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Systematic review

Damage control resuscitation strategies in emergency department trauma patients: a systematic review

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Abstract

Background: Damage control resuscitation (DCR) integrates hemorrhage control with restricted crystalloid exposure, balanced hemostatic transfusion, antifibrinolytic therapy, permissive hypotension in selected patients, and physiology-guided correction of trauma-induced coagulopathy. **Objective:** In this systematic review we synthesized comparative studies on DCR strategies used during emergency management of adult trauma patients with major bleeding or hemorrhagic shock. **Methods:** A PRISMA-aligned framework was designed for PubMed, Scopus, Web of Science Core Collection, and the Cochrane Library from inception through July 2026. Eligible studies evaluated early resuscitation interventions and reported mortality, hemostasis, transfusion exposure, coagulation outcomes, or adverse events. Randomized trials and comparative observational studies were analyzed narratively because interventions, settings, and endpoints were heterogeneous. **Results:** We included studies of restricted-volume resuscitation, balanced plasma-platelet-red cell transfusion, viscoelastic-guided hemostatic therapy, tranexamic acid, prehospital plasma, and whole blood. Balanced transfusion improved hemostasis and reduced death from exsanguination in a randomized trial without a significant difference in overall 24-hour or 30-day mortality. Tranexamic acid reduced bleeding-related mortality when given early in an international trial. Plasma trials produced discordant mortality findings across transport systems. Contemporary whole-blood evidence included favorable observational associations but no superiority over component therapy in a 2026 randomized trial. **Conclusion:** DCR is best supported as an integrated, time-critical strategy rather than a single product or fixed ratio.

Keywords: Damage control resuscitation; trauma; hemorrhagic shock; massive transfusion; whole blood; tranexamic acid; permissive hypotension; thromboelastography

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Introduction

Damage control resuscitation (DCR) is a response to the observation that severely injured bleeding patients often arrive with coagulopathy already established, making large-volume crystalloid replacement and delayed plasma delivery physiologically mismatched to the first minutes of traumatic hemorrhage (1). Hemorrhagic shock is a major mechanism of preventable trauma death, with fatal bleeding events occurring early enough that emergency and prehospital resuscitation decisions directly influence survival opportunity (2). Shock management include rapid bleeding control, preservation of oxygen delivery, avoidance of dilutional injury, and early blood-based resuscitation rather than normalization of conventional vital signs with crystalloid alone (3).

Trauma-induced coagulopathy is a dynamic disturbance involving impaired clot formation, fibrinogen depletion, platelet dysfunction, endothelial injury, and abnormal fibrinolysis, with shock, tissue damage, acidosis, and hypothermia interacting during early resuscitation (4). DCR translates these mechanisms into a clinical bundle that combines restricted crystalloid use, permissive hypotension before definitive hemostasis in selected patients, early balanced blood components or whole blood, tranexamic acid, temperature control, calcium replacement, and rapid hemorrhage control (5). Major European guidance places early coagulation support, limited crystalloid exposure, timely tranexamic acid, and targeted correction of hemostatic deficits within an integrated approach to severe traumatic bleeding (6).

The studies still clinically heterogeneous because DCR contains several interventions delivered at

different times, in different transport systems, and to trauma populations with different mechanisms, injury burdens, and bleeding rates (7). Recent transfusion research has also renewed interest in low-titer group O whole blood as a practical method of delivering red cells, plasma, and platelets in a single product while reducing component-handling complexity during massive hemorrhage (8). These differences create an important emergency medicine question: which DCR strategies show patient-centered benefit when applied during the immediate prehospital-to-emergency-department phase (5).

This systematic review evaluates comparative original studies for early DCR in adult trauma patients with major hemorrhage or hemorrhagic shock, emphasizing mortality, hemostasis, transfusion burden, coagulation outcomes, and major adverse events. The review examines restricted-volume and hypotensive resuscitation, balanced component transfusion, viscoelastic-guided therapy, tranexamic acid, prehospital plasma, and whole-blood resuscitation as interconnected domains rather than isolated procedures. Attention is given to differences between randomized and observational findings and to operational factors that explain why a strategy performs differently across emergency transport and trauma-system contexts.

Methods

This review was structured according to PRISMA 2020 principles, with focus on adult trauma patients with major hemorrhage or hemorrhagic shock, early DCR interventions, comparative resuscitation strategies, and clinically relevant outcomes. The intended search period extended from database inception through July 2026. The prespecified

information sources were PubMed, Scopus, Web of Science Core Collection, and the Cochrane Library, including CENTRAL for controlled trials.

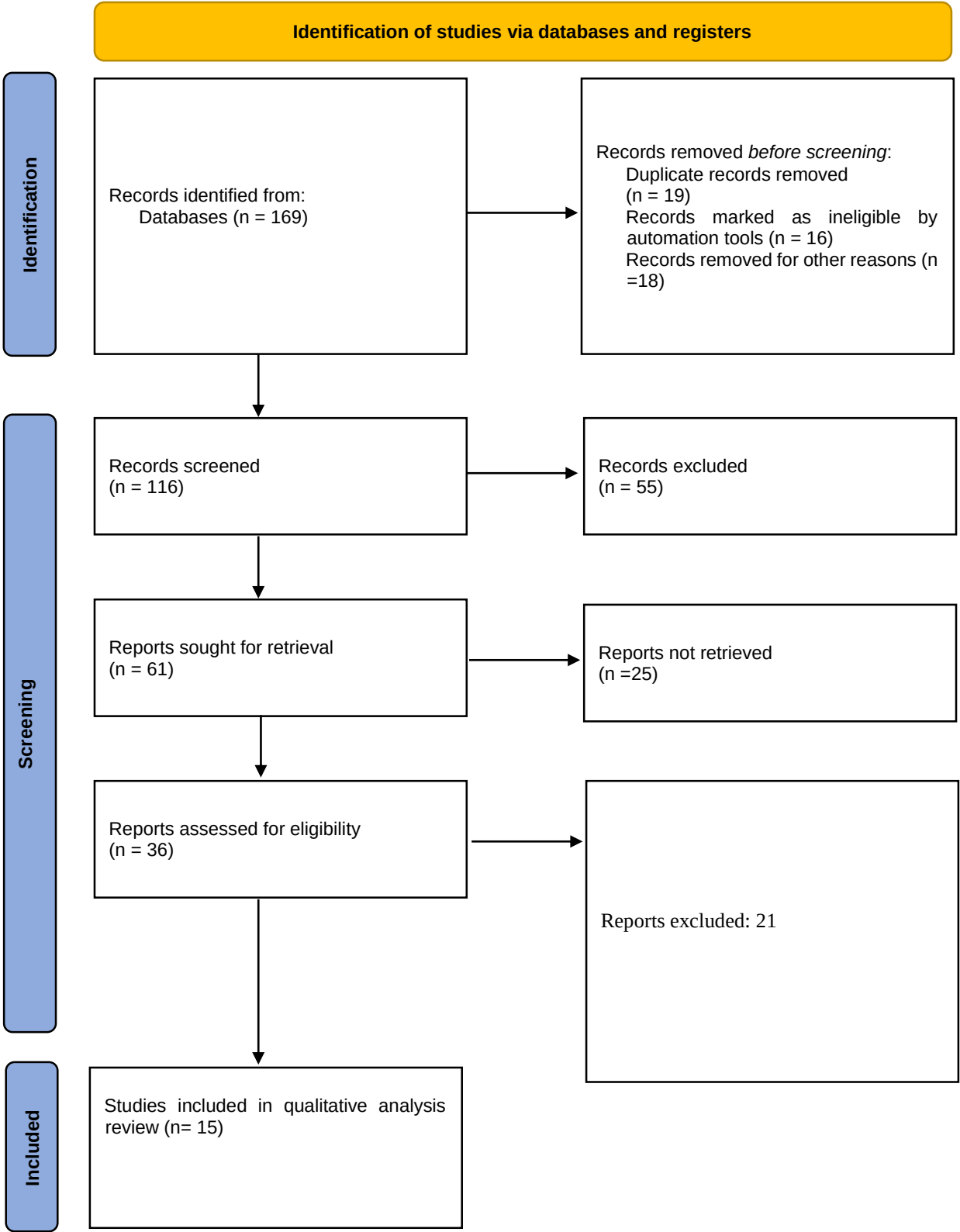
The search framework combined controlled vocabulary and free-text terms for “trauma,” “hemorrhagic shock,” “traumatic hemorrhage,” “damage control resuscitation,” “hemostatic resuscitation,” “massive transfusion,” “balanced transfusion,” “plasma,” “platelets,” “whole blood,” “low-titer group O whole blood,” “tranexamic acid,” “permissive hypotension,” “hypotensive resuscitation,” “thromboelastography,” “rotational thromboelastometry,” and “viscoelastic.” Boolean operators linked trauma and hemorrhage concepts to individual DCR strategies. Reference lists of eligible studies were also used to identify additional original studies.

Eligible studies enrolled adults aged 16 years or older, or adult cohorts with traumatic bleeding, hemorrhagic shock, massive transfusion activation, or high risk of major hemorrhage. Randomized trials, prospective controlled studies, and comparative observational cohorts were eligible when they assessed an intervention during the prehospital or emergency-department phase and reported mortality, hemostasis, transfusion exposure, coagulation outcomes, lactate-related outcomes, or major adverse events. Prehospital studies were retained when the intervention formed part of the resuscitation pathway before emergency-department arrival. We exclude pediatric-only studies, isolated burn or obstetric hemorrhage, nontraumatic bleeding, animal studies, case reports, editorials, and noncomparative technical reports.

Screening was designed for a single reviewer, with title and abstract assessment followed by full-text

eligibility review. Duplicate publications were linked to the same study, and the most complete report was retained for each principal outcome. Reasons for full-text exclusion were assigned to one dominant category to support transparent PRISMA reporting. Data fields included study design, setting, sample size, injury population, intervention, comparator, mortality time point, hemostatic endpoints, blood-product exposure, coagulation measures, and adverse events. Extraction was organized in a standardized evidence table, with numerical results checked against the published report before synthesis. Randomized studies were appraised using RoB 2 domains and nonrandomized comparative studies using ROBINS-I domains. Because interventions, timing, transport environments, transfusion protocols, and outcome definitions differed, a narrative synthesis was selected instead of a pooled meta-analysis. Database-specific record counts, duplicate counts, and exclusion totals are intentionally not fabricated in this draft.

Fig 1: PRISMA flow chart



Results

We include 15 comparative studies spanning restricted-volume resuscitation, balanced component therapy, viscoelastic-guided transfusion, tranexamic acid, prehospital plasma, and whole blood (9-23). In penetrating torso trauma, Bickell and colleagues reported higher survival to hospital discharge with delayed fluid administration until operative control than with immediate prehospital crystalloid resuscitation (9). A later randomized trial targeting a systolic pressure of 70 mmHg versus 100 mmHg during active hemorrhage found identical numbers of deaths in both groups (10). Morrison and colleagues subsequently found that a lower mean arterial pressure target during operative management reduced early blood-product and fluid requirements and severe postoperative coagulopathy without a significant difference in overall 30-day mortality (11).

The prospective PROMMTT study found that early plasma:RBC and platelet:RBC ratios closer to 1:1 were associated with lower early hemorrhagic mortality, while the observational design left residual concern for time-dependent and treatment-selection bias despite sophisticated competing-risk analysis (12). PROPPR then randomized 680 severely bleeding trauma patients to 1:1:1 or 1:1:2 plasma:platelets:RBCs and found no significant difference in 24-hour or 30-day all-cause mortality, although 1:1:1 achieved hemostasis more often and reduced death from exsanguination (13). A pragmatic randomized study of thromboelastography-guided versus conventional coagulation-assay-guided resuscitation reported significantly better survival with the viscoelastic strategy (14).

CRASH-2 enrolled 20,211 bleeding or bleeding-risk trauma patients and showed lower all-cause mortality and death due to bleeding with tranexamic acid compared with placebo (15). The later STAAMP trial found no statistically significant reduction in 30-day mortality for prehospital tranexamic acid across the overall enrolled population (16). In PAMPer, two units of prehospital thawed plasma during air transport reduced 30-day mortality compared with standard care, whereas the urban ground-transport COMBAT trial did not demonstrate a survival benefit from prehospital plasma (17,18). RePHILL found that prehospital packed RBCs plus lyophilized plasma did not improve its composite primary outcome relative to saline, and PREHO-PLYO found no significant improvement in arrival INR, massive transfusion, or 30-day survival with lyophilized plasma (19,20).

Whole-blood studies produced a similar contrast between early signals and randomized evidence (21-23). A pilot randomized trial of modified whole blood versus component therapy did not reduce overall transfusion volume in the primary analysis, although exploratory findings favored whole blood after excluding patients with severe traumatic brain injury (21). A prospective observational study associated low-titer group O whole blood with improved 24-hour and 28-day survival after adjustment, while nonrandomized exposure left confounding as an important limitation (22). The 2026 SWiFT randomized trial found no superiority of prehospital whole blood over component therapy for the composite of death or massive transfusion within 24 hours, with event rates of 48.7% and 47.7%, respectively (23).

Table 1. Primary comparative studies included in the evidence synthesis

Study; design and Sample size	Intervention/comparator	Main finding
Bickell et al.; prospective controlled; n=598	Immediate versus delayed crystalloid	Discharge survival: 62% versus 70%, favoring delayed fluids.
Dutton et al.; randomized; n=110	SBP 100 versus 70 mmHg	Four deaths occurred in each group; no mortality difference.
Morrison et al.; randomized; n=90	MAP 65 versus 50 mmHg	Lower MAP reduced fluid/product use and severe postoperative coagulopathy.
PROMMTT; prospective multicenter observational	Early component ratios	Ratios approaching 1:1 were associated with lower early hemorrhagic mortality.
PROPPR; randomized; n=680	1:1:1 versus 1:1:2	Overall mortality was neutral; 1:1:1 improved hemostasis and reduced exsanguination.
Gonzalez et al.; pragmatic randomized; n=111	TEG versus conventional assays	28-day mortality: 19.6% versus 36.4%, favoring TEG guidance.
CRASH-2; randomized; n=20,211	TXA versus placebo	All-cause mortality: 14.5% versus 16.0%; bleeding death: 4.9% versus 5.7%.
STAAMP; randomized; n=903	Prehospital TXA versus placebo	30-day mortality: 8.1% versus 9.9%; overall difference not significant.
PAMPer; cluster-randomized crossover; n=501	Prehospital plasma versus standard care	30-day mortality: 23.2% versus 33.0%, favoring plasma.
COMBAT; randomized; n=144	Plasma-first versus standard care	28-day mortality: 15% versus 10%; no significant benefit.
RePHILL; randomized; n=432	PRBC + lyophilized plasma versus saline	Composite primary outcome: 64% versus 65%; no superiority.
PREHO-PLYO; randomized; n=150	Lyophilized plasma versus standard care	Arrival INR, massive transfusion, and 30-day survival were not significantly different.
Cotton et al.; pilot randomized; n=107	Modified whole blood versus components	Overall 24-hour transfusion volume did not decrease.
Shea et al.; prospective observational	LTOWB versus components	LTOWB was independently associated with improved 24-hour and 28-day survival.
SWIFT; randomized; primary outcome n=616	Whole blood versus components	Death or massive transfusion by 24 hours: 48.7% versus 47.7%; no superiority.

Table 2. Synthesis by DCR domain

DCR domain	Overall evidence signal	limitation	Studies
Restricted-volume and hypotensive resuscitation	Supports limiting aggressive prehemostatic fluid in selected bleeding patients	Different injury mechanisms, phases, and pressure targets	(9-11)
Balanced component therapy	Improves early hemostatic outcomes; overall mortality advantage remains uncertain	Ratio changes over time and endpoint choice	(12,13)
Viscoelastic-guided therapy	Randomized survival signal favors goal-directed TEG resuscitation	Single-center pragmatic trial	(14)
Tranexamic acid	Strong evidence for early treatment in bleeding-risk trauma; overall prehospital effect varies by cohort	Treatment timing and baseline risk differ	(15,16)
Prehospital plasma/blood products	Mixed results across air, urban ground, and mixed systems	Transport time and comparator resuscitation differ	(17-20)
Whole blood	Observational survival associations; randomized evidence does not show superiority over balanced components	Product protocols and comparators vary	(21-23)

Discussion

This review supports DCR as a coordinated resuscitation architecture (5,6). The clearest randomized evidence favors early blood-based hemostatic resuscitation, rapid hemorrhage control, and avoidance of unnecessary crystalloid exposure, while the optimal product configuration varies with transport time, injury pattern, and local logistics (7,13). PROPPR is informative because the 1:1:1 strategy did not significantly lower overall 24-hour or 30-day mortality (13).

The permissive-hypotension literature illustrates why DCR requires patient selection rather than a universal low-pressure target (9-11). Bickell's penetrating-torso cohort benefited from delayed fluid before operative control, whereas Dutton found no mortality difference between two systolic targets and Morrison demonstrated reductions in transfusion exposure and postoperative coagulopathy under a lower-pressure strategy (9-11). These studies differ in mechanism of injury, resuscitation phase, operative timing, and pressure targets, so their collective message is stronger for limiting excessive prehemostatic fluid than for prescribing one numeric blood-pressure threshold to every bleeding trauma patient (3,9-11).

Balanced transfusion is stronger when interpreted as early delivery of hemostatic components rather than strict adherence to a ratio throughout the entire resuscitation (12,13). PROMMTT linked earlier high plasma:RBC and platelet:RBC ratios with lower early mortality, and survivor bias and changing ratios over time complicated causal interpretation in observational transfusion research (12). PROPPR addressed much of that uncertainty experimentally and demonstrated that 1:1:1 delivered more platelets and plasma early,

improved hemostasis, and reduced exsanguination despite neutral all-cause mortality endpoints (13). Viscoelastic-guided resuscitation adds a complementary precision approach because trauma-induced coagulopathy varies between patients, and the Gonzalez trial linked thromboelastography-guided treatment with improved survival compared with conventional assays (4,14).

Tranexamic acid has the broadest international randomized evidence in pharmacologic DCR interventions, with CRASH-2 demonstrating reductions in all-cause and bleeding mortality in a large heterogeneous trauma population (15). STAAMP did not reproduce a statistically significant overall 30-day mortality reduction in its prehospital North American population, emphasizing that baseline risk, administration timing, and enrollment criteria influence absolute treatment benefit (16). These findings support early TXA as part of a bleeding-focused pathway rather than indiscriminate administration to low-risk trauma patients (6,15,16).

Prehospital plasma and whole blood show the greatest dependence on system design (17-23). PAMPer demonstrated a mortality benefit during air medical transport, while COMBAT, RePHILL, and PREHO-PLYO reported neutral primary or major clinical outcomes across different ground and mixed prehospital systems (17-20). Transport duration, crystalloid exposure, injury severity, blood-product availability, and time to definitive hemorrhage control provide plausible explanations for this heterogeneity (17-20). Whole-blood observational data showed favorable adjusted survival associations, and the 2026 SWiFT randomized trial found no superiority over component therapy for

death or massive transfusion at 24 hours, reinforcing the value of randomized confirmation before interpreting logistical elegance as clinical superiority (22,23).

Conclusion

DCR is supported by a convergent strategy of early hemorrhage control, limited crystalloid exposure, timely hemostatic blood products, and targeted correction of coagulopathy. Randomized studies supports balanced component resuscitation for improved hemostasis and reduced exsanguination. Prehospital plasma produces inconsistent results in trauma systems, and recent randomized evidence does not establish whole blood as superior to component therapy. Emergency departments therefore benefit from protocolized DCR pathways that remain adaptable to physiology, transport context, and blood-product resources.

Abbreviations

DCR, damage control resuscitation; ED, emergency department; INR, international normalized ratio; LTOWB, low-titer group O whole blood; MAP, mean arterial pressure; MTP, massive transfusion protocol; PRBC, packed red blood cells; RBC, red blood cells; RoB 2, Risk of Bias 2; ROBINS-I, Risk Of Bias In Non-randomized Studies of Interventions; ROTEM, rotational thromboelastometry; SBP, systolic blood pressure; TEG, thromboelastography; TXA, tranexamic acid.

References

1. Holcomb JB. Damage control resuscitation: directly addressing the early coagulopathy of trauma. *J Trauma*. 2007;62(2):307-310. doi:10.1097/TA.0b013e3180324124. PMID: 17297317.
2. Eastridge BJ, Holcomb JB, Shackelford S. Outcomes of traumatic hemorrhagic shock and the epidemiology of preventable death from injury. *Transfusion*. 2019;59(S2):1423-1428. doi:10.1111/trf.15161. PMID: 30980749.
3. Cannon JW. Hemorrhagic shock. *N Engl J Med*. 2018;378(4):370-379. doi:10.1056/NEJMra1705649. PMID: 29365303.
4. Moore EE, Moore HB, Kornblith LZ, Neal MD, Hoffman M, Mutch NJ, et al. Trauma-induced coagulopathy. *Nat Rev Dis Primers*. 2021;7(1):30. doi:10.1038/s41572-021-00264-3. PMID: 33927200.
5. Cannon JW, Khan MA, Raja AS, Cohen MJ, Como JJ, Cotton BA, et al. Damage control resuscitation in patients with severe traumatic hemorrhage: a practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg*. 2017;82(3):605-617. doi:10.1097/TA.0000000000001333. PMID: 28225743.
6. Rossaint R, Afshari A, Bouillon B, Cerny V, Cimpoesu D, Curry N, et al. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. *Crit Care*. 2023;27(1):80. doi:10.1186/s13054-023-04327-7. PMID: 36859355.
7. Brunskill SJ, Disegna A, Wong H, Fabes J, Desborough MJ, Dorée C, et al. Blood transfusion strategies for major bleeding in

- trauma. *Cochrane Database Syst Rev.* 2025;4(4):CD012635.
doi:10.1002/14651858.CD012635.pub2.
PMID: 40271704.
8. Spinella PC, Pidcock HF, Strandenes G, Hervig T, Fisher A, Jenkins D, et al. Whole blood for hemostatic resuscitation of major bleeding. *Transfusion.* 2016;56(Suppl 2):S190-S202. doi:10.1111/trf.13491. PMID: 27100756.
 9. Bickell WH, Wall MJ Jr, Pepe PE, Martin RR, Ginger VF, Allen MK, et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med.* 1994;331(17):1105-1109. doi:10.1056/NEJM199410273311701. PMID: 7935634.
 10. Dutton RP, Mackenzie CF, Scalea TM. Hypotensive resuscitation during active hemorrhage: impact on in-hospital mortality. *J Trauma.* 2002;52(6):1141-1146. doi:10.1097/00005373-200206000-00020. PMID: 12045644.
 11. Morrison CA, Carrick MM, Norman MA, Scott BG, Welsh FJ, Tsai P, et al. Hypotensive resuscitation strategy reduces transfusion requirements and severe postoperative coagulopathy in trauma patients with hemorrhagic shock: preliminary results of a randomized controlled trial. *J Trauma.* 2011;70(3):652-663. doi:10.1097/TA.0b013e31820e77ea. PMID: 21610356.
 12. Holcomb JB, del Junco DJ, Fox EE, Wade CE, Cohen MJ, Schreiber MA, et al. The prospective, observational, multicenter, major trauma transfusion (PROMMTT) study: comparative effectiveness of a time-varying treatment with competing risks. *JAMA Surg.* 2013;148(2):127-136. doi:10.1001/2013.jamasurg.387. PMID: 23560283.
 13. Holcomb JB, Tilley BC, Baraniuk S, Fox EE, Wade CE, Podbielski JM, et al. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. *JAMA.* 2015;313(5):471-482. doi:10.1001/jama.2015.12. PMID: 25647203.
 14. Gonzalez E, Moore EE, Moore HB, Chapman MP, Chin TL, Ghasabyan A, et al. Goal-directed hemostatic resuscitation of trauma-induced coagulopathy: a pragmatic randomized clinical trial comparing a viscoelastic assay to conventional coagulation assays. *Ann Surg.* 2016;263(6):1051-1059. doi:10.1097/SLA.0000000000001608. PMID: 26720428.
 15. CRASH-2 trial collaborators. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial. *Lancet.* 2010;376(9734):23-32. doi:10.1016/S0140-6736(10)60835-5. PMID: 20554319.
 16. Guyette FX, Brown JB, Zenati MS, Early-Young BJ, Adams PW, Eastridge BJ, et al. Tranexamic acid during prehospital transport in patients at risk for hemorrhage

- after injury: a double-blind, placebo-controlled, randomized clinical trial. *JAMA Surg.* 2021;156(1):11-20. doi:10.1001/jamasurg.2020.4350. PMID: 33016996.
17. Sperry JL, Guyette FX, Brown JB, Yazer MH, Triulzi DJ, Early-Young BJ, et al. Prehospital plasma during air medical transport in trauma patients at risk for hemorrhagic shock. *N Engl J Med.* 2018;379(4):315-326. doi:10.1056/NEJMoa1802345. PMID: 30044935.
 18. Moore HB, Moore EE, Chapman MP, McVane K, Bryskiewicz G, Blechar R, et al. Plasma-first resuscitation to treat haemorrhagic shock during emergency ground transportation in an urban area: a randomised trial. *Lancet.* 2018;392(10144):283-291. doi:10.1016/S0140-6736(18)31553-8. PMID: 30032977.
 19. Crombie N, Doughty HA, Bishop JRB, Desai A, Dixon EF, Hancox JM, et al. Resuscitation with blood products in patients with trauma-related haemorrhagic shock receiving prehospital care (RePHILL): a multicentre, open-label, randomised, controlled, phase 3 trial. *Lancet Haematol.* 2022;9(4):e250-e261. doi:10.1016/S2352-3026(22)00040-0. PMID: 35271808.
 20. Jost D, Lemoine S, Lemoine F, Derkenne C, Beaume S, Lanoë V, et al. Prehospital lyophilized plasma transfusion for trauma-induced coagulopathy in patients at risk for hemorrhagic shock: a randomized clinical trial. *JAMA Netw Open.* 2022;5(7):e2223619. doi:10.1001/jamanetworkopen.2022.23619. PMID: 35881397.
 21. Cotton BA, Podbielski J, Camp E, Welch T, del Junco D, Bai Y, et al. A randomized controlled pilot trial of modified whole blood versus component therapy in severely injured patients requiring large volume transfusions. *Ann Surg.* 2013;258(4):527-532; discussion 532-533. doi:10.1097/SLA.0b013e3182a4ffa0. PMID: 23979267.
 22. Shea SM, Staudt AM, Thomas KA, Schuerer D, Mielke JE, Folkerts D, et al. The use of low-titer group O whole blood is independently associated with improved survival compared to component therapy in adults with severe traumatic hemorrhage. *Transfusion.* 2020;60(Suppl 3):S2-S9. doi:10.1111/trf.15696. PMID: 32478896.
 23. Smith JE, Cardigan R, Sanderson E, et al. Prehospital whole blood in traumatic hemorrhage: a randomized controlled trial. *N Engl J Med.* 2026;394(23):2305-2316. doi:10.1056/NEJMoa2516043. PMID: 41841706.