot et al., 2023). Hypothermia independently worsens outcome and compounds coagulopathy, the more so in cold and prolonged evacuation (Azarkane et al., 2024; Rund, 2023), and trauma-induced coagulopathy itself, the mechanistic core of the lethal triad, is now understood in detail (Moore et al., 2021). Together these establish that prolonged transfusion is not simply more of the golden-hour intervention but a qualitatively different undertaking whose metabolic costs must be actively managed, and that recognition is what the present protocol operationalises.

Research Methodology

This article is an original protocol-development study using structured evidence synthesis, and I should state plainly what that is and is not. It does not report a clinical trial; it designs a protocol by integrating the best current evidence and specifies the predictions by which the protocol can be tested. The method had three steps. First, the relevant literature was identified through structured searches of Scopus, PubMed, and Crossref, combining a whole-blood and point-of-injury transfusion set of terms with a prolonged-field-care, damage-control-resuscitation, and adjunct set, restricted to peer-reviewed work from 2019 onward except for a single landmark ratio-therapy trial retained for foundational context. Second, the mortality evidence for whole blood and early transfusion was synthesised narratively, and the reported effect estimates were assembled into a forest plot to display both the direction of benefit and its heterogeneity. Third, the protocol was constructed by mapping the proven point-of-injury intervention onto the prolonged-care timeline and resolving, at each step, the problems that the timeline introduces: how to titrate rather than bolus, how to renew the blood supply, and how to manage the accumulating metabolic costs.

The synthesis is presented as a narrative forest plot in Figure 2 rather than as a formal meta-analysis, and the distinction matters. The included estimates are heterogeneous in metric, hazard ratios, odds ratios, and relative risks, in population, and in outcome timepoint, so they cannot be statistically pooled into a single summary estimate without violating the assumptions such pooling requires. The forest plot therefore displays each verified estimate with its confidence interval against a common reference line, as a transparent depiction of the evidence base, and the values are quoted exactly as reported in the source studies. I want to be candid that this is a deliberately conservative use of the figure: it shows the weight and the spread of the evidence, including the null and unfavourable findings, without claiming a precision the underlying heterogeneity does not support. The protocol itself, presented in Figure 1, is an evidence-informed design, and its specific thresholds and intervals are reasoned recommendations, not empirically optimised values.

Four limitations are intrinsic to this design and are stated here rather than deferred. First, the protocol is a synthesis and has not been prospectively validated; its thresholds, the titration endpoint, the monitoring interval, the calcium schedule, are reasoned from the evidence but require field evaluation. Second, the efficacy evidence is dominated by golden-hour and short-transport settings, so its extrapolation to the multi-hour prolonged scenario is an inference, supported by the transport-time and high-risk-subgroup signals but not by direct trial data in the prolonged context. Third, the walking-blood-bank and titration elements assume far-forward capability and trained personnel that may not be uniformly available, so the protocol describes a target standard rather than a universal minimum. Fourth, the synthesis is narrative and not a systematic meta-analysis, so it is subject to the selection and weighting judgements that such an approach entails, which I have tried to make transparent by including the unfavourable evidence explicitly.

RESEARCH RESULTS

The results are presented in three parts: the synthesised efficacy evidence, the protocol algorithm, and the two comparative tables that specify its departures from golden-hour practice and its metabolic-monitoring schedule. Interpretation is developed in the analytical sections that follow.

The efficacy evidence, assembled in Figure 2, supports the first proposition while displaying the heterogeneity that qualifies it. Across recent cohorts and trials the central tendency favours whole blood and early transfusion, with mortality effect estimates clustering below the line of no effect, from a twenty-four-hour hazard ratio of 0.63 with whole-blood-augmented massive transfusion (Torres et al., 2023) and a pooled twenty-four-hour odds ratio of 0.72 for whole blood versus components (van der Horst et al., 2023) to the strong benefit seen in the highest-risk subgroups and when transport is prolonged (Sperry et al., 2023; Pusateri et al., 2020). The figure also shows the countervailing evidence honestly, including the null pooled estimate of a prehospital-transfusion meta-analysis and the non-significant result of the prehospital whole-blood randomised trial, whose confidence intervals cross the line of no effect (Schoenfeld et al., 2024; Sperry et al., 2026). The overall picture is of a real but context-dependent benefit, strongest where the casualty is sickest and the journey longest, which is the warrant for the protocol that follows.

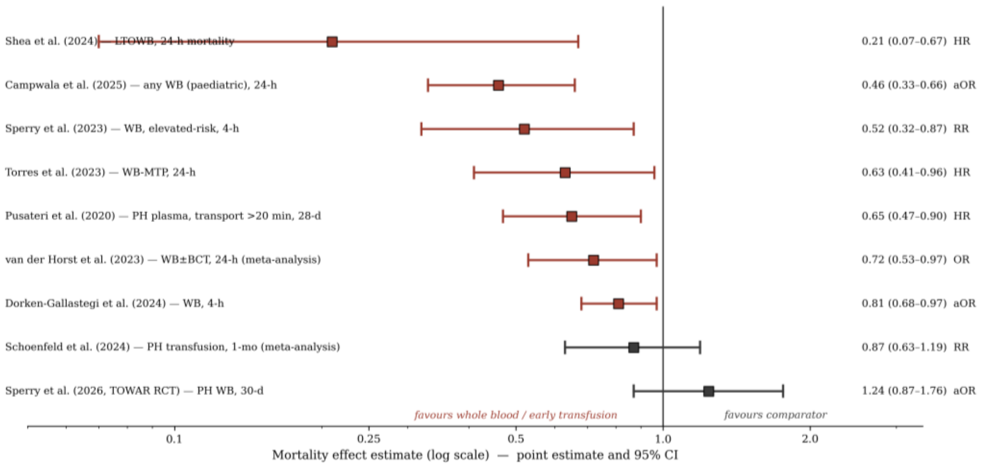

Figure 2. Narrative forest plot of mortality effect estimates for whole blood / early transfusion versus comparators in haemorrhage. Each square is a point estimate with its 95% confidence interval; the vertical line marks no effect; estimates below 1.0 favour whole blood or early transfusion. Metrics are heterogeneous (HR, OR, RR) and are not statistically pooled. Values are quoted exactly as reported in the cited studies. Source: author, from the cited literature.

The protocol itself, shown in Figure 1, operationalises the second and third propositions as a single decision algorithm. After standard tactical-combat-casualty-care measures to control compressible haemorrhage and the administration of tranexamic acid, the algorithm initiates point-of-injury whole blood when signs of haemorrhagic shock are present, judged without laboratory support by the character of the radial pulse, the casualty's mentation, and a shock index above one. It then departs from golden-hour practice in three linked ways that the figure makes explicit: it titrates transfusion to a sustained permissive perfusion endpoint reassessed after every unit rather than delivering a fixed bolus; it renews the blood supply through a serial walking-blood-bank cycle when a single unit proves insufficient; and it runs a continuous time-indexed monitoring loop, recurring every thirty to sixty minutes, that manages temperature, calcium, and the recurrence of shock across the prolonged course.

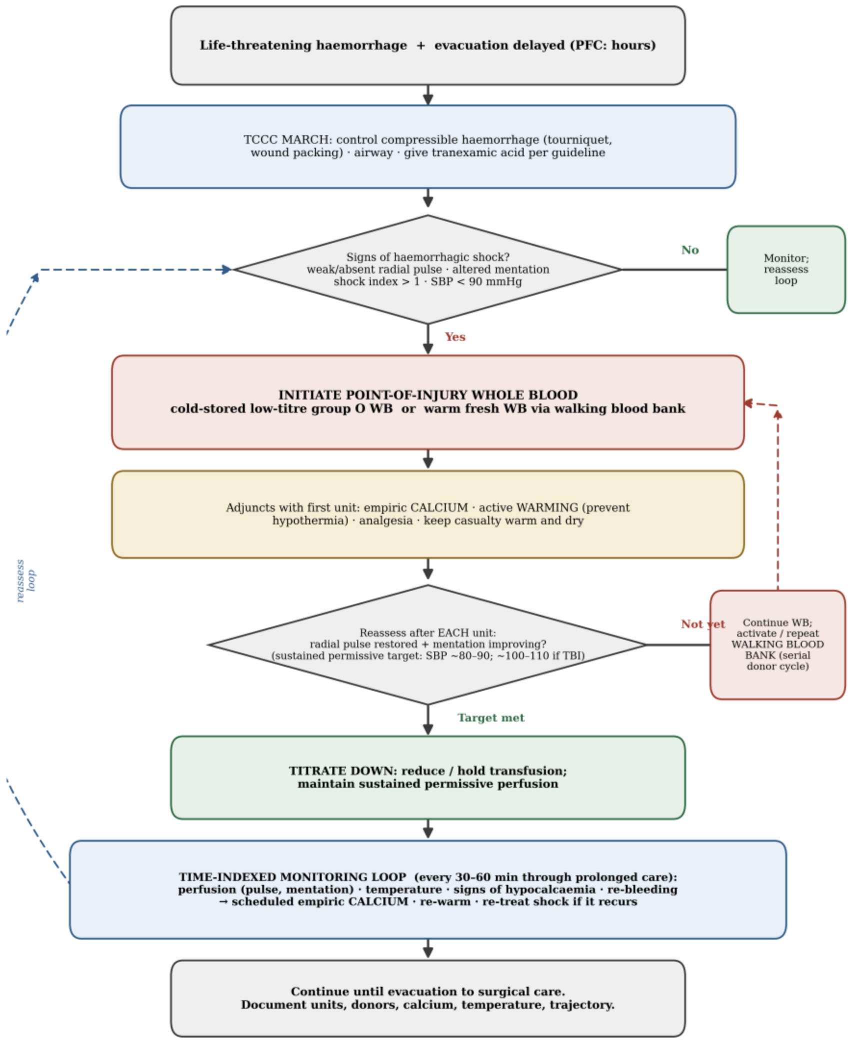

Figure 1. The Point-of-Injury Whole Blood protocol for Prolonged Field Care (POI-WB/PFC): a phased, titratable resuscitation algorithm for delayed tactical evacuation. The four novel elements are the sustained permissive titration endpoint, the serial walking-blood-bank loop, the empiric calcium and warming adjuncts, and the time-indexed metabolic-monitoring loop. Thresholds are reasoned recommendations pending field validation. Source: author.

Table 1 specifies the protocol's departures from golden-hour practice across the dimensions that matter operationally, and Table 2 details the time-indexed management of the metabolic threats that accumulate over a prolonged transfusion, each drawn from the adjunct literature (Kronstedt et al., 2022; Helsloot et al., 2023; Azarkane et al., 2024; Moore et al., 2021).

Dimension	Golden-hour paradigm	POI-WB/PFC protocol (this article)
Goal	Bridge to surgery within ~60 min	Sustain perfusion across hours of delay
Endpoint	Fixed bolus (1–2 units)	Titrate to sustained permissive perfusion, reassessed each unit
Blood supply	Finite carried stock	Renewable via serial walking blood bank
Adjunct timing	Often deferred to surgical facility	Empiric calcium + warming from the first unit
Monitoring	Brief, largely unmonitored transit	Time-indexed loop every 30–60 min
Endpoint of care	Hand-off at surgery	Continue + document until evacuation possible

Table 1. The golden-hour point-of-injury transfusion paradigm versus the proposed POI-WB/PFC protocol.

Threat	Mechanism in prolonged transfusion	PFC monitoring / action
Hypocalcaemia	Citrate chelation; worsens with each unit; impairs clotting	Empiric calcium after first unit; repeat per units / signs (Kronstedt et al., 2022)
Hypothermia	Cold blood + exposure + shock; impairs coagulation	Warm casualty and products; insulate; monitor temp (Azarkane et al., 2024)
Acidosis	Hypoperfusion + stored-blood load; impairs clotting	Restore perfusion; avoid over-transfusion; reassess trajectory (Moore et al., 2021)
Coagulopathy	The lethal-triad core; amplified over time	Balanced whole blood + TXA + correct the triad (LaGrone et al., 2024)

Table 2. Accumulating metabolic threats in prolonged transfusion and their time-indexed management.

The results, taken together, specify a protocol that is evidence-grounded in its premise and explicit in its departures. The forest plot grounds the decision to transfuse; the algorithm operationalises how to sustain it under delay; and the two tables specify what the golden-hour paradigm omits and what the prolonged course demands. The analytical sections justify each element.

THE EFFICACY PREMISE: WHOLE BLOOD AND EARLY TRANSFUSION REDUCE EARLY MORTALITY

The protocol rests on a premise that must be defended before its design can be justified: that giving blood early saves lives. The premise is supported, though not unanimously, and the honest reading of the evidence is the one the forest plot displays. The weight of recent observational evidence associates whole blood with lower early mortality, in multicentre cohorts of severe haemorrhage (Hazelton et al., 2022; Torres et al., 2023), in analyses of the whole-blood-to-component ratio (Dorken-Gallastegi et al., 2024), and in meta-analysis of whole blood against component therapy (van der Horst et al., 2023; Morgan et al., 2024). The military evidence, generated in precisely the population this article concerns, points the same way, associating far-forward warm fresh whole blood and a favourable transfusion balance with reduced early combat mortality (Gurney et al., 2022; Gurney et al., 2023). The direction is consistent enough, and the mechanism, replacing shed blood with the thing most like it, plausible enough, that the premise can carry the protocol's weight.

The countervailing evidence sharpens rather than overturns this conclusion, and the protocol is designed in full view of it. The randomised trials are more equivocal than the cohorts: the prehospital whole-blood trial did not reach significance for thirty-day mortality, and the prehospital red-cell-and-plasma trial was null (Sperry et al., 2026; Crombie et al., 2022), as were pooled analyses of civilian prehospital transfusion and prehospital plasma (Schoenfeld et al., 2024; Abuelazm et al., 2024). A premise that ignored these would be propaganda rather than science. But two features of the discordance matter for the present argument. The first is that observational benefit and trial nullity can coexist when the trials are underpowered for the sickest patients or diluted by those who would have survived anyway, and the second is that the benefit re-emerges, even in the trial-derived evidence, exactly where this article operates.

That re-emergence is the empirical hinge of the whole article. When transport times exceed twenty minutes, the pooled trial evidence shows a significant survival benefit of prehospital plasma, with a twenty-eight-day hazard ratio of 0.65 (Pusateri et al., 2020), and whole blood shows its clearest and largest benefit in the subgroups at the highest probability of death (Sperry et al., 2023). The signal is coherent: early blood helps most when the casualty is sickest and the evacuation longest, which is the definition of the prolonged-field-care casualty. The protocol does not extrapolate a uniform benefit to all casualties; it targets the intervention at the population in whom even the cautious trial evidence shows it works, and it then asks the question the trials do not, which is how to sustain that intervention when the long transport becomes a very long one.

There is a boundary to the premise that the protocol respects rather than obscures. The evidence concerns the giving of blood, not the giving of unlimited blood, and over-transfusion carries its own costs in dilution, metabolic load, and the depletion of a scarce far-forward supply (Banerjee et al., 2025; April et al., 2023). The premise therefore supports not maximal transfusion but titrated transfusion, enough to sustain perfusion and no more, which is precisely the endpoint the protocol adopts. The efficacy evidence, read carefully, licenses the protocol's central move from bolus to titration as much as it licenses transfusion itself.

WHY THE GOLDEN-HOUR PARADIGM FAILS IN DELAYED EVACUATION

The second proposition is that the golden-hour model of point-of-injury transfusion fails when evacuation is delayed, and the failure is structural rather than incidental. The golden-hour protocol is a bridge: it assumes that a finite intervention, a unit or two of blood, need only hold the casualty until definitive surgical control of haemorrhage arrives within the hour (Remondelli et al., 2023; Deaton et al., 2021). Every feature of that protocol, the fixed dose, the carried supply, the deferral of metabolic management to the surgical facility, the minimal monitoring, is rational under that assumption and irrational without it. When the bridge has no far bank, when surgery is hours or days away because a peer adversary has contested the air and the roads, the assumptions invert and the protocol's rational features become liabilities (Remondelli et al., 2023; Tadlock et al., 2024).

Consider each feature under delay. The fixed bolus, adequate to bridge sixty minutes, cannot sustain perfusion across twelve hours, because ongoing or recurrent bleeding and the redistribution of fluid will erode the restored circulation, and a protocol with no provision for re-dosing leaves the provider watching the casualty deteriorate with no instruction (LaGrone et al., 2024). The carried supply, sufficient for a bridge, is exhausted by a sustained resuscitation, and a protocol that does not renew it simply runs out (Song et al., 2023). The deferral of calcium and warming to the surgical facility, harmless over an hour, becomes dangerous over a day, because the metabolic derangements that the facility would have corrected instead accumulate unmanaged in the field (Kronstedt et al., 2022; Azarkane et al., 2024). And the minimal monitoring appropriate to a brief transit is inadequate to a prolonged course in which the casualty's state will change repeatedly. The golden-hour protocol does not merely become less effective under delay; each of its design choices becomes actively wrong.

The deeper point is that prolonged field care is not a longer version of golden-hour care but a different task, and the resuscitation literature has begun to recognise this even where it has not yet operationalised it. The damage-control-resuscitation principles of balance and permissive hypotension were articulated for the acute phase, yet their logic, give what is lost in the proportions it is lost, sustain perfusion without provoking rebleeding, extends naturally into the prolonged phase if the protocol is built to apply them over time rather than once (LaGrone et al., 2024). The prolonged-care concept, in turn, supplies the timeline but has not been integrated with the point-of-injury transfusion that is now standard practice (Remondelli et al., 2023; Tadlock et al., 2024). The gap the protocol fills is exactly this junction: the proven intervention of golden-hour transfusion and the emerging reality of prolonged care have not been joined, and joining them requires the four departures the protocol specifies.

It would be a mistake to read this as a wholesale rejection of golden-hour doctrine, and the protocol does not. The golden-hour approach remains correct when evacuation is rapid, and the protocol's early steps are continuous with it, control haemorrhage, give tranexamic acid, transfuse for shock. The protocol diverges only where the timeline diverges, branching from the shared early pathway into a sustained resuscitation when evacuation is delayed. This continuity is deliberate, because a far-forward provider should not have to learn two unrelated protocols but should follow one algorithm that adapts to the evacuation reality, and the protocol is designed so that the prolonged-care pathway is the golden-hour pathway with the delay-specific elements added rather than a separate doctrine.

SUSTAINING RESUSCITATION: TITRATION AND THE SERIAL WALKING BLOOD BANK

The first two departures of the protocol, the titratable endpoint and the renewable supply, together solve the problem of sustaining resuscitation across the delay, and they are best understood as a pair. Titration replaces the fixed bolus with a perfusion target that the provider maintains over time, transfusing not a set quantity but the quantity required to keep the casualty at a sustained permissive endpoint, a palpable radial pulse and preserved mentation, reassessed after every unit (LaGrone et al., 2024). The endpoint is permissive because over-resuscitation to a normal blood pressure can dislodge clot and provoke rebleeding before haemorrhage is surgically controlled, and it is sustained because, unlike the golden-hour bolus that need only hold for an hour, the prolonged-care target must be held for as long as evacuation is delayed. The protocol raises the target where a concomitant traumatic brain injury makes cerebral perfusion the priority, reflecting the standard tension between permissive hypotension and the injured brain (LaGrone et al., 2024).

Titration is only sustainable if the blood supply is renewable, and this is where the walking blood bank becomes not a contingency but a core element of the protocol. The walking blood bank, in which screened fellow service members donate fresh whole blood on demand, converts a finite carried supply into a renewable one, and it is documented in deployed far-forward practice as a feasible source of whole blood when stored product is unavailable or exhausted (Song et al., 2023; Gurney et al., 2022). The protocol's innovation is to schedule it: rather than treating donor collection as a desperate last resort, the algorithm activates a serial donor cycle as soon as a single unit proves insufficient, establishing a cadence of collection that can sustain a titrated resuscitation over hours. This converts the walking blood bank from an emergency improvisation into a planned logistic loop, which is what prolonged care requires.

The serial collection of fresh whole blood under prolonged conditions raises practical and safety questions that the protocol must address rather than assume away. Donor selection and rotation must respect the physiological limits of the donors, who are themselves operational personnel that cannot be bled without cost to the mission and their own safety, so the protocol specifies a cadence and donor pool rather than open-ended collection. Screening under field conditions is necessarily abbreviated, accepting a managed transfusion risk in exchange for the larger and more immediate benefit of sustaining perfusion in a casualty who will otherwise die of haemorrhage, a trade-off the far-forward literature has long accepted for the same reason (Song et al., 2023; Banerjee et al., 2025). These constraints make the walking-blood-bank element the most logistically demanding part of the protocol, and the one most dependent on prior training and unit preparation, which the article acknowledges as a precondition rather than a guarantee.

The pairing of titration and renewable supply yields a resuscitation that is, in principle, sustainable for as long as donors and provider endurance allow, which is the property the prolonged scenario demands and the golden-hour protocol lacks. The casualty is held at a perfusion endpoint that prevents both the exsanguination of under-resuscitation and the rebleeding of over-resuscitation, and the supply that holds them there is replenished as it is consumed. This is the heart of the protocol's answer to the second proposition: the single fixed transfusion is insufficient, but a titrated transfusion drawn from a serially renewed supply is sufficient, and it is feasible within documented far-forward capability provided the unit has prepared for it.

THE TIME-INDEXED METABOLIC LOOP: MANAGING THE ACCUMULATING THREATS

The third departure, the time-indexed monitoring loop, addresses the costs that the golden-hour protocol can ignore but the prolonged course cannot, and it is the element most specific to the extended timeline. Transfusion is not free of metabolic consequence, and over a sustained resuscitation those consequences accumulate. Citrate, the anticoagulant in stored blood, chelates calcium, and each transfused unit deepens a hypocalcaemia that impairs both coagulation and cardiac function, a derangement now recognised as early, central, and correlated with coagulopathy, transfusion requirement, and death (Kronstedt et al., 2022; Helsloot et al., 2023). Over the golden hour a single bolus produces a hypocalcaemia the surgical facility will correct; over a prolonged transfusion the deficit compounds with every unit and, uncorrected, becomes itself a cause of the bleeding the transfusion is meant to treat. The protocol therefore gives empiric calcium from the first unit and repeats it on a schedule indexed to units transfused and clinical signs, rather than deferring correction to a facility that is hours away.

Temperature is the second accumulating threat, and the prolonged and often cold evacuation environment makes it more dangerous than in the golden-hour case. Hypothermia independently worsens trauma outcome and amplifies coagulopathy, and the casualty in haemorrhagic shock, transfused with cold product and exposed to the elements over many hours, is at compounding risk, the more so in the arctic and maritime settings to which prolonged care is now being extended (Azarkane et al., 2024; Rund, 2023; Tadlock et al., 2024). The protocol accordingly elevates warming from an afterthought to a scheduled element of the monitoring loop, warming both the casualty and, where possible, the transfused product, and treating temperature as a vital sign to be defended throughout the prolonged course rather than restored at the receiving facility.

Hypothermia, acidosis, coagulopathy, and hypocalcaemia together constitute what the trauma literature has come to call the lethal triad extended to a diamond, and the mechanistic core, trauma-induced coagulopathy, is amplified by exactly the time and volume that prolonged transfusion entails (Moore et al., 2021). The protocol's monitoring loop, summarised in Table 2, treats these not as separate complications to be managed reactively but as a coupled system to be defended proactively, because each worsens the others and the casualty who slides into the full diamond is difficult to retrieve in a field setting without laboratory or imaging support. Tranexamic acid, given early per the evidence, attacks the fibrinolytic component of the coagulopathy and is retained in the protocol as a standing element (PATCH-Trauma Investigators, 2023; Thomas et al., 2025). The loop's recurring interval, every thirty to sixty minutes, is a reasoned compromise between the vigilance the accumulating threats demand and the realistic capacity of a single provider managing a casualty over many hours.

The monitoring loop is, finally, what makes the protocol safe rather than merely sustaining, and it is the element whose omission from golden-hour doctrine is most consequential under delay. A protocol that titrated transfusion from a renewable supply but ignored the metabolic costs would sustain perfusion while the casualty slid into a transfusion-induced coagulopathy and arrest, which is the failure mode the loop exists to prevent. Embedding the loop is therefore not an optional refinement but a necessary condition for the safety of prolonged transfusion, which is the third proposition stated as a design requirement. The golden-hour protocol could omit the loop because the surgical facility would supply its function within the hour; the prolonged-care protocol cannot, because in prolonged care the field provider is the facility, for hours, and must do its metabolic work as well as its transfusing.

CONCLUSION

The next war's wounded may wait hours for the evacuation that today's doctrine assumes will come within sixty minutes, and the resuscitation that bridges the golden hour will not, unmodified, sustain them across that wait. This article set out to specify how point-of-injury whole blood should be delivered when evacuation is delayed, and the protocol it proposes supports an ordered set of conclusions.

The first proposition, that whole blood and early transfusion reduce early mortality in haemorrhagic shock, is supported by the weight of recent evidence while honestly qualified by its null findings, and it is supported most clearly where this article operates, in the sickest casualties and the longest transports (Torres et al., 2023; van der Horst et al., 2023; Pusateri et al., 2020; Sperry et al., 2023). The second proposition, that a single fixed point-of-injury transfusion is insufficient under delay and must be replaced by a titrated resuscitation drawn from a serially renewed walking-blood-bank supply, follows from the structural failure of the golden-hour design once its bridging assumption is removed, and the renewable, titrated alternative is feasible within documented far-forward capability (Song et al., 2023; LaGrone et al., 2024; Gurney et al., 2022).

The third proposition, that the accumulating metabolic costs of prolonged transfusion must be managed by a time-indexed loop that golden-hour protocols omit, follows from the recognition that hypocalcaemia, hypothermia, acidosis, and coagulopathy compound with time and volume and that, in prolonged care, the field provider must perform the metabolic work a surgical facility would otherwise do (Kronstedt et al., 2022; Helsloot et al., 2023; Azarkane et al., 2024; Moore et al., 2021). Each proposition translates into one of the protocol's departures from golden-hour practice, and the four departures together, titration, renewal, metabolic monitoring, and their integration into a single algorithm, constitute the protocol.

The principal original contribution of this article is that protocol, the Point-of-Injury Whole Blood protocol for Prolonged Field Care, which extends the proven point-of-injury whole blood intervention from a golden-hour bridge into a sustained, titratable, and metabolically monitored resuscitation for delayed evacuation, and presents it as an algorithm a far-forward provider can follow without laboratory or imaging support. The protocol joins the transfusion and prolonged-care literatures that have developed in parallel, it resolves the specific problems that the delayed timeline introduces, and it does so in the form, a decision algorithm and a supporting evidence synthesis, that this branch of medicine uses to move evidence into practice. That integrative and practical ambition is the proper aim of an original contribution, and it is the one pursued here.

The limitations bound the claims and define the agenda. The protocol is an evidence-informed design and has not been prospectively validated; its thresholds and intervals are reasoned, not optimised; the efficacy evidence is drawn largely from short-transport settings and extrapolated to the prolonged one on the strength of the transport-time and high-risk signals; and the walking-blood-bank and titration elements presume a far-forward capability that is a target rather than a universal reality. These boundaries specify what is needed next: a prospective field evaluation of the protocol's feasibility and safety in realistic prolonged-care exercises and, where ethically possible, in operational practice; a study of the serial walking blood bank's sustainability and donor safety over extended collection; and an examination of whether the time-indexed metabolic loop measurably reduces transfusion-induced coagulopathy in the field. Until that work is done, the responsible reading is that the casualty who must wait hours for evacuation is not served by a doctrine written for minutes, and that giving such a casualty a single unit of blood and hoping is a plan only until a better one is tested.

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PRIMJENA PUNE KRVI NA TAČKI RANJAVANJA U USLOVIMA PRODUŽENE POLJSKE NJEGE: PROTOKOL ZA SCENARIJE ODGOĐENE TAKTIČKE EVAKUACIJE

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Sažetak: Krvarenje ostaje vodeći uzrok potencijalno preživljive smrti na bojištu, a transfuzija pune krvi blizu tačke ranjavanja danas je utvrđena kao reanimacija izbora. Doktrina koja je okružuje, međutim, pisana je za „zlatni sat" — svijet u kojem ranjenik stiže na hiruršku njegu u roku od šezdeset minuta — a taj svijet nestaje. U velikim borbenim operacijama protiv ravnopravnog protivnika evakuacija može biti odgođena više sati, a bolničar koji da jednu jedinicu pune krvi i čeka helikopter koji ne dolazi ostaje bez plana. Ovaj rad razvija taj plan. Originalni doprinos jeste protokol primjene pune krvi na tački ranjavanja u produženoj poljskoj njezi — fazni i titrabilni reanimacioni algoritam izgrađen upravo za odgođenu evakuaciju — uz argument da produženi scenario zahtijeva četiri odstupanja od prakse zlatnog sata: prelazak s jednokratnog fiksnog bolusa na titrabilnu reanimaciju vođenu održivim permisivnim ciljem perfuzije; serijski ciklus „hodajuće banke krvi" koji konačne zalihe pretvara u obnovljive; eksplicitnu vremenski indeksiranu petlju nadzora metaboličkih poremećaja — hipokalcemije, hipotermije i acidoze — koji se nagomilavaju tokom sati transfuzije i koje protokoli za kratku evakuaciju mogu zanemariti; te integraciju svega toga u jedan algoritam koji pružalac na isturenom položaju može slijediti bez laboratorije ili imaginga. Protokol je utemeljen u sintezi dokaza, prikazanoj kao narativni forest plot procjena mortaliteta iz novijih studija, koja podržava efikasnost pune krvi i rane transfuzije uz pošteno priznanje nultih nalaza koji je umjeravaju. Predstavljen je kroz dvije figure i dvije tabele: klinički algoritam, forest plot dokaza, poređenje paradigmi zlatnog sata i produžene njege, te vremenski raspored za metaboličke prijetnje. Protokol je dizajn utemeljen na dokazima, a ne validovani standard; generiše konkretna, provjerljiva predviđanja koja rad precizira za prospektivnu terensku evaluaciju.

Ključne riječi: *puna krv, tačka ranjavanja, produžena poljska njega, damage control reanimacija, hodajuća banka krvi, odgođena evakuacija, hemoragijski šok*.