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# CURRENT PROTOCOLS FOR PRE-HOSPITAL CARE IN SEVERE TRAUMA: IMPACT ON MORTALITY AND MORBIDITY

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**Abstract:** Severe trauma is one of the main causes of morbidity and mortality worldwide and is responsible for a large proportion of admissions to intensive care units and for considerable costs to health systems. In this context, pre-hospital care has emerged as a fundamental component of the line of care for polytraumatized patients, playing a decisive role in the clinical stabilization and prognosis of the victim. The implementation of standardized care protocols, such as Advanced Trauma Life Support (ATLS) and Prehospital Trauma Life Support (PHTLS), has been essential to systematize conduct and optimize the response time of emergency teams. These protocols emphasize primary and secondary assessment, prioritizing the guarantee of a patent airway, effective ventilation, hemorrhage control and rapid identification of life-threatening injuries. Advanced pre-hospital care, carried out by trained professionals and with the support of appropriate equipment, allows for early interventions that directly influence clinical outcomes, such as reducing mortality, reducing complications and improving patients' functional recovery. In addition, the careful choice of means of transportation, adequate response time and efficient communication with the referral service are all factors that contribute to successful care. This article proposes an updated review of the main protocols used in pre-hospital care for severe trauma, highlighting their practical applications, benefits and challenges, with the aim of reinforcing the importance of this critical phase in the continuum of care for trauma patients.

**Keywords:** Pre-hospital care; Severe trauma; Emergency protocols; Mortality.

## INTRODUCTION

Severe trauma is one of the main causes of morbidity and mortality worldwide, accounting for a significant proportion of preventable deaths. Advanced pre-hospital care plays a key role in mitigating these deaths by offering early and effective interventions in the out-of--hospital setting. Appropriate management in the early stages of trauma care has been shown to have a positive impact on patient survival, reducing complications and improving prognosis.

The main causes of preventable death in trauma include severe hemorrhage, chest injuries and traumatic brain injury (TBI). Uncontrolled bleeding remains the leading cause of potentially preventable death in polytraumatized patients, with evidence showing that early intervention with bleeding control, tranexamic acid administration and adequate use of blood products can significantly reduce mortality. Chest injuries, such as tension pneumothorax and hemothorax, also represent challenges in pre-hospital care and require rapid interventions, such as thoracic decompression with a needle or thoracostomy. TBI, on the other hand, requires measures aimed at neuroprotection, control of intracranial pressure and adequate stabilization to avoid aggravation of the secondary injury.

Over the last few decades, pre-hospital trauma care protocols have undergone important developments. Guidelines such as Prehospital Trauma Life Support (PHTLS) and Advanced Trauma Life Support (ATLS) emphasize a systematic, evidence-based approach to the management of critically ill patients. The implementation of strategies such as the use of point-of-care ultrasound (eFAST) in the pre--hospital environment, advanced aeromedical transport and the concept of "damage control resuscitation" have been fundamental to improving clinical outcomes.

Thus, understanding the importance of pre-hospital care in the context of severe trauma, its evidence-based interventions and its impact on mortality and morbidity is essential for optimizing emergency care and improving care guidelines.

## THEORETICAL FRAMEWORK

### HISTORY AND EVOLUTION OF PRE-HOSPITAL CARE PROTOCOLS

The evolution of pre-hospital care protocols dates back to the beginning of the 20th century, with the first records of ambulance systems created to transport the wounded. During the World Wars, the military played a crucial role in developing rescue and triage techniques. From this, medical practices were systematized, with the establishment of protocols that focused on rapid triage and trauma control.

In the 1960s and 1970s, advances in emergency medicine, especially with the increase in mobile rescue units and the professionalization of teams, led to the creation of the first formalized protocols, such as the Manchester Triage System and Protocol-Based Care.

With advances in technology and clinical research, these protocols have been refined, incorporating new approaches such as hemorrhage control and advanced airway management, as well as the use of new technologies for triage and communication.

### CURRENT PROTOCOLS FOR ADVANCED PRE-HOSPITAL CARE

Prehospital care for severe trauma is based on up-to-date guidelines and systematized protocols aimed at ensuring the initial stabilization of the patient, preventing complications and optimizing clinical outcomes. The main guidelines used include **Advanced Trauma Life Support (ATLS)** and **Prehospital Trauma Life Support (PHTLS)**, both of which emphasize a structured, evidence-based approach.

**XABCDE of Trauma - Updated Primary Assessment**

The XABCDE approach prioritizes the immediate control of exsanguinating hemorrhages (X), even before assessing the airways. The aim is to treat injuries with an imminent risk of death, in the order in which they kill:

**X - eXsanguination (immediate control of severe bleeding)**

- Identify and control massive external bleeding immediately with tourniquets, direct compression, hemostatic dressings or topical agents.
- Non-compressible bleeding should be suspected and treated with immediate transportation and guided resuscitation.

A - Airway (Airway with cervical spine protection)

- Ensure a patent and safe airway, with manual stabilization of the cervical spine until the cervical collar and complete immobilization are applied.
- If necessary, perform airway opening maneuvers, aspiration or orotracheal intubation.

B - Breathing (Ventilation and Respiration)

- Assess chest expansion, respiratory rate, presence of vesicular murmurs, signs of respiratory failure or inadequate ventilation.
- Treat conditions such as tension pneumothorax, hemothorax or unstable chest.

C - Circulation (Circulation and shock control)

- Assess central pulse, peripheral perfusion and capillary refill time.
- Establish venous or intraosseous access and start volume resuscitation, preferably with warmed fluids and early transfusion, if indicated.

D - Disability (neurological deficit)

- Rapid neurological assessment with the Glasgow Coma Scale.
- Assess pupils, motor response and signs of cerebral herniation.

E - Exposure (Exposure and temperature control)

- Remove clothing for a full body assessment.
- Prevent hypothermia with thermal blankets, environmental control and heated fluids.

**TRAUMA CLASSIFICATION AND CARE PRIORITIES**

Trauma can be classified into two main categories: **blunt trauma** (usually caused by external forces, such as collisions, falls or traffic accidents) and **penetrating trauma** (generated by objects that pierce the body, such as stab wounds or gunshots).

Triage protocols prioritize care based on the severity of the injury and the patient's clinical condition, usually following the Emergency Triage System (e.g. Manchester Triage System), which classifies patients into priority levels. Initial triage aims to determine which patients need immediate life-saving intervention.

**Severe head, chest, abdominal and orthopedic trauma**

- **Traumatic brain injury (TBI)**: The initial management protocol involves stabilizing the airway, controlling bleeding, and monitoring intracranial pressure. Vital signs should be constantly assessed.
- **Thoracic Trauma**: Breathing and ventilation should be monitored, identifying signs of pneumothorax, hemothorax or lung damage. The protocol includes chest drainage and, when necessary, assisted ventilation.
- **Abdominal trauma**: Injuries can be subtle, and clinical assessment is essential. Initial stabilization includes blood pressure control and preparation for rapid transport.

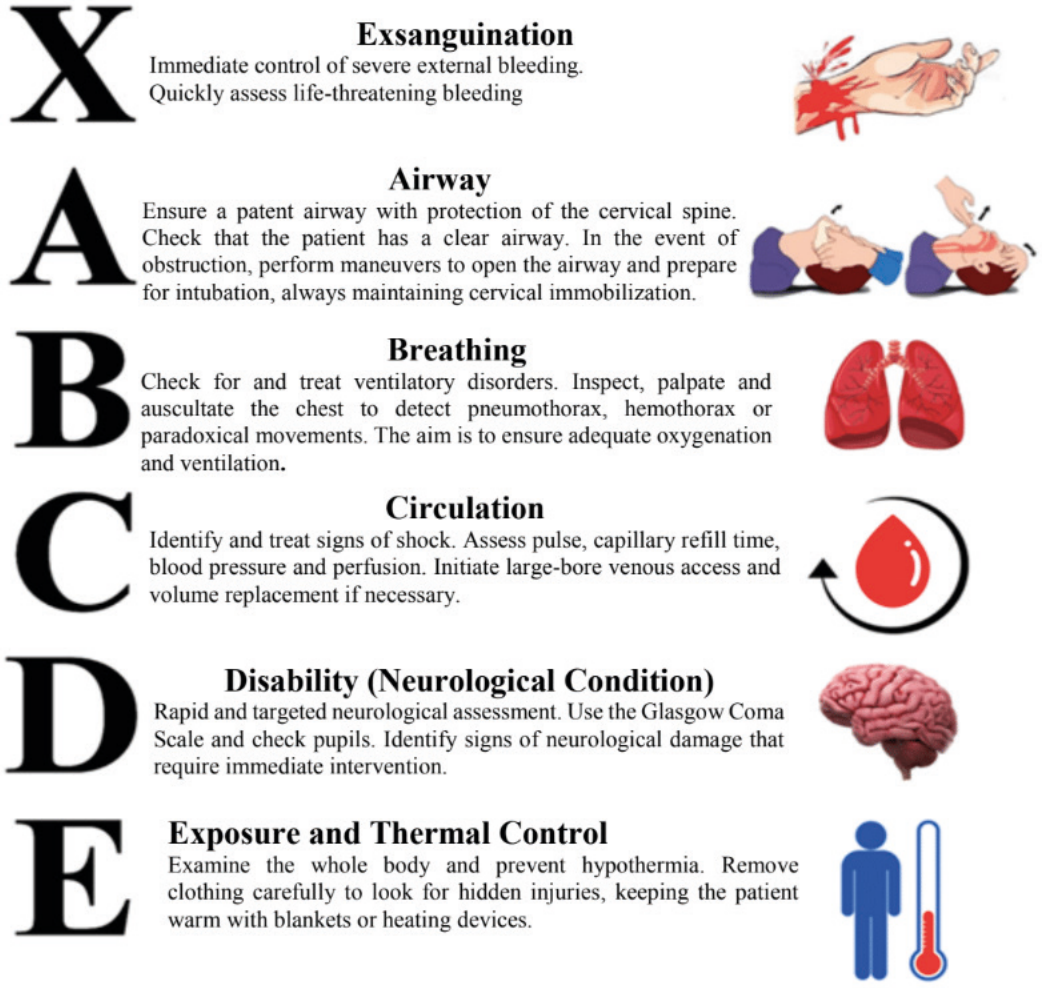


Figure 1: XABCDE of trauma

Source: Prepared by Vedana (2025).

- **Orthopaedic trauma**: Proper immobilization of fractures and orthopaedic injuries, management of associated bleeding and transport in positions that minimize the risk of complications are fundamental.

## SPECIFIC PROTOCOLS BY TYPE OF TRAUMA

Each type of trauma requires specific interventions based on stabilization priorities:

a) Severe Traumatic Brain Injury (TBI)

- Stabilize the airway (early OTI), avoid hypoxia and hypotension.
- Monitor intracranial pressure (when possible).
- Avoid excessive hyperventilation.
- Elevate the head, maintain normothermia and normoglycemia.

b) Thoracic Trauma

- Identify and treat causes of immediate death:
  - Unstable chest
    - Hypertensive pneumothorax (treated with decompressive thoracentesis followed by water-seal drainage)
    - Massive hemothorax
    - Cardiac tamponade (assessed via FAST USG)
- Positive pressure ventilation, if necessary.

c) Abdominal trauma

- Evaluation with FAST (trauma-focused ultrasound) or CT scan (when available and patient stable).
- Emergency surgery in hemodynamic instability with suspected intra-abdominal bleeding.
- Avoid nasogastric probing in suspected skull base fractures.

d) Orthopaedic trauma

- Initial stabilization of long fractures with splints.
- Reduction of dislocations and immobilization.
- Control of external bleeding and prevention of compartment syndrome.
- Application of a tetanization and antibiotic prophylaxis protocol for open fractures.

## POINT-OF-CARE ULTRASOUND (eFAST) IN PRE-HOSPITAL CARE

The use of bedside ultrasound, especially through the eFAST (Extended Focused Assessment with Sonography for Trauma) protocol, has been gaining ground in the pre-hospital environment as a fast, accurate and non-invasive diagnostic tool for the initial assessment of polytraumatized patients.

### Objective of eFAST

The eFAST protocol is an extension of the traditional FAST exam, including an assessment of the chest to detect pneumothorax and hemothorax. It aims to quickly identify the presence of:

- **Free intra-abdominal fluid** (suggestive of bleeding).
- **Cardiac tamponade** (by assessing the pericardial space).
- **Hemothorax and pneumothorax** (by anterior and posterior thoracic evaluation).
- **Pelvic fractures associated with free fluid in the pelvis.**

### Pre-Hospital Applicability

In out-of-hospital scenarios, eFAST has proven to be effective when used by trained teams:

- **Early clinical decision-making**, such as prioritizing transport to a trauma center with surgical capacity.
- **Rationalization of the use of resources**, avoiding unnecessary tests on patients with no signs of internal bleeding.
- **Identification of critical conditions** that indicate an immediate need for intervention, such as emergency thoracostomy or laparotomy.

### Advantages of eFAST in Pre-Hospital

- **Speed**: The test can be carried out in less than 5 minutes by a trained professional.
- **Portability**: Portable and compact ultrasound devices have become more affordable and reliable.
- **High sensitivity and specificity** for the detection of free liquids and pneumothorax, especially when performed by experienced professionals.
- **Complement to clinical assessment:** Helps confirm physical examination findings, especially in unconscious or unstable patients.

### Limitations

- **Operator-dependent**: Accuracy is directly related to the training and experience of the professional.
- **Technical limitations**: Imaging may be difficult in obese patients, those with subcutaneous emphysema or in environments with excessive vibrations (such as moving ambulances).

**Recent Evidence**

Recent studies have shown that the use of eFAST in the pre-hospital setting:

- **Reduces the time until definitive diagnosis** and transfer to an appropriate trauma center.
- **It increases survival** in patients with thoracoabdominal injuries by anticipating interventions such as thoracentesis or exploratory surgery.
- It is included in the **ATLS best practice** recommendations, especially in centers with advanced mobile support (SAMU, helicopters, mobile ICUs).

**HEMORRHAGE CONTROL IN SEVERE TRAUMA**

Uncontrolled bleeding is one of the **main causes of preventable death** in trauma patients. The **ATLS 10th edition** emphasizes that immediate control of bleeding should be a priority in the early stages of care. In the pre-hospital environment, certain measures are essential to prevent exsanguination and optimize tissue perfusion until arrival at the hospital.

**Use of tourniquets**

The **use of commercial tourniquets** is strongly recommended for the control of exsanguinating hemorrhages in limbs, especially in:

- Traumatic amputations;
- Penetrating wounds with visible arterial bleeding;
- Bleeding that does not respond to direct compression.

The ATLS stresses that the tourniquet should be applied **above the bleeding site**, noting the time of application and monitoring the affected limb. Studies such as the CRoC (Combat Ready Clamp) have shown that the proper use of tourniquets **significantly increases survival**, especially in victims of penetrating trauma and combat injuries.

**ATLS (2018):** "Early application of tourniquets in limb injuries with massive hemorrhage can save lives and should be considered an essential part of prehospital management."

**Early Administration of Tranexamic Acid (TXA)**

TXA is an antifibrinolytic that **reduces clot degradation** and is indicated if significant bleeding is suspected, preferably in the first **three hours after the trauma**.

- Recommended dose: 1g IV bolus, followed by 1g infusion over 8 hours.
- The **CRASH-2 study** showed a reduction in mortality in polytraumatized patients who received TXA early.

The **ATLS and WHO** recommendations are clear: TXA should be included in pre-hospital protocols whenever there is **evidence or strong suspicion of active bleeding**.

"TXA administration in trauma should be done as early as possible, ideally in the pre-hospital setting, in patients at risk of significant bleeding." - ATLS, 10th edition

**Management of Hypovolemic Shock**

Hypovolemic shock, mainly due to blood loss, is the most common type of shock in trauma patients. Management follows the following principles:

- **Early recognition of shock**: Monitoring vital signs, level of consciousness (Glasgow Coma Scale) and peripheral perfusion (capillary refill time, cold extremities, pallor).
- **Volume replacement:**
  - Warmed crystalloid solutions (e.g. Ringer's lactate or SF 0.9%): initially used as a 1L bolus in adults, with reassessment after administration.
  - Early blood transfusion: indicated in patients with grade III or IV shock, especially if there is no adequate response to volume.

- Mass transfusion protocol: in severe cases, use a 1:1:1 ratio (red blood cell concentrate, fresh frozen plasma and platelets).

**Stabilization of Pelvic Fractures**

Unstable pelvic fractures are often associated with **severe retroperitoneal bleeding**. The ATLS recommends immediate stabilization as a measure to control internal bleeding.

- The use of **commercial pelvic belts or fitted sheets** over the trochanteric region (not the abdomen) can **reduce pelvic volume and compress bleeding vessels**.
- This measure is simple, quick and should be carried out at the trauma site as soon as pelvic instability is identified, especially in hemodynamically unstable patients with high-energy trauma.

**ATLS (2018):** "Initial stabilization of the pelvis with a compressive device can be a measure of life and death and should precede transport."

## INDICATIONS AND ADVANCES IN THE AIRWAY IN PRE-HOSPITAL CARE

Airway management is one of the fundamental pillars of pre-hospital care for patients with severe trauma. Airway obstruction and hypoxemia are directly associated with increased morbidity and mortality, especially in cases of traumatic brain injury and polytrauma. In this context, the choice of the appropriate airway control technique depends on the patient's clinical condition, the resources available and the training of the rescue team.

**Orotracheal Intubation (OTI)**

**Orotracheal intubation with a cuffed tube** is considered the gold standard for definitive airway protection, according to the guidelines of **Advanced Trauma Life Support (ATLS, 10th edition)** and the **National Association of Emergency Medical Technicians (NAEMT).** It is indicated in the following situations:

- Lowered level of consciousness (Glasgow ≤ 8);
- Respiratory failure with signs of hypoxemia or hypercapnia;
- Inability to protect the airways against aspiration;
- Facial or neck trauma with imminent risk of obstruction;
- Cardiorespiratory arrest.

Studies show that pre-hospital OI, when performed by trained professionals and under appropriate conditions, is associated with improved oxygenation and cerebral perfusion in patients with severe head trauma (Dunne et al., 2017).

The use of **quantitative capnography ($EtCO_2$)** is mandatory after intubation to confirm the correct position of the tracheal tube, as recommended by the American Heart Association (AHA).

**Supraglottic devices (DSG)**

Supraglottic devices are safe and effective alternatives for airway management in situations where:

- Intubation is not possible or has failed;
- The environment is hostile or there are limited resources;
- There is a need to quickly guarantee a functional airway, such as in cardiac arrests.

The DSGs most commonly used in pre-hospital care include:

- **Laryngeal Mask (LMA);**
- **I-gel device** (without cuff inflation);
- **Combitube** (double lumen for esophageal or tracheal ventilation).

The literature shows that these devices have **insertion success rates of over 85%,** with an average **insertion** time of less than 30 seconds, making them ideal for services with less medical support, but with trained nursing staff or paramedics (Frerk et al., 2015 - DAS Guidelines).

## STATE-OF-THE-ART TECHNOLOGY IN PREHOSPITAL CARE

The incorporation of advanced technologies has revolutionized pre-hospital care, allowing for more precise, safe and effective interventions:

- **Real-time telemedicine**: Allows direct communication between field teams and specialist doctors in hospitals. Doctors can guide critical clinical decisions, such as intubation, drug administration or choice of destination hospital. It is especially useful in remote areas or with less experienced teams.
- **Portable Monitoring Devices**: Compact and mobile equipment such as:
  - Multiparametric monitors (ECG, $SpO_2$, blood pressure, respiratory rate).
  - Capnography for ventilation assessment.
  - Blood glucose and lactate monitors for metabolic assessment.
  - Portable ultrasound devices (pre-hospital FAST) for screening internal bleeding.
- **Transport Ventilators and Intelligent Infusion Pumps**: Used for continuous ventilatory support and precise administration of fluids and medicines while on the move.
- **Geolocation technology**: Allows real-time tracking of the ambulance and patient, optimizing response times and the route to the hospital.

### Use of Applications and Coordination Systems

The use of integrated digital solutions has increased the efficiency and organization of customer service:

- **Clinical Decision Support Applications**: Tools that help professionals follow protocols (such as the ABCDE of trauma), calculate drug doses, trauma scales (e.g. RTS, ISS, GCS), and automated checklists.
- **Medical Regulation Systems**: Platforms that connect the Regulation Centers to the mobile care teams, making it easier:
  - More effective patient screening.
  - Referral to hospitals with adequate facilities.
  - Prior notification to the hospital of the patient's arrival.
- **Electronic Pre-Hospital Record (e-SUS, SIATE, among others)**: Allows digital recording of interventions made at the scene and during transportation, ensuring continuity of care, traceability and generation of data for epidemiological analysis.
- **Integration with Hospital Systems**: Hospitals receive advance information such as vital signs, imaging tests sent from the scene (e.g. photos of injuries, portable ultrasound), estimated time of arrival and case severity, which allows them to activate specific teams (e.g. neurosurgery, trauma, hemodynamics) in advance.

## IMPACT OF ADVANCED PRE-HOSPITAL CARE ON MORTALITY AND MORBIDITY

Advanced pre-hospital care has been one of the main factors in reducing mortality and morbidity in polytraumatized patients. The implementation of evidence-based protocols, the training of specialized teams and the use of emerging technologies are key elements in improving clinical outcomes.

## EVIDENCE-BASED PROTOCOLS

The adoption of protocols such as Advanced Trauma Life Support (ATLS) and Pre-Hospital Trauma Life Support (PHTLS) has been associated with improvements in the early identification of critical injuries, effective stabilization and adequate patient transport. These protocols promote a systematic approach that contributes to reducing mortality and improving clinical outcomes

## CONTINUOUS TEAM TRAINING

The continuous training and education of pre-hospital care teams is fundamental to guaranteeing the effectiveness of the protocols implemented. The qualification of professionals allows for a faster and more appropriate response to emergencies, with a positive impact on patient survival.

## USE OF EMERGING TECHNOLOGIES

- The incorporation of technologies such as telemedicine and remote monitoring devices has improved the quality of pre-hospital care. These innovations allow for more accurate assessment and more effective interventions, contributing to a reduction in mortality and morbidity.

## REDUCED RESPONSE TIME

Response time is a determining factor in the survival of polytraumatized patients. Studies indicate that rapid interventions at the scene of the accident and during transportation are associated with better prognoses, especially in the first few hours after the trauma

In summary, advanced pre-hospital care, based on solid protocols, well-trained teams and innovative technologies, has proven to be effective in reducing mortality and morbidity in polytraumatized patients. continuity in the training of professionals and investment in technological resources are essential to further improve clinical results.

## EXAMPLES OF EFFICIENT EMERGENCY SYSTEMS

Different countries and regions have implemented pre-hospital care models that have shown a positive impact on trauma outcomes. Among the most recognized are:

- **SAMU (Mobile Emergency Care Service)**: In Brazil, SAMU plays an essential role in the rapid response to trauma, with teams trained in basic and advanced care, contributing to the reduction of mortality in urban and rural settings.
- **HEMS (Helicopter Emergency Medical Services)**: Aeromedical transportation has been a differential in trauma care in regions that are difficult to access, reducing the time until definitive care and improving survival rates.
- **International models**: Countries like Germany and France adopt the "stay and play" model with medical teams in the pre-hospital area, while the US prioritizes rapid transport to trauma centers, both with good results depending on the local context.

The evolution of advanced pre-hospital care protocols, combined with the qualification of teams and the implementation of technologies, has been decisive in reducing mortality and morbidity in serious trauma. Investment in ongoing training and infrastructure is essential to optimize results and guarantee effective care for all trauma victims.

## EVIDENCE ON THE REDUCTION OF TRAUMA MORTALITY WITH ADVANCED PRE-HOSPITAL CARE

Advanced pre-hospital care (APHA) plays a fundamental role in reducing mortality in trauma patients. Several studies show that interventions carried out at the scene of the accident, especially when guided by protocols, can be decisive for survival.

## IDENTIFICATION AND EARLY CONTROL OF MASSIVE BLEEDING

Bleeding is the main preventable cause of death in trauma. Immediate intervention is essential to avoid hypovolemic shock and the lethal triad (hypothermia, acidosis and coagulopathy).

- **Tourniquets**: Studies show that the use of tourniquets on limbs with exsanguinating hemorrhages drastically reduces mortality, especially in combat environments and urban penetrating trauma (Kragh et al., 2012).
- **Hemostatic agents**: Compresses impregnated with substances that accelerate coagulation (such as kaolin and oxidized cellulose) are effective in controlling non-compressible external bleeding.
- **Early transfusion and massive transfusion protocol**: Early initiation of whole blood transfusion or transfusion in balanced proportions (1:1:1) in the field helps stabilize the patient before arrival at the hospital.]

## ADVANCED AIRWAY MANAGEMENT

Hypoxemia and airway obstruction are common causes of cardiac arrest in trauma patients.

- **Early orotracheal intubation**: This is indicated in patients with reduced consciousness (Glasgow ≤ 8) or ineffective ventilation. Studies show that out-of-hospital intubation is associated with greater respiratory control and a reduction in complications during prolonged transportation (JAMA Surg, 2018).
- **Supraglottic devices**: These are effective alternatives when OTI is not possible, especially in environments with non-medical professionals. They reduce hypoxia time and improve oxygenation in facial trauma or difficult airways.

## GOAL-ORIENTED RESUSCITATION AND ADJUVANT MEDICATIONS

The controlled and directed resuscitation approach has been effective in preventing the complications of excessive volume replacement.

- **Restrictive volume replacement**: Used especially in penetrating trauma with a risk of active bleeding. The aim is to maintain systolic pressure at around 80-90 mmHg until definitive surgical control of bleeding.
- **Tranexamic acid (TXA):** The **CRASH-2** study (Lancet, 2010) showed that the administration of TXA in the first 3 hours after trauma significantly reduced mortality in patients with severe hemorrhage. The recommended dose is 1g bolus followed by 1g infusion over 8 hours.
- **Continuous monitoring**: With the use of capnography, peripheral saturation, portable ECG and non-invasive blood pressure, it is possible to guide interventions with greater precision, especially during transportation.

## CONCLUSION

Advanced pre-hospital care (APHA) has become an essential pillar in the care of severe trauma patients, and is crucial in reducing mortality and morbidity. The evolution of care protocols, the continuous training of teams and the adoption of state-of-the-art technologies have demonstrated substantial improvements in efficiency and in patients' clinical outcomes.

Standardized guidelines, such as Advanced Trauma Life Support (ATLS) and Pre-Hospital Trauma Life Support (PHTLS), guarantee a structured and systematic approach that optimizes response times and provides effective assistance, from the scene of the accident to the destination hospital. The consistent application of these guidelines, coupled with the conti-


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nuous training of teams, is essential to ensure that professionals make quick decisions based on the best scientific evidence available, especially in highly complex scenarios.

The impact of technological innovations, such as telemedicine, remote monitoring devices and portable ultrasound (pre-hospital FAST), has revolutionized the pre-hospital approach. Technologies such as hemorrhage control with tourniquets, hemostatic agents, and the early use of tranexamic acid have shown a significant reduction in mortality. In addition, the use of transport ventilators and real-time coordination with medical specialists increase the effectiveness of interventions at the scene and during transport.

The debate between the "load and go" and "stay and play" models of care highlights the importance of adapting protocols and resources according to regional needs and the type of trauma. The choice of the ideal model can directly impact the effectiveness of care and the prognosis of patients, reinforcing the need for flexibility and personalization of care.

The future of advanced pre-hospital care is closely linked to the continuous development of evidence-based protocols, the expansion of emerging technologies and efficient integration between emergency systems and trauma centers. Investing in training teams, implementing new technologies and strengthening the care infrastructure is essential to further improve the effectiveness of APHA and reduce the impact of severe trauma on the population.

It is therefore essential that health policies prioritize the strengthening of pre-hospital care structures, ensuring that scientific and technological innovations are accessible and implemented effectively. Only with these advances will it be possible to optimize the response to trauma and save more lives, especially in regions with major logistical and operational challenges.

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