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# Prehospital Assessment and Early Intervention in Trauma Patients: Emerging Trends and Innovations

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## Abstract

**Background:** Early prehospital assessment and timely interventions are critical determinants of survival in trauma. Emerging technologies and system innovations, including prehospital imaging, tailored resuscitation, endovascular adjuncts, and digital decision-support, are reshaping early trauma care.

**Methods:** We performed a structured narrative review of peer-reviewed literature published between January 2018 and December 2025. PubMed and Scopus were searched using keywords related to prehospital assessment, triage, diagnostics, and early interventions.

**Results:** Recent randomized and large observational trials support selective prehospital use of blood products (e.g., PAMPer) and prehospital plasma to reduce early mortality in selected cohorts [Sperry et al., 2018]. Prehospital ultrasound (p-FAST) improves diagnostic accuracy and shortens time to definitive care [Lucas et al., 2022], and feasibility studies demonstrate tele-supervised POCUS can extend expert interpretation to the field [Hermann et al., 2022]. Large registry data suggest REBOA may offer a survival advantage in controlled settings compared with thoracotomy, although randomized data are mixed [Cralley et al., 2023; Jansen et al., 2023]. Recent trials of prehospital TXA show mixed long-term functional benefits (PATCH-Trauma) and variable effects in smaller RCTs, arguing for selective use. Wearable sensors, AI-driven triage, drone logistics, and mobile CT show promising operational gains,

but evidence for patient-level outcomes remains limited.

**Conclusions:** Innovations in prehospital assessment and early intervention show clear potential to reduce time to diagnosis and life-saving care. However, benefits are variable depending on system capability, patient selection, and implementation logistics. Future research should prioritize controlled trials and standardized endpoints.

**Key words:** prehospital trauma; early intervention; p-FAST; REBOA; tranexamic acid; telemedicine; wearable sensors; mobile CT.

## * Introduction

Uncontrolled hemorrhage, airway compromise, and delayed diagnosis of critical injuries remain leading causes of early preventable death after trauma. The prehospital methods are, therefore, a target for innovations that can reduce time to diagnosis and definitive care, thus improving treatment outcomes. Over the last decade, two parallel trends have developed: miniaturization and ruggedization of diagnostic tools (such as portable ultrasound, handheld vital-sign monitors, and mobile CT concepts) that bring imaging faster, more accurate and more helpful in prehospital settings, while the second one are digital and organizational innovations (telemedicine, AI triage, prehospital blood logistics) that change how early decisions are made and implemented.

This review synthesizes high-quality evidence published between 2018 and 2025 on prehospital assessment and early intervention in trauma. We aim to (1) summarize recent trial data for interventions that influence mortality and early outcomes (prehospital plasma, TXA, REBOA, balanced transfusion strategies), (2) review diagnostic innovations that alter triage and time to treatment (p-FAST, tele-POCUS, mobile CT), and (3) assess the role of digital systems (telemedicine, wearables, predictive analytics) in improving prehospital decision-making. We emphasize trials, pragmatic studies, and implementation research that inform real-world deployment and identify gaps for future research.

## * Methodology

### * Search Strategy

This narrative review used a structured approach to synthesize recent innovations in prehospital assessment and early intervention for trauma. We searched for peer-reviewed studies, systematic reviews, meta-analyses, guidelines, and major position statements published between January 2018 and December

2025. Primary bibliographic research was performed in PubMed/MEDLINE and Scopus. In addition, targeted manual screening was conducted in specialty journals with high relevance to prehospital and trauma care (for example, Prehospital Emergency Care, Journal of Trauma and Acute Care Surgery, European Journal of Trauma and Emergency Surgery, and The Lancet).

Search terms combined controlled vocabulary and keywords related to prehospital care, early intervention and emergent diagnostics (including: “prehospital trauma”, “prehospital assessment”, “prehospital triage”, “prehospital ultrasound”, “mobile CT”, “prehospital blood”, “REBOA”, “tranexamic acid”, “telemedicine”, “wearable sensors”, and “artificial intelligence in trauma”). The final search strategy and date ranges for each database are provided as a supplement.

*** Inclusion and exclusion criteria**

Studies were included if they met the following criteria: original research (randomized trials, observational cohorts), systematic reviews and meta-analyses, clinical guidelines, or major position statements; studies reporting prehospital assessment or early intervention in human subjects; and publication dates within the 2018–2025 window. Excluded materials were conference abstracts, editorials or commentaries without original data, animal studies, non-English manuscripts, and studies not focused on prehospital trauma or early intervention.

*** Data Extraction and Organization**

PDFs of included studies were reviewed in detail. Key information, study design, population, intervention, or innovation assessed, outcomes, advantages, and limitations were highlighted. Themes were grouped into categories to structure the narrative of the review. The most relevant findings were incorporated into the review to provide an evidence-based synthesis of advancements from the last seven years.

This approach ensured a focused, up-to-date synthesis of innovations in prehospital trauma care while maintaining transparency about inclusion and search boundaries.

*** Results**

**1- Prehospital Assessment**

Prehospital assessment and care represent the first critical steps before hospital transfer, playing a crucial role in reducing trauma-

related morbidity and mortality. It is based on using evidence-based approaches and protocols to assess the patient's injury level, improve the patient's outcomes, and reduce the risk of developing life-threatening conditions before transferring the patient to the hospital. According to the WHO, millions of people are affected by injuries that require adequate prehospital emergency care.(Cimino & Braun, 2023)

Throughout the decades, the interest in developing and improving prehospital care has increased. A variety of technological advances have been developed to support EMS personnel in achieving optimal outcomes during the prehospital phase. Health technologies were integrated into prehospital care and improved patient outcomes significantly. Moreover, it has developed better communication between the prehospital care personnel and healthcare professionals, as it helped the EMS personnel encompass crucial metrics such as vital signs and electrocardiograms, to hospitals and healthcare practitioners, so that when the patient arrives at the hospital, all the needed resources would be available.(Cimino & Braun, 2023)

A retrospective, registry-based, observational study was performed, including 15,320 trauma patients, most of whom were males and the average age is mid-40s, to assess the difference between the vital signs recorded in the prehospital care settings and the vital signs of the patients recorded after their arrival to the hospital, to measure how the prehospital measurements can affect the early mobilization of personnel and resources for the patients.(Trust et al., 2020)

The study analyzed real-world registry data from trauma patients presenting to a Level I urban trauma center between 2008 and 2018. The study included patients who activated the highest level of trauma team activation (TTA). At this hospital (LAC + USC Medical Center), trauma team activation follows the American College of Surgeons – Committee on Trauma (ACS-COT) criteria, following an additional rule that states that any patient over 70 years old with a traumatic injury automatically triggers the trauma team because older adults tend to have worse outcomes. Patients were also included if the trauma team was activated after they arrived in the emergency department. (Trust et al., 2020)

When researchers compared the vital signs recorded in the prehospital settings to the first record

in the emergency department, they found the following: for the Glasgow Coma Scale (GCS), which measures consciousness, heart rate (HR), and Systolic Blood Pressure (SBP), there was a good agreement between the prehospital and emergency department records. While for the pulse pressure (PP) and respiratory rate (RR), there was a difference between the two settings' measurements, as shown in Table 1. (Trust et al., 2020)

The study results highlight that prehospital assessment can help the emergency department physicians in making better-informed decisions, so that reduced mortality-related trauma could be achieved.(Trust et al., 2020)

| Vital Sign | Prehospital Measurement | Initial ED Measurement | P Value | ICC |
|---|---|---|---|---|
| GCS | 14 (SD = 3); 15 [14–15] | 14 (SD = 3); 15 [14–15] | < .001 | 0.79 |
| HR | 98 (SD = 20); 98 [84–110] | 94 (SD = 21); 92 [80–110] | < .001 | 0.59 |
| SBP | 134 (SD = 27); 133 [118–149] | 136 (SD = 25); 135 [121–150] | < .001 | 0.48 |
| PP | 52 (SD = 19); 50 [40–62] | 51 (SD = 20); 49 [38–61] | < .001 | 0.32 |
| RR | 19 (SD = 5); 18 [16–20] | 19 (SD = 6); 18 [16–21] | < .001 | 0.13 |

Table 1. Prehospital versus Initial ED Vital Signs Note: Vital signs are presented as mean (standard deviation); median (range). Prehospital vital signs were compared to first ED vital signs using the paired Student's t-test; ICC was calculated from the Bland Altman analysis.(Trust et al., 2020)

Despite recent research and advances in prehospital care, a gap remains in our understanding of the best approach to use. Additionally, prehospital care personnel work in a highly challenging environment with limited resources and time constraints; therefore, conducting high-quality research in this field is particularly challenging. (Cimino & Braun, 2023)

**2- Prehospital Triage Systems**

The assessment and treatment provided by emergency medical services (EMS) guide the evaluation of injury severity, the selection of the appropriate destination hospital, and the immediate interventions required. This decision-making pathway forms the basis of the prehospital triage system, which plays a critical role in determining patient survival and clinical outcomes following hospital arrival (Kim & Oh, 2023).

Despite its importance, several limitations challenge the accuracy of prehospital triage. Time pressure and limited on-scene resources can hinder comprehensive assessment and increase the risk of misclassification. Overtriage occurs when patients with minor injuries are incorrectly categorized as severely injured, while undertriage refers to severely injured patients being classified as less critical. Both errors can negatively impact treatment decisions, resource allocation, and patient safety (Kim & Oh, 2023).

A recent cohort study conducted in England evaluated the accuracy of prehospital triage decisions among 2,757 trauma patients transported to four major trauma centers. The study included all ambulance-transported trauma patients between November 2019 and February 2020, along with a reference group of patients with confirmed major trauma. The index test was the paramedics' decision to alert and transport patients directly to a major trauma center, while the reference standard was a consensus-based definition of severe injury requiring specialized care (Fuller et al., 2024).

The study found that EMS assessments demonstrated high specificity, indicating low rates of unnecessary major trauma center activation. However, sensitivity was low, meaning a significant proportion of seriously injured patients, particularly older adults, were undertriaged. The likelihood of false-negative triage decisions increased with patient age. The authors also noted variability across ambulance services, attributed to differences in provider training and triage protocols (Fuller et al., 2024).

**3- Airway, Breathing, Circulation (ABC) approach**

The ABC approach is a resuscitation that was developed for the assessment and treatment of critically injured trauma patients. Its main purpose is to identify life-threatening injuries through sequential techniques, starting with the airway assessment that aims to check that the airway is not obstructed, especially in unconscious patients. Suctioning of the mouth with a chin lift or jaw thrust maneuver is the primary approach usually used for this assessment. If it is not adequate, oropharyngeal intubation must be initiated, and shifting to endotracheal intubation must be carried out if the other methods do not help the patient. In the cases of risk aspiration of gastric contents, surgical airways must be established. (Abhilash & Sivanandan, 2020)

In the 'Breathing' step, we assess gas exchange and provide ventilatory support as needed. This assessment should include inspection, palpation, and auscultation of the chest, followed by appropriate interventions (BVM, non-invasive or invasive ventilation). There are two main supports for ventilation used in prehospital settings: bag-valve-mask (BVM)

ventilation and mechanical ventilation (MV). (Pinto-Villalba & Leon-Rojas, 2023)

BVM ventilation is more popular because of its inexpensive benefit, simple technique, and minimal training, but although it is more popular, it performs poorly in real-world prehospital environments, as only about 16.7% of the physiologic end-tidal $CO_2$ ($ETCO_2$) is maintained in addition to the inappropriate tidal volume, which is crucial for survival in prehospital care. On the other hand, Mechanical ventilation (MV), either when used invasively, which is suited for conscious patients by using endotracheal tube or non-invasively (NIMV) using external interfaces, is the common method for maintaining COPD exacerbations, asthma flare-ups, and acute pulmonary oedema patients' air pathway. Despite its benefits, it requires specialized training as improper settings or inadequate monitoring can result in significant complications, including ventilator-induced lung injury and abnormalities in blood gases (hypo-/hypercapnia, hypo-/hyperoxia). (Pinto-Villalba & Leon-Rojas, 2023)

In a systematic review by Pinto-Villalba and Leon-Rojas (2023) that included 26 studies, a total of 9418 patients aged between 18 to 82 years old received out-of-hospital mechanical ventilation, with 56.4% of the cohort being male. The review showed that prehospital respiratory management relies almost entirely on non-invasive ventilation, which accounted for nearly 97% of all prehospital ventilation episodes. (Pinto-Villalba & Leon-Rojas, 2023)

The review also noted a higher prehospital mortality rate of around 14%, underscoring that patients requiring ventilatory support before hospital arrival are often critically ill and that inadequate or delayed ventilation may worsen the case. (Pinto-Villalba & Leon-Rojas, 2023)

Moving to the third step in the approach, which is circulation, in which pulse, neurological status, and blood pressure are assessed to provide information about the circulation status. A variety of parameters indicate different conditions in that case, as a rapid, weak pulse is an indicator of hypovolemia, and behavioral changes such as restlessness or unusual calmness may reflect reduced cerebral perfusion. Circulation assessment begins with placing two large-bore IV cannulas to allow rapid fluid delivery. Any obvious external bleeding should be controlled with direct

pressure.(Abhilash & Sivanandan, 2020)

For hypotensive patients, an initial 1–2 L bolus of Ringer's lactate is given, and the response is reassessed. Ongoing hypotension after the first bolus suggests continued hemorrhage, requiring urgent identification and control, and is often supported by FAST or CT imaging for internal bleeding. It is also important to recognize that resuscitation targets are not well defined; rapidly normalizing blood pressure in uncontrolled hemorrhage may worsen bleeding. Traditional markers such as blood pressure, heart rate, and urine output may therefore be unreliable early indicators of adequate resuscitation.(Abhilash & Sivanandan, 2020)

Currently, evidence suggests that the traditional ABC approach is not always optimal for trauma patients suffering from active hemorrhage or hypotension. In a systematic review and meta-analysis by Martinez et al. (2023), hypotensive trauma patients who received circulation-focused resuscitation (CAB sequence) before airway management were analyzed to find that using the CAB sequence led to lower mortality rates. The review highlighted that early intubation in the setting of ongoing hemorrhage can precipitate post-intubation hypotension and worsening outcomes.(Breeding et al., 2023)

In conclusion, early airway management remains essential when patency or oxygenation is compromised, but in patients with uncontrolled bleeding or shock, rapid volume resuscitation and hemorrhage control may take precedence. Integrating such evidence reinforces the importance of tailoring the ABC framework to patient physiology, ensuring that interventions are guided by real-time clinical risk rather than rigid sequencing. (Breeding et al., 2023)

**4- Pharmacologic Interventions (TXA)**

Pharmacologic interventions also play a role in trauma patients in prehospital settings. Tranexamic acid (TXA) is an anti-fibrinolytic agent widely used in trauma patients to reduce the bleeding risks. TXA affects the coagulation process by inhibiting plasminogen activation completely, leading to inhibition of plasminogen conversion to plasmin and reduction of hemorrhage. Studies recently emphasized using TXA within the first 3 hours of injury onset to reduce fetal traumatic occurrence, especially in patients aged 18 and above. (PATCH-Trauma Investigators & Gruen, 2023)

In a recent randomized, double-blind, placebo-controlled trial, PATCH-Trauma that conducted to evaluate the prehospital administration of Tranexamic Acid (TXA) on long-term outcomes in major trauma patients at risk of coagulopathy. 1310 randomized patients (661 of them received the TXA intervention, while 646 received a placebo), functional outcome rates at 6 months were identical (53.7% in TXA vs 53.5% in placebo; risk ratio 1.00; 95% CI 0.90–1.12; P = 0.95). Although 28-day mortality was modestly lower in the TXA group (17.3% vs 21.8%; RR 0.79; 95% CI 0.63–0.99), the long-term mortality difference by six months did not reach statistical significance (19.0% vs 22.9%; RR 0.83; 95% CI 0.67–1.03). Importantly, serious adverse events, such as vascular occlusive events, were similar between the two groups. The authors therefore conclude that prehospital TXA did not increase the proportion of trauma patients achieving favorable long-term functional recovery compared with placebo. (PATCH-Trauma Investigators & Gruen, 2023)

In another recent double-blind randomized clinical trial, evaluated early administration of Tranexamic acid (TXA) was evaluated in 140 trauma patients randomized to receive either 1 g TXA (bolus over 10 min) or a placebo on admission. The study compared outcomes, including need for blood transfusion, number of packed-cell units required, surgical procedures, thrombosis rates, and mortality. The authors found no significant difference between the TXA and placebo groups in mortality or transfusion requirement; in fact, the TXA group required more units of blood on average than the placebo, and the rates of venous thrombosis varied with patient sex, trauma type (pneumothorax, abdominal injury), and comorbidities. Based on these results, the authors concluded that early TXA did not confer a clear survival benefit in this trauma cohort and raised concerns about variability in blood-loss demands and thrombotic risk depending on patient factors. (Esfandyari et al., 2025)

Although TXA offers potential benefit, its effect is not uniform across all trauma phenotypes. TXA should therefore be used selectively, targeting patients at elevated risk of hemorrhage. With careful monitoring for transfusion requirements and thrombotic complications. (Esfandyari et al., 2025)

**5- Resuscitative Blood Products**

Hemorrhage shocks account for 30% to 40% of total deaths caused

by trauma, so blood transfusions, in which balanced components of red cell concentrate, platelets, plasma, and cryoprecipitate are transfused for the patient to improve the outcome in hemorrhage patients in prehospital settings, and it is now the standard used in hemorrhage shocks.(Crowe et al., 2020)

In a multicenter, cluster-randomized trial by Sperry et al., PAMPer evaluated the effect of thawed plasma administration during air medical transport and its improved outcomes among a total of 501 patients at risk for hemorrhagic shock (230 patients received plasma (plasma group) and 271 received standard-care resuscitation). Patients meeting prehospital physiological or anatomic criteria were assigned by transport cluster to receive either standard care or a prehospital infusion of two units of thawed plasma in addition to standard resuscitation. (Sperry et al., 2018)

The trial showed a statistically significant reduction in 30-day mortality in the plasma group compared to the control group (23.2% coefficient, 33.0%; difference, −9.8 percentage points; 95% confidence interval [CI], −18.6 to −1.0; P = 0.03; intracluster correlation coefficient, 0.02). The primary outcome results show a clinical survival benefit from blood transfusion administration in the pre-hospital settings.(Sperry et al., 2018)

Additionally, the authors reported improved coagulation parameters (reduced INR) at hospital arrival among plasma recipients, supporting a plausible physiological mechanism for the survival effect. However, subgroup analyses suggested the benefit was concentrated in patients with shorter transport times and severe injury patterns.(Sperry et al., 2018)

In another multicenter randomized clinical trial in France involving 134 patients with (median age,34[IQR, 26-49] years; 110 men [82.1%]), 68 of them were assigned randomly to the plasma group, and the other 66 patients were in the control group. The study aimed to determine if the lyophilized plasma transfusion can affect the trauma-induced coagulopathy incidence when compared to standard care of normal saline transfusion. (Jost et al., 2022)

The trial's primary outcome indicated that the median INR upon hospital arrival was 1.21 (IQR, 1.12–1.49) in the plasma group and 1.20 (IQR, 1.10–1.39) in the control group. In the plasma group, 37 patients (54.4%) had an INR above 1.20, and 18 patients (26.5%) had an

INR above 1.50, compared with 41 patients (62.1%) and 16 patients (24.2%), respectively, in the control group (P = .51). These results demonstrate that there was no significant difference in INR between the two groups following blood transfusion.(Jost et al., 2022)

**6- Resuscitative Endovascular Adjuncts (REBOA-type)**

Bleeding that results from vascular injury is a common cause of death in trauma patients. Bleeding in the vascular injury could be from sites amenable to direct compression or sites where direct compression is not possible, which is called non-compressible torso hemorrhage (NCTH). NCTH can cause 45% death rates, but studies have shown that most of those deaths are preventable. One of the devices that could be used in prehospital settings and is associated with improved outcomes in NCTH cases is REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta). REBOA is an invasive endovascular procedure used to occlude the aorta, although it is traditionally used in hospital settings, recent studies have encouraged exploration of using this technique in prehospital settings. Resources are still limited in this field.(Ordoñez et al., 2017)

In a comparative effectiveness research study using a multicenter registry of postinjury Aortic occlusion (AO) patients' records between 2013 and 2024, A total of 991 patients from 28 trauma centers were included to compare between use of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) versus traditional Resuscitative Thoracotomy (RT) in trauma patients. 306 (30.9%) received REBOA, and 685 (69.1%) underwent RT.(Cralley et al., 2023)

Authors found that REBOA was associated with significantly lower in-hospital mortality compared with RT: 78.6% survival in the REBOA group vs 92.9% in the RT group in matched analysis (P = 0.03). The adjusted relative risk (RR) for survival with REBOA was 1.25 (95% CI 1.15–1.36). Secondary outcomes, such as ventilator-free days (VFD), ICU-free days, and neurological outcomes at discharge (Glasgow Outcome Score), did not differ significantly between the two groups. The authors conclude that, in experienced trauma centers, zone-1 REBOA is a safe and effective alternative to RT for aortic occlusion in severe hemorrhagic shock, but there is a need for establishing more future randomized controlled trials to

assess REBOA's effectiveness and safety (Cralley et al., 2023)

**7- Prehospital Point-of-Care Imaging**

Prehospital use of imaging techniques has gained increasing research interest recently, using prehospital ultrasound has evolved from niche technology to a widely used one. Ultrasound use in prehospital settings is significantly associated with better outcomes, improved mortality, and increased diagnosis accuracy in traumatic patients who need immediate care based on a limited history.(Amaral et al., 2020)

In a prospective, randomized, multicenter trial enrolling 296 trauma patients who were suspected of having abdominal trauma, the effect of the prehospital focused assessment with sonography in trauma (p-FAST) on the prehospital decision-making and time to hospital admission was assessed in comparison to using clinical exam alone or when combined with p-FAST. Authors found that p-FAST (CEX-p-FAST) had a sensitivity of 94.7% and specificity of 97.6% for detecting free intra-abdominal fluid, which was better than clinical exam alone (CEX only: sensitivity 80.0%, specificity 84.4%). Moreover, Time to admission in patients with positive findings as when free fluid was detected, p-FAST was associated with a median reduction of 13 minutes in time from scene to hospital admission compared to CEX-only. Therefore, developing prehospital imaging techniques as p-FAST, is significantly associated with better hospital management and reduced admission time. (Lucas et al., 2022)

Prehospital portable ultrasound devices are increasingly proving their value in early trauma assessment, too. Recent clinical evaluations show that handheld systems make it easy to detect rapidly life-threatening conditions, such as pneumothorax, pericardial effusion, and intra-abdominal free fluid, directly at the scene. An observational cohort study was conducted to evaluate the frequency and effect of using point-of-care ultrasound (POCUS) in prehospital settings. Total callouts were 546, while ultrasound was used in 99 cases (18.1%), among them 31% cases were traumatic. Authors found that Diagnostic agreement between prehospital and in-hospital occurred in 90.8% of cases, which is significantly high. (Scharonow & Weilbach, 2018)

While point-of-care imaging in the prehospital setting is recently

commonly used and leads to early assessment and triage of time-sensitive conditions, its impact depends on operator skill, system configuration, and robust clinical governance; therefore, there are important knowledge gaps that remain that need more investigation (training, cost-effectiveness, and generalizability). (Amaral et al., 2020)

**8- Technologies and Innovations**

Recently, a variety of innovations and technologies have been developed in prehospital emergency care, aiming for earlier diagnosis and treatment decisions. Using generative AI in diagnostics provides potential in developing human capabilities in reaching quick, accurate diagnoses and earlier interventions. However, safety, aligning with protocols, and validity still need to be further investigated in that field. A recent scoping review, Artificial Intelligence in Emergency Trauma Care (2024), evaluated applications of AI in emergency trauma from 2014 to 2024 and found growing evidence for AI's diagnostic performance (especially in imaging), triage support, and predictive analytics.(Ventura et al., 2024)

The study, Remote real-time supervision of prehospital point-of-care ultrasound, a feasibility study conducted in 2022, tested whether on-scene portable ultrasound (POCUS) could be live-transmitted for expert review, enabling remote guidance in emergencies. Results showed that among 24 attempted prehospital ultrasound exams, 71% (17 cases) were successfully streamed live with good image and communication quality. The authors concluded that this method, which is called telemedicine, is promising, and further research could be conducted to develop it. (Hermann et al., 2022)

Another review about wearable healthcare devices for clinical and prehospital use, and how their use has developed over time. Wearable healthcare devices (WHDs) combine a variety of technologies as sensors and data transmission, to monitor vital data continuously and trigger an alert for any intervention or deterioration. The authors highlight the potential of WHDs to track physiological parameters during transport or while waiting for EMS, improving early detection of hypoxia, shock, or other critical changes, and they also emphasize challenges of data privacy, the need for robust validation, and algorithmic bias.(Gathright et al., 2024)

Another innovation that should be sorted is prehospital computed

tomography (CT), which represents a promising advancement in early diagnostics for patients with suspected acute stroke or severe head injury. The 2019 Norwegian HTA evaluated the clinical effectiveness, feasibility, and economic implications of deploying mobile CT units, CT scanners integrated into ambulances or specialized vehicles, for on-scene imaging. Evidence from stroke-focused studies demonstrated that prehospital CT could significantly reduce time from emergency call to imaging and treatment, with alarm-to-thrombolysis times shortened by approximately 30 minutes compared with conventional pathways. Moreover, early imaging enabled more accurate triage decisions, ensuring that patients were transported directly to appropriate centers and potentially avoiding unnecessary transfers.

Together, these technologies represent a trajectory toward data-driven, connected, and prehospital-ready trauma care. Telemedicine and remote supervision can democratize expert-level diagnostics; wearable sensors may allow early detection of deterioration; AI algorithms could support triage, diagnosis, and risk stratification; and portable imaging, from ultrasound to future mobile CT or smart imaging devices, may bring advanced diagnostics directly to patients in the field. However, challenges and limitations of validation and privacy should be considered.

*** Discussion**

This review summarizes evidence that targeted techniques and technologies can shorten the interval to lifesaving care and, in selected populations, reduce early deaths from hemorrhage.

In current findings, interventions were developed aiming to decrease the diagnosis time, such as prehospital plasma, faster imaging, and even prehospital REBOA in specialized systems and how this can alter the outcomes and trauma results.

Randomized and cluster trials offer a variety of conclusions. The PAMPer trial demonstrated a survival advantage with prehospital thawed plasma in air-medical transport, particularly in patients with longer prehospital times and severe injuries. By contrast, trials of prehospital packed cell/lyophilized plasma combinations (e.g., RePHILL) and smaller RCTs of TXA reported neutral outcomes, underscoring that not all contexts or patient mixes will benefit equally. The recent PATCH-Trauma trial is notable: while short-term mortality decreased

significantly, the primary outcome of favorable long-term functional recovery was neutral, and it highlighted that a single early intervention may not change downstream care or recovery without a comprehensive system.

Research has recently shown interest in prehospital diagnostic advances. Prehospital POCUS (p-FAST) consistently improves diagnostic accuracy and shortens time to definitive treatment in positive cases; tele-supervision models allow expert interpretation on scene, widening applicability where expertise is limited. Mobile CT (MSU) demonstrates clear benefit in stroke and shows potential for triage in severe injury, though cost and resource requirements are challenges.

Resuscitative endovascular adjuncts (REBOA) represent a high-risk, high-reward intervention. Registry data suggest favorable survival compared with thoracotomy in experienced centers,but randomized data are mixed; prehospital REBOA is feasible in physician-led services yet remains experimental in most EMS systems. Wearable sensors and AI-driven triage tools promise continuous monitoring and earlier warnings of deterioration, but currently, the evidence for improved patient-level outcomes remains under investigation.

Overall, the evidence supports selective adoption of innovations where system capability and patient selection align with the intervention's mechanism of benefit. For all innovations, we recommend rigorous implementation studies, pragmatic trials with standardized endpoints (e.g., 24-hour exsanguination death, 30-day mortality, 6-month functional outcome), and routine surveillance for adverse events.

*** Conclusion**

Innovations in prehospital assessment and early intervention have moved from concept to practice over the last decade. Portable diagnostics (p-FAST, handheld sensors), selective prehospital therapeutics (plasma, targeted TXA use), endovascular adjuncts, and telemedicine each offer a pathway to reduce time to critical care and improve early outcomes but using them in all trauma cases is still under investigation. Real benefit depends on aligning the intervention with the right patient, the right time window, and a system capable of rapid, definitive care. Future implementation must therefore couple technology with training, governance, and surveillance. High-quality pragmatic trials and

standardized outcome frameworks will be essential to ensure the method's efficacy.

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