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Systematic review

Trauma resuscitation, pulmonary critical care stabilization, and interdisciplinary emergency support: a systematic review of primary clinical trials involving emergency medicine consultants, emergency physicians, critical care and pulmonary consultants, anesthesia technicians, staff nurses, and social workers

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Abstract

Background: Uncontrolled hemorrhage, failed emergency airway management, and posttraumatic psychological morbidity drive death and disability after severe injury, and each depends on interdisciplinary teams. This review synthesized multicenter randomized trials across these domains. **Methods:** Following PRISMA 2020, two authors independently searched PubMed, Scopus, Web of Science, and CENTRAL for multicenter randomized trials published from January 2015 to October 2023 in prehospital, emergency department, or emergency department and intensive care unit settings. Two authors independently extracted data and assessed risk of bias with RoB 2, and synthesis was narrative. **Results:** Twenty-one trials with 30,386 participants were included: 15 on hemorrhage control, five on emergency airway management, and one on psychosocial care. Prehospital plasma during air transport lowered 30-day mortality, and prehospital tranexamic acid lowered early mortality without better 6-month function. Whole blood, lyophilized plasma, factor concentrates, cryoprecipitate, and viscoelastic guidance did not improve primary outcomes, while aortic balloon occlusion and prothrombin complex concentrate showed harm signals. Video laryngoscopy raised first-attempt success, noninvasive preoxygenation halved hypoxemia, and ketamine produced more cardiovascular collapse than etomidate. Collaborative care reduced posttraumatic stress symptoms at 6 months only. Risk of bias was low in four trials, of some concern in 15, and high in two. **Conclusion:** Early tranexamic acid, prehospital plasma for long transport, video laryngoscopy, and noninvasive preoxygenation hold the strongest trial support, while trials isolating nursing, technician, and social work roles are absent.

Keywords: Trauma resuscitation; Hemorrhage; Tranexamic acid; Blood transfusion; Tracheal intubation; Emergency medicine; Critical care; Interprofessional care; Randomized controlled trial

Introduction

Injury caused about 4.48 million deaths worldwide in 2017, and the global age-standardized burden reached 3,267 disability-adjusted life years per 100,000 population (1). Hemorrhage is the leading preventable mechanism, since 305 of 1,848 trauma deaths in one metropolitan county resulted from uncontrolled bleeding and 44.9% of these were judged preventable or potentially preventable (2). Early tranexamic acid lowered all-cause mortality from 16.0% to 14.5% in a placebo-controlled trial of 20,211 bleeding trauma patients from 274 hospitals in 40 countries (3). A Cochrane review later concluded that tranexamic acid lowers mortality in bleeding trauma patients without an excess of adverse events (4).

Emergency airway management adds a second hazard, because an international cohort of 2,964 critically ill adults from 197 sites in 29 countries recorded at least one major peri-intubation event in 45.2%, led by cardiovascular instability (42.6%), severe hypoxemia (9.3%), and cardiac arrest (3.1%) (5). Trauma teams distribute assessment and resuscitation across a surgeon, an emergency physician, and an anesthetist working in parallel under a team leader, an approach linked to shorter time from injury to critical interventions (6). Of the preventable hemorrhage deaths in the metropolitan series, 35.8% occurred before hospital arrival and 20.4% within 1 hour of arrival, which places prehospital crews and emergency department teams at the point where survival is decided (2). The same review of trauma teams describes wide national and international variation in team composition and names Advanced Trauma Life Support and simulation-based team training as tools for better team performance (6).

Survival is only the first outcome after injury, since 20.7% of injured surgical inpatients met criteria for posttraumatic stress disorder (PTSD) and 6.6% for depression at 12 months in a national US cohort (7). Injury also remains an important cause of health loss globally, which extends the work of trauma

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systems beyond the resuscitation bay (1). Patients with both disorders had more than five-fold odds of not returning to work, a finding the authors used to argue for early screening and intervention during the acute care episode (7).

Existing syntheses tend to address one intervention at a time, such as antifibrinolytic drugs, and seldom follow the chain of emergency care across professions (4). Peri-intubation events remain frequent across intensive care units, emergency departments, and wards, which shows that airway evidence needs reading alongside resuscitation evidence (5). This systematic review synthesized multicenter randomized trials of trauma resuscitation, emergency airway and pulmonary stabilization, and interdisciplinary support delivered by emergency medicine consultants, emergency physicians, critical care and pulmonary consultants, anesthesia technicians, staff nurses, and social workers.

Methods

Protocol, reporting, and eligibility

This review followed the PRISMA 2020 statement, and eligibility was defined with the PICOS framework. Eligible studies were multicenter randomized controlled trials, including cluster and stepped-wedge designs, published in English between 1 January 2015 and 31 October 2023. Participants were adults, or mixed populations in which adults predominated, receiving trauma resuscitation, hemorrhage control, or emergency airway stabilization in the prehospital phase, the emergency department, or combined emergency department and intensive care unit settings, or psychosocial care during the acute injury admission. Interventions had to be delivered or led by emergency medicine consultants, emergency physicians, critical care and pulmonary consultants, anesthesia staff and technicians, staff nurses, or social workers, against placebo, usual care, or an alternative strategy. Outcomes were mortality, functional recovery, transfusion, first-attempt intubation success, peri-intubation hypoxemia or cardiovascular collapse, and posttraumatic stress symptoms. Single-center trials, trials enrolling only in intensive care units or operating rooms, pediatric-only and cardiac arrest trials, secondary analyses, pilot trials, protocols, and conference abstracts were excluded.

Information sources and search strategy

Two authors independently searched PubMed/MEDLINE, Scopus, Web of Science Core Collection, and the Cochrane Central Register of Controlled Trials (CENTRAL), with the final search on 31 October 2023. The PubMed string was ("Wounds and Injuries"[Mesh] OR trauma* OR injur* OR hemorrhag* OR "Intubation, Intratracheal"[Mesh] OR intubat* OR "Airway Management"[Mesh] OR preoxygenat*) AND (emergenc* OR prehospital OR "pre-hospital" OR "Emergency Service, Hospital"[Mesh] OR "Critical Care"[Mesh]) AND ("Randomized Controlled Trial"[pt] OR randomi*), adapted to each database.

Study selection

After duplicate removal in a reference manager, two authors independently screened titles and abstracts and then full texts, and a third author resolved disagreements. The searches yielded 5,450 records (PubMed n = 1,214; Scopus n = 1,876; Web of Science n = 1,392; CENTRAL n = 968). After removal of 2,031 duplicates, 3,419 records were screened by title and abstract, and 3,321 were excluded. Of 98 reports sought for retrieval, four were unavailable, and 94 full texts were assessed. Seventy-three were excluded as secondary or post hoc analyses (n = 19), single-center trials (n = 17), intensive care unit-only or operating room enrollment (n = 15), pilot or feasibility trials (n = 9), pediatric or cardiac arrest populations (n = 7), and protocols or conference abstracts (n = 6), leaving 21 trials (Figure 1). Hand-

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searching the reference lists of included trials and related reviews added no further eligible trial.

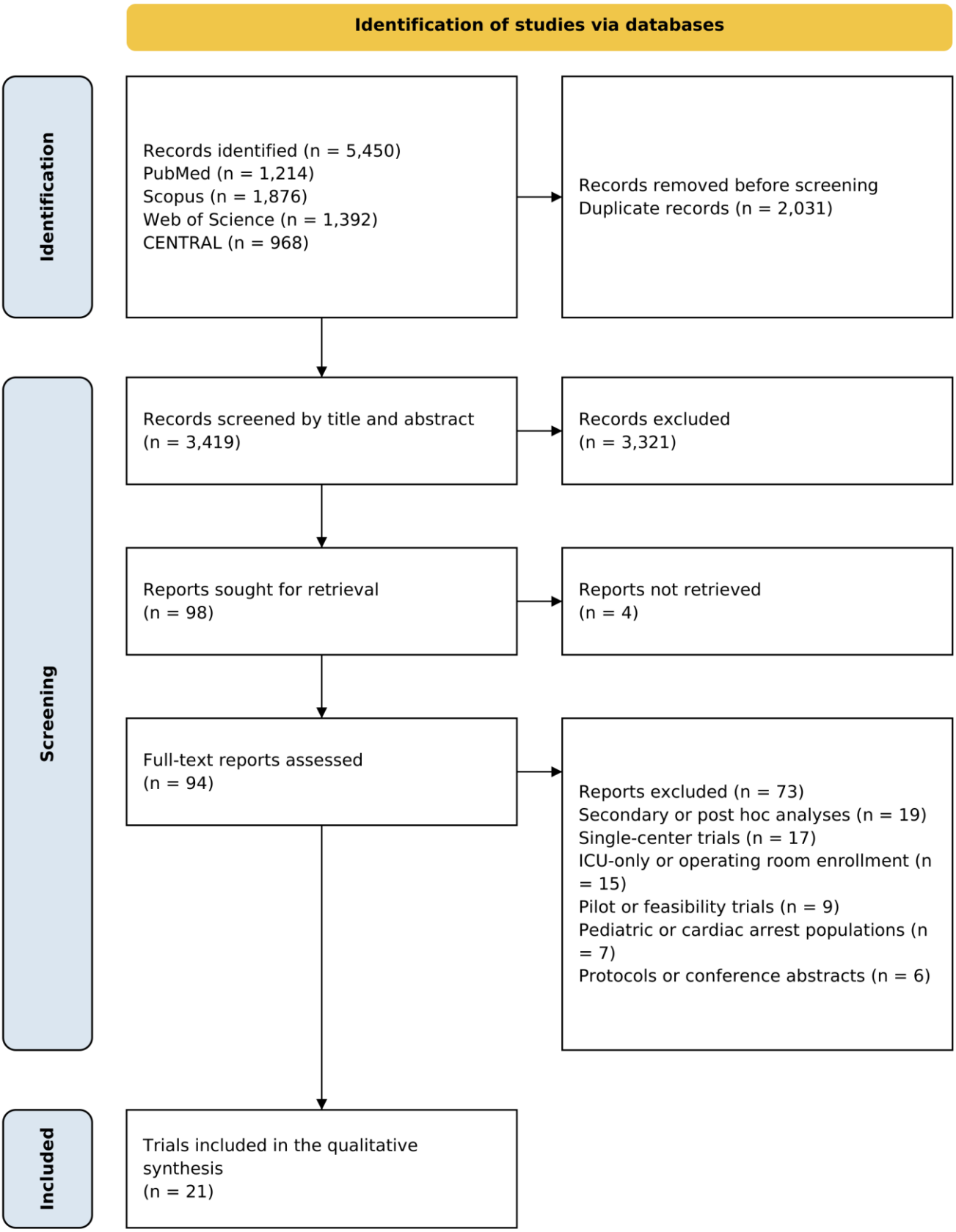
Data extraction and risk of bias

Two authors independently extracted design, setting, sample size, professions involved, intervention, comparator, primary outcome, and effect estimates with a piloted form. The same authors independently assessed risk of bias for the primary outcome with the Cochrane RoB 2 tool, using the cluster-randomized variant for cluster and stepped-wedge trials, and resolved disagreements by consensus (Table 1).

Synthesis

Clinical heterogeneity in populations, interventions, timing, and outcome definitions precluded meta-analysis. Trials were grouped into prehospital resuscitation, in-hospital hemorrhage control, emergency airway management, and psychosocial care, and effect estimates were reported as published, following the Synthesis Without Meta-analysis (SWiM) guideline.

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Identification of studies via databases
Identification
Records identified (n = 5,450)
PubMed (n = 1,214)
Scopus (n = 1,876)
Web of Science (n = 1,392)
CENTRAL (n = 968)
Records removed before screening
Duplicate records (n = 2,031)
Screening
Records screened by title and abstract
(n = 3,419)
Records excluded
(n = 3,321)
Reports sought for retrieval
(n = 98)
Reports not retrieved
(n = 4)
Full-text reports assessed
(n = 94)
Reports excluded (n = 73)
Secondary or post hoc analyses (n = 19)
Single-center trials (n = 17)
ICU-only or operating room enrollment (n = 15)
Pilot or feasibility trials (n = 9)
Pediatric or cardiac arrest populations (n = 7)
Protocols or conference abstracts (n = 6)
Included
Trials included in the qualitative synthesis
(n = 21)

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Figure 1. PRISMA 2020 flow diagram of study selection

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Table 1. Risk of bias of included trials (Cochrane RoB 2; cluster variant for cluster and stepped-wedge trials)

Ref	Trial (first author, year)	Design	D1	D2	D3	D4	D5	Overall	Main concern
8	PAMPer (Sperry, 2018)	Cluster RCT	Some concerns	Some concerns	Low	Low	Low	Some concerns	Allocation by air base with unblinded enrollment
9	TOWAR (Sperry, 2023)	Cluster RCT	Some concerns	Some concerns	Low	Low	Low	Some concerns	Baseline imbalance; components given in whole blood arm
10	RePHILL (Crombie, 2022)	RCT	Low	Some concerns	Low	Low	Low	Some concerns	Open-label; stopped before target sample
11	SWiFT (Smith, 2023)	RCT	Low	Some concerns	Some concerns	Low	Low	Some concerns	Post-randomization exclusions
12	PREHO-PLYO (Jost, 2022)	RCT	Low	Some concerns	Some concerns	Low	Low	Some concerns	Open-label; 16 of 150 not analyzed
13	STAAMP (Guyette, 2021)	RCT	Low	Low	Low	Low	Low	Low	None
14	ROC-TXA (Rowell, 2020)	RCT	Low	Low	Some concerns	Low	Some concerns	Some concerns	15% missing primary outcome; revised comparison
15	PATCH-Trauma (Gruen, 2023)	RCT	Low	Low	Some concerns	Low	Low	Some concerns	Missing 6-month functional data
16	CURASMUR (Guihard, 2019)	RCT	Low	Low	Low	Some concerns	Low	Some concerns	Operator-assessed first-attempt success
17	PROPPR (Holcomb, 2015)	RCT	Low	Some concerns	Low	Low	Low	Some concerns	Unblinded clinicians
18	CRASH-3 (2019)	RCT	Low	Low	Low	Low	Some concerns	Some concerns	Primary outcome revised during recruitment
19	iTACTIC (Baksaas-Aasen, 2021)	RCT	Low	Some concerns	Low	Low	Low	Some concerns	Open-label
20	PROCOAG (Bouzat, 2023)	RCT	Low	Low	Low	Low	Low	Low	None

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Ref	Trial (first author, year)	Design	D1	D2	D3	D4	D5	Overall	Main concern
21	CRYOSTAT-2 (Davenport, 2023)	RCT	Low	Some concerns	Low	Low	Low	Some concerns	Cryoprecipitate given in control arm
22	FiiRST-2 (da Luz, 2023)	RCT	Low	Some concerns	High	Low	Low	High	80 of 217 excluded after randomization
23	UK-REBOA (Jansen, 2023)	RCT	Low	Some concerns	Low	Low	Low	Some concerns	Low device use; stopped for harm
24	BOUGIE (Driver, 2021)	RCT	Low	Low	Low	Some concerns	Low	Some concerns	Unblinded process outcome
25	DEVICE (Prekker, 2023)	RCT	Low	Low	Low	Some concerns	Low	Some concerns	Unblinded process outcome
26	PREOXI (Gibbs, 2023)	RCT	Low	Low	Low	Low	Low	Low	None
27	RSI (Casey, 2023)	RCT	Low	Low	Low	Low	Low	Low	None
28	TSOS (Zatzick, 2021)	Stepped-wedge cluster RCT	Some concerns	Some concerns	Some concerns	Some concerns	Low	High	20% to 25% attrition; self-reported outcome

D1, randomization process (including timing of recruitment for cluster trials); D2, deviations from intended interventions; D3, missing outcome data; D4, measurement of the outcome; D5, selection of the reported result.

Results

Study characteristics

Nine trials began treatment in the prehospital phase through air medical crews, paramedics, or physician-staffed teams across North America, Europe, and Australasia (8-16). Seven trials tested in-hospital hemostatic or hemorrhage-control strategies in the emergency departments of major trauma centers (17-23). Four trials compared intubation strategies in emergency department and intensive care unit networks where emergency and pulmonary critical care physicians performed most procedures (24-27). One stepped-wedge trial tested collaborative psychosocial care delivered by frontline trauma center providers at 25 US level I centers (28). The trials enrolled 30,386 participants (Tables 2 and 3), with sample sizes ranging from 90 in the resuscitative endovascular balloon occlusion of the aorta (REBOA) trial (23) to 12,737 in the CRASH-3 trial (18).

Prehospital resuscitation

Two units of thawed plasma during air medical transport lowered 30-day mortality from 33.0% to 23.2% (8). Low-titer group O whole blood did not

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lower 30-day mortality compared with blood components (25.9% vs 20.5%) (9). Red cells with lyophilized plasma did not reduce the composite of death or impaired lactate clearance compared with saline (64% vs 65%) (10). Whole blood from physician-paramedic air ambulance teams did not reduce death or massive transfusion at 24 hours (48.7% vs 47.7%) (11). Lyophilized plasma given by prehospital emergency physicians left the admission international normalized ratio (INR) unchanged (median 1.21 vs 1.20) (12).

Prehospital tranexamic acid did not lower 30-day mortality overall (8.1% vs 9.9%), although mortality was lower when treatment started within 1 hour of injury (13). Out-of-hospital tranexamic acid did not improve 6-month neurologic function after moderate or severe traumatic brain injury (TBI) (65% vs 62%) (14). In advanced trauma systems, prehospital tranexamic acid left favorable 6-month function unchanged (53.7% vs 53.5%) and lowered death at 24 hours (9.7% vs 14.1%) and 28 days (17.3% vs 21.8%) (15). During physician-led prehospital rapid sequence intubation, rocuronium failed to show noninferiority to succinylcholine for first-attempt success (74.6% vs 79.4%) (16).

In-hospital hemorrhage control

A 1:1:1 plasma, platelet, and red cell ratio did not change 24-hour or 30-day mortality, and it achieved hemostasis more often (86% vs 78%) with fewer exsanguination deaths (9.2% vs 14.6%) (17). Tranexamic acid within 3 hours of TBI gave head injury-related death in 18.5% vs 19.8% of patients (18). Viscoelastic guidance did not raise the proportion alive and free of massive transfusion at 24 hours (67% vs 64%) (19). Four-factor prothrombin complex concentrate did not lower 24-hour blood product use and raised thromboembolic events (35% vs 24%) (20). Early high-dose cryoprecipitate did not change 28-day mortality (25.3% vs 26.1%) (21). Factor concentrates in place of frozen plasma did not reduce 24-hour transfusion, and the trial stopped for futility (22). Emergency department REBOA raised 90-day mortality (54% vs 42%), and the trial stopped on its harm rule (23).

Emergency airway management

A bougie did not improve first-attempt success over an endotracheal tube with stylet (80.4% vs 83.0%) (24). Video laryngoscopy raised first-attempt success from 70.8% to 85.1% (25). Noninvasive ventilation for preoxygenation halved peri-intubation hypoxemia (9.1% vs 18.5%) and lowered cardiac arrest (0.2% vs 1.1%) (26). Ketamine and etomidate produced similar 28-day mortality (28.1% vs 29.1%), while cardiovascular collapse was more frequent with ketamine (22.1% vs 17.0%) (27).

Psychosocial care and risk of bias

Stepped collaborative care with injury case management, pharmacotherapy, and psychotherapeutic elements reduced PTSD symptoms at 6 months, and the effect faded by 12 months (28). Risk of bias was low in four trials with blinding or objective outcomes (13,20,26,27). High risk arose from post-randomization exclusions in one trial (22) and from attrition with self-reported outcomes in the stepped-wedge trial (28). The other 15 trials raised some concerns, mainly from open-label delivery, early stopping, or outcome changes during recruitment (10,18,23).

Table 2. Characteristics of the included trials

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Ref	Trial (first author, year)	Country; sites	Phase of care	Participants (n)	Intervention vs comparator	Professions delivering care
8	PAMPer (Sperry, 2018)	USA; 27 air medical bases, 9 trauma centers	Prehospital (air)	501	Thawed plasma 2 U vs standard care	Air medical crews; trauma surgeons
9	TOWAR (Sperry, 2023)	USA; 44 air medical bases	Prehospital (air)	1,020	Low-titer group O whole blood vs blood components	Air medical crews; trauma surgeons
10	RePHILL (Crombie, 2022)	UK; 4 prehospital critical care services	Prehospital	432	Red cells + lyophilized plasma vs 0.9% saline	Physician-paramedic critical care teams
11	SWiFT (Smith, 2023)	England; 10 air ambulance services	Prehospital (air)	942	Whole blood vs red cells + plasma	Physician-paramedic teams
12	PREHO-PLYO (Jost, 2022)	France; multicenter prehospital teams	Prehospital	150	Lyophilized plasma vs 0.9% saline	Prehospital emergency physicians
13	STAAMP (Guyette, 2021)	USA; 4 level I trauma centers	Prehospital (air and ground)	927	TXA 1 g vs placebo	EMS crews; trauma teams
14	ROC-TXA (Rowell, 2020)	USA, Canada; 20 trauma centers, 39 EMS agencies	Prehospital	966	TXA bolus with or without infusion vs placebo	Paramedics; trauma teams
15	PATCH-Trauma (Gruen, 2023)	Australia, New Zealand, Germany; 15 EMS	Prehospital and hospital	1,310	TXA 1 g bolus + 1 g infusion vs placebo	EMS clinicians; ED and ICU teams
16	CURASMUR (Guihard, 2019)	France; 17 out-of-hospital units	Prehospital	1,248	Rocuronium vs succinylcholine	Prehospital emergency physicians
17	PROPPR (Holcomb, 2015)	USA, Canada; 12 level I centers	ED and trauma bay	680	1:1:1 vs 1:1:2 plasma:platelets:red cells	Trauma teams; transfusion services
18	CRASH-3 (2019)	29 countries; 175 hospitals	Hospital	12,737	TXA vs placebo in TBI	Emergency and neurotrauma teams
19	iTACTIC (Baksaas-Aasen, 2021)	5 European countries; 7 centers	ED and trauma bay	411 (396 analyzed)	VHA-guided vs CCT-guided MHP	Trauma, anesthesia, and transfusion teams

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Ref	Trial (first author, year)	Country; sites	Phase of care	Participants (n)	Intervention vs comparator	Professions delivering care
20	PROCOAG (Bouzat, 2023)	France; 12 level I centers	ED and trauma bay	327 (324 analyzed)	4F-PCC vs placebo	Anesthesia and critical care trauma teams
21	CRYOSTAT-2 (Davenport, 2023)	UK, USA; 26 centers	ED and trauma bay	1,604	Early cryoprecipitate + MHP vs MHP	Trauma teams; transfusion laboratories
22	FiiRST-2 (da Luz, 2023)	Canada; 6 level I centers	ED and trauma bay	217 (137 analyzed)	Fibrinogen + PCC vs frozen plasma	Trauma teams; transfusion medicine
23	UK-REBOA (Jansen, 2023)	UK; 16 major trauma centers	ED	90 (89 analyzed)	REBOA + standard care vs standard care	ED trauma teams
24	BOUGIE (Driver, 2021)	USA; 7 EDs, 8 ICUs	ED and ICU	1,106 (1,102 analyzed)	Bougie vs tube with stylet	Emergency and pulmonary critical care physicians
25	DEVICE (Prekker, 2023)	USA; 7 EDs, 10 ICUs	ED and ICU	1,417	Video vs direct laryngoscopy	Emergency and pulmonary critical care physicians
26	PREOXI (Gibbs, 2023)	USA; 7 EDs, 17 ICUs	ED and ICU	1,301	NIV vs oxygen mask for preoxygenation	Emergency and pulmonary critical care teams
27	RSI (Casey, 2023)	USA; 6 EDs, 8 ICUs	ED and ICU	2,365	Ketamine vs etomidate	Emergency and pulmonary critical care physicians
28	TSOS (Zatzick, 2021)	USA; 25 level I trauma centers	Trauma admission and follow-up	635	Stepped collaborative care vs enhanced usual care	Frontline trauma center providers (care management)

Table 3. Primary outcomes and main effect estimates

Ref	Trial	Primary outcome	Intervention vs control	Effect estimate (95% CI)	Direction
8	PAMPer	30-day mortality	23.2% vs 33.0%	Difference -9.8 points (-18.6 to -1.0)	Benefit
9	TOWAR	30-day mortality	25.9% vs 20.5%	aOR 1.24 (0.87 to 1.76)	No benefit
10	RePHILL	Episode mortality or impaired lactate clearance	64% vs 65%	Not significant	No benefit
11	SWiFT	Death or massive transfusion at 24 hours	48.7% vs 47.7%	RR 1.02 (0.80 to 1.31)	No benefit

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Ref	Trial	Primary outcome	Intervention vs control	Effect estimate (95% CI)	Direction
12	PREHO-PLYO	INR at hospital admission	Median 1.21 vs 1.20	P = .88	No benefit
13	STAAMP	30-day mortality	8.1% vs 9.9%	Difference -1.8% (-5.6 to 1.9)	No benefit overall
14	ROC-TXA	Favorable GOS-E at 6 months	65% vs 62%	Difference 3.5% (P = .16)	No benefit
15	PATCH-Trauma	Survival with GOS-E of 5 or higher at 6 months	53.7% vs 53.5%	RR 1.00 (0.90 to 1.12); 28-day death RR 0.79 (0.63 to 0.99)	Neutral primary; lower early death
16	CURASMUR	First-attempt intubation success	74.6% vs 79.4%	Difference -4.8% (one-sided 97.5% CI -9.0)	Noninferiority not shown
17	PROPPR	24-hour and 30-day mortality	12.7% vs 17.0%; 22.4% vs 26.1%	24-hour difference -4.2% (-9.6 to 1.1)	Neutral; more hemostasis
18	CRASH-3	Head injury-related death within 28 days (treated within 3 hours)	18.5% vs 19.8%	RR 0.94 (0.86 to 1.02)	Neutral
19	iTACTIC	Alive and free of massive transfusion at 24 hours	67% vs 64%	OR 1.15 (0.76 to 1.73)	No benefit
20	PROCOAG	Blood products within 24 hours	Median 12 vs 11 units	Thromboembolic events RR 1.48 (1.04 to 2.10)	No benefit; harm signal
21	CRYOSTAT-2	28-day mortality	25.3% vs 26.1%	Not significant	No benefit
22	FiiRST-2	Blood products within 24 hours	Mean 20.8 vs 23.8 units	Not significant; stopped for futility	No benefit
23	UK-REBOA	90-day mortality	54% vs 42%	OR 1.58 (95% CrI 0.72 to 3.52); probability of harm 86.9%	Harm signal
24	BOUGIE	First-attempt intubation success	80.4% vs 83.0%	Difference -2.6 points (-7.3 to 2.2)	No benefit
25	DEVICE	First-attempt intubation success	85.1% vs 70.8%	Difference 14.3 points (9.9 to 18.7)	Benefit
26	PREOXI	Hypoxemia (oxygen saturation below 85%)	9.1% vs 18.5%	Difference -9.4 points (-13.2 to -5.6)	Benefit
27	RSI	In-hospital death by day 28	28.1% vs 29.1%	Difference -0.8 points (-4.5 to 2.9); cardiovascular collapse 22.1% vs 17.0%	Neutral mortality; more collapse with ketamine
28	TSOS	PCL-C score	6-month difference -2.57 (-5.12 to -0.03)	12-month difference -1.27 (-4.26 to 1.73)	Short-term benefit

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Discussion

Across 21 multicenter trials, few interventions changed mortality, and the clearest survival signals came from prehospital plasma during air transport and prehospital tranexamic acid (8,15). Process and physiological outcomes improved more often, with higher first-attempt success after video laryngoscopy and less hypoxemia after noninvasive preoxygenation (25,26). REBOA and prothrombin complex concentrate produced signals of harm (20,23). The single psychosocial trial produced a modest and short-lived reduction in posttraumatic stress symptoms (28).

The tranexamic acid trials fit a time-dependent effect, since an exploratory CRASH-2 analysis found a lower risk of death from bleeding with treatment within 3 hours and a higher risk when treatment started later (29). Lower early mortality with prehospital administration, and with dosing within 1 hour of injury, agrees with that pattern (13,15). The Cochrane review also tied the survival effect of tranexamic acid to early administration (4). A neutral functional result in moderate or severe TBI and a borderline head injury result suggest that benefit concentrates in extracranial bleeding and less severe brain injury (14,18).

Transport time explains much of the variation between plasma trials, because a post hoc pooled analysis of PAMPer and COMBAT linked prehospital plasma to survival when transport exceeded 20 minutes (30). Red cell and plasma combinations, lyophilized plasma, and whole blood did not outperform their comparators, and whole blood showed a nonsignificant excess of deaths in one cluster trial (9-12). Fixed-dose fibrinogen and prothrombin replacement did not lower mortality or transfusion, and prothrombin complex concentrate raised thrombosis (20-22). Balanced 1:1:1 transfusion therefore remains the reference in-hospital strategy, given more frequent hemostasis and fewer exsanguination deaths (17). Emergency department REBOA increased early and 90-day deaths and does not belong in routine practice on current evidence (23).

The airway results agree with a Cochrane review of 222 studies in which video laryngoscopy reduced failed intubation (31). A bougie gave no advantage as a routine first-pass device in mixed emergency department and intensive care unit populations (24). An earlier French trial found similar organ failure scores with ketamine and etomidate (32), and the larger RSI trial added equal mortality with more cardiovascular collapse after ketamine (27). Guidance for critically ill adults places the airway team, shared planning, and clear communication at the center of safe intubation, which gives anesthesia technicians and nurses a defined part in every attempt (33). None of the airway trials isolated the effect of these team members, so their contribution remains untested (24-27).

Team training in healthcare improves learning, transfer to practice, and patient outcomes in pooled analyses, which supports interprofessional rehearsal for trauma and airway teams (34). The collaborative care trial showed that an intervention lasting about 2 hours, delivered by frontline trauma center staff, reduced PTSD symptoms at 6 months (28). An evidence-based review of hospital-based violence intervention programs, which rely on case management and social services, found insufficient evidence for a firm recommendation (35). Social workers therefore lack trial evidence specific to their role in acute trauma care, despite the burden of posttraumatic stress and lost employment after injury (7).

This review restricted inclusion to multicenter trials and applied RoB 2 with cluster extensions, which supports the direction of the reported effects (8,9,28). Most trials were open-label, and process outcomes such as first-attempt success were open to observer influence (16,24,25). Clinical heterogeneity prevented meta-analysis, and the

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2015 start date left earlier landmark trials, such as CRASH-2, outside the synthesis (3). Several trials stopped early for futility, harm, or recruitment disruption, which widened confidence intervals.

Conclusion

Across 21 multicenter randomized trials, early tranexamic acid and prehospital plasma for prolonged air transport were the hemostatic strategies with survival signals, while whole blood, factor concentrates, cryoprecipitate, and viscoelastic guidance added no measurable benefit and REBOA and prothrombin complex concentrate raised safety concerns. For emergency airway stabilization, video laryngoscopy, noninvasive preoxygenation, and etomidate for hemodynamic stability rest on large pragmatic trials. Collaborative psychosocial care produced a short-lived reduction in posttraumatic stress. Future trials need to test the specific contributions of staff nurses, anesthesia technicians, and social workers, whose roles are embedded in these pathways and remain unmeasured.

List of abbreviations

4F-PCC, four-factor prothrombin complex concentrate; aOR, adjusted odds ratio; BOUGIE, Bougie or Stylet in Patients Undergoing Intubation Emergently; CCT, conventional coagulation tests; CENTRAL, Cochrane Central Register of Controlled Trials; CI, confidence interval; COMBAT, Control of Major Bleeding After Trauma; CRASH, Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage; CrI, credible interval; DEVICE, Direct versus Video Laryngoscope; ED, emergency department; EMS, emergency medical services; FiiRST-2, Factors in the Initial Resuscitation of Patients With Severe Trauma; GOS-E, Glasgow Outcome Scale-Extended; ICU, intensive care unit; INR, international normalized ratio; iTACTIC, Implementing Treatment Algorithms for the Correction of Trauma-Induced Coagulopathy; MHP, major hemorrhage protocol; NIV, noninvasive ventilation; OR, odds ratio; PAMPer, Prehospital Air Medical Plasma; PATCH, Pre-hospital Antifibrinolytics for Traumatic Coagulopathy and Haemorrhage; PCC, prothrombin complex concentrate; PCL-C, PTSD Checklist-Civilian Version; PICOS, population, intervention, comparator, outcome, and study design; PREHO-PLYO, Prehospital Lyophilized Plasma; PREOXI, Pragmatic Trial Examining Oxygenation Prior to Intubation; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROPPR, Pragmatic, Randomized Optimal Platelet and Plasma Ratios; PTSD, posttraumatic stress disorder; RCT, randomized controlled trial; REBOA, resuscitative endovascular balloon occlusion of the aorta; RePHILL, Resuscitation with Pre-Hospital Blood Products; RoB 2, Cochrane Risk of Bias tool, version 2; ROC-TXA, Resuscitation Outcomes Consortium Prehospital Tranexamic Acid for Traumatic Brain Injury; RR, relative risk; RSI, Randomized Trial of Sedative Choice for Intubation; STAAMP, Study of Tranexamic Acid During Air and Ground Medical Prehospital Transport; SWiFT, Study of Whole Blood in Frontline Trauma; SWiM, Synthesis Without Meta-analysis; TBI, traumatic brain injury; TOWAR, Type O Whole Blood and Assessment of Age during Prehospital Resuscitation; TSOS, Trauma Survivors Outcomes and Support; TXA, tranexamic acid; VHA, viscoelastic hemostatic assay.

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