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AN UPDATE ON PRE-HOSPITAL MANAGEMENT OF MAJOR TRAUMA

INTRODUCTION The goals of pre-hospital care for severe trauma are the detection of life-threatening injuries, the early application of therapeutic measures and the timely transfer to an appropriate hospital centre. The response of the emergency services to major trauma incidents involves different responders with specific functions and in a variety of often challenging contexts. Therefore, a common language, preparation and coordination are essential to ensure compliance with the goals and quality of care. OBJECTIVE To carry out an update on the management of the adult trauma patient based on new evidence and practices. METHODS Literature review search mainly through PubMed. A secondary search on UptoDate and the latest editions of reference books on prehospital and advanced major trauma, and in reference organizations such as Difficult Airway Society, Advanced Trauma Life Support, European Trauma Course, and Anaesthesia, Trauma and Critical Care Course (ATACC). A tertiary search through the references in the UpToDate guidelines to identify new sources. Search terms included: prehospital care, major trauma, difficult airway, permissive hypotension, immobilization, both in Spanish and English. RESULTS The management of catastrophic bleeding is the first step in the primary assessment, because it can cause death even before an obstructed airway. Airway management and ventilation remain a priority. Permissive hypotension is increasingly accepted in the management of major trauma with hypovolemic shock except in the case of patients with head trauma. Prevention and control of the deadly triad (acidosis, hypoxia and hypothermia) improve the prognosis. An "excessive stabilization" approach should be avoided, so that access to definitive treatment is not delayed. CONCLUSIONS Prehospital trauma care is necessarily multidisciplinary, requiring coordination and communication between teams to ensure quality of care.

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CASE

You work in a rural emergency health team. It is January 1st, and you are dispatched at 8.30 am to a traffic accident. The car has rolled over about 5 meters from the curb of a secondary road after passing a bend probably at a considerable speed. A police patrol at the scene reports that there are 4 young occupants in the vehicle:

The co-pilot is unconscious, with no signs of life.

The pilot is conscious, but confused, and bleeding from the head.

An occupant in the back seat complains of leg pain.

Another young person has got out through the window without help. While lying on the floor, the victim is supporting his arm, complaining of pain and saying that his right shoulder is "dislocated".

Additionally, the coordination centre has dispatched a local basic life support ambulance (BLSA) an advanced life support ambulance (ALSA) form the main city, with an emergency physician and nurse. A fire brigade unit is about to arrive to perform extrication.

The police alsoy report the deployment of both the front and side airbags. They are bottles of alcohol inside the passenger compartment.

From the information regarding the condition of the victims and the vehicle, you imagine a high energy injury mechanism.

From this information, can you prioritize the team's role at the scene? What safety measures will you consider? What immobilization material do you need? Have you checked the airway management material, medication, etc? Are you familiar with the basic material in the local BLSA?

INTRODUCTION

Given the complexity of scoring scales and at the hospital level, major trauma (MT) is defined when a patient who has suffered an injury due to a traumatic external cause and has a score on the New Injury Severity Score (NISS) scale of > 15 points.

Prehospital major trauma remains a public health challenge in modern society[1].

The attention and response of the emergency health services to prehospital major trauma requires preparation and coordination among the first responders (police, firefighters, mountain rescue group, health technicians, witnesses, victims, advanced life support personnel, coordination centre, and staff of the receiving hospital). Unlike the hospital environment, the time of day, environmental and climatic conditions, can pose a risk to patients and professionals. In addition, patient-related conditions (access, inside or outside a building, entrapment, complexity of extrication...) can prolong the intervention time.

Prehospital health care can be basic and advanced. These levels of care vary widely depending on the regions, health model or major trauma response system, the context itself (urban-rural, terrain), and the characteristics and needs of the victims. On many occasions the various responders are not known. Therefore, regardless of the level of care, **the common principle of any health response at the hospital level is quality care in the shortest possible time, minimizing the time of transfer to an appropriate health centre.**

PREVENTION

Prehospital health professionals can not only provide health assistance, but also offer advice on prevention whenever possible on site through a **"teachable moment"**[2,3]. A teachable moment is one in which the patient does not need critical medical intervention or in which family members or witnesses are receptive to information we can provide them.

It's not always possible to give advice on injury prevention. However, the reality is that a high percentage of cases may not involve vital risk, requiring minor or no treatment. Individualized preventive advice can be essential in these cases, requiring no more than one or two minutes and not interfering with the treatment or with transfer.

Implementing and developing educational programmes for professionals on how to provide on-site prevention advice can be a very useful measure.

KINEMATICS OF TRAUMA

The trauma scene reveals very important information in the management of patients with major trauma. There are traumatic events in which initially the anatomical and physiological aspects appear unaltered, but there may be a hidden injury that can become critical. Kinematic criteria are a complement to management and make it possible to suspect such hidden injuries and act accordingly[4,5].

Kinematics is defined as the process of analysing the trauma scene to determine the injuries potentially caused by the forces and movements involved. The injury mechanism allows us to identify and suspect both obvious and hidden injuries, and make management decisions for the patient.

DETERMINING FACTORS OF INJURY

The degree of severity can be determined by[4]:

- **Energy exchange:** influenced by the mass and to a greater extent the speed. In a collision between two vehicles with a difference in weight, (truck and passenger car), this difference will give an advantage to the occupants of the truck, who will possibly suffer less serious injuries.
- **Density and surface impact:** body tissues have three degrees of density, from lowest to highest: air (lungs, intestine), aqueous (muscles, solid viscera such as the liver or spleen) and bone. Therefore, the injuries will also depend on the organ affected by the impact. The wider the surface affected, the greater the force that affects it, the greater the energy exchange and the possibility of injury.

Coordination and communication between the first responders are key to ensuring quality car

- **Braking distance and cavitation:** the greater the braking distance, the lower the deceleration on the body. Falling on soft ground or wearing a seat belt, imply a greater braking distance and therefore a better prognosis.

KINEMATICS ASSESSMENT AT THE TRAUMA SCENE

The patient's care begins with the notification of a traumatic event. The coordination centre carries out an anamnesis inquiring about the mechanism of injury and anatomical and physiological alterations. For the emergency caller, it is easier to answer questions about the scene than about the victim's condition.

Emergency teams en route to the scene, can assess and suspect the injuries and their potential severity.

When assessing kinematics there are several factors to consider depending on the injury mechanism.

Vehicle occupants

The deformity of the vehicles after a collision and the position occupied by each victim helps consider possible injuries and severity.

Observe the main external deformity of the vehicle; look for bullseye fractures on windscreens, intrusion into the passenger compartment, pillar deformity, collapsed roof, dashboard deformity, steering wheel deformity, airbag deflagration, and if safety belts or child restraint systems were used.

The Structural Deformity Index (SDI), developed from the variables indicated, can be easily collected at the scene, quantifies the energy exchange suffered by a vehicle occupant after a collision, and serves to supplement the anatomical and physiological criteria[5]. The SDI recorded by the police or firefighters at the scene can be conveyed in real time to the coordinating centre, emergency teams, and hospital emergency teams. It provides objective data on potential severity of the victims, helping coordination centres to make decisions to deploy additional resources, and is an early warning to the pre and hospital teams en route.

Motorcycles and bicycles

The scene of a motorcycle or bike collision can be challenging when the victim is far from the vehicle. Above 30 km/h there is a probability of suffering critical injuries.

Estimate the speed (distance from the victim to the vehicle, deformities of the vehicle, etc.), assess the type of collision (frontal, lateral, against another vehicle...), and find out if the victim was wearing a helmet.

In the case of motorcycles, in addition to the helmet, consider the use of protective clothing

Run over

Look for information from witnesses, about the speed (existence of sudden braking, distance between the pedestrian and the vehicle...). Observe the pedestrian's height, the type of vehicle and its height to suspect possible collision regions.

Observe the deformity of the bumper, the hood, a star break on windshield or mirrors when assessing the kinematics of the scene.

Adults usually have lateral injuries since the defence reflex leads them to flee from danger. In a vehicle-pedestrian collision, three impacts can occur: the first, when the bumper hits the legs, the second, against the hood and/or windshield, and a third impact when the pedestrian falls off at a distance.

Children often have frontal injuries because their defence reflex is less developed. Their lower height means that they can present a single impact and increases the possibility of ending up under the vehicle and run over.

Falls and precipitation

The major trauma database of Navarra (first in Spain), launched in 20106, shows a change in the pattern of severe trauma, the victims are often elderly patients, under anticoagulant therapy, and fall from own height resulting in head trauma (HT)[7]. Therefore, cautious management of these patients is necessary even though they may not initially present alterations in the state of consciousness[8].

Attempt to find out the height from which the victim has fallen, the surface on which they land and the part of the body that first hits that surface.

It is estimated that a height of ≥6 meters in adults and ≥3 meters in children (2-3 times the height of the child) can lead to serious injuries.

Stab wounds

The kinematic assessment includes identifying the wound location, the type of weapon and size of the blade used to suspect possible injuries with movement once inserted into the body.

Remember that the diaphragm can reach as high as nipple level in a deep exhalation, so there may be abdominal organ injuries in addition to intrathoracic injury, in case of a stab injury in the chest

Gunshots

In our setting, firearm injuries are usually due to self-harm attempts, accidental and while hunting.

Find out the type of weapon used if it was air gun with pellets or a shotgun. You can ask what animal they were hunting. The higher the energy (shotguns or big game rifles), the greater the temporary cavity and therefore the greater the injury.

Assess the region where the projectile hits and ask about the distance of the shot (the greater the distance, the less harmful).

Explosions

Explosions cause primary injuries (due to the shock wave effect and greater involvement of airway organs such as the lungs, ears...); secondary injuries (penetrating injuries caused by fragments); tertiary (when exiting the body or crushed by the collapse of the structures); quaternary (burns and injuries due to inhalation of fumes and toxic gases); and quinary (by specific additives such as bacteria or radiation).

MAJOR TRAUMA ASSESSMENT

Key: How do we prepare before attending a major trauma event?

Zero Point Survey

The 'Zero-point survey', is applicable both at the pre-hospital level and in the emergency department and is a preliminary step to the primary survey. It consists of an evaluation of the individuals and team's physical and mental preparation, a review of equipment and material, consideration of environmental factors before the intervention to plan for optimum management of patients, establish a common approach and improve team communication[9].

In a *briefing* the roles and tasks are distributed and clarified to identify who leads the intervention and communicates with the coordinating centre and to make an a pre-arrival action plan, subject to change depending on the real scenario.

Before any departure and on a routine and daily basis, check the available material: airway, ventilation, venous, intraosseous access, fluid therapy, immobilization material, (boards, splints, vacuum mattress...), electro-medical devices, or ultrasound to ensure functioning.

As for the environment, evaluate the safety, light, workspace, personal protective equipment, and the organization of people around the scene. On the way to the incident, it will be possible to specify the roles, and anticipate the actions considering the available information.

Action plan

- **Assess for safety and organise the scene.** Prioritize safety of the team, the victims, and bystanders, in this order. The emergency team should wear personal protective equipment (PPE). Investigate if there are police or other responders, if traffic is halted, and there is access for the ambulance or evidence of potential hazards and secondary risk.

- **Interpret the accident:** mechanism of injury, number of victims, or if "someone is missing" (is there an empty child seat in the vehicle? Are there any witnesses?). Ask yourself if there are sufficient resources and if patient triage is necessary. Look for skid marks distance of victims from the vehicle. Listen to information from witnesses or first responders.

- **Take a photo or video of the scene** as a brief report when transferring the victim to the Emergency department.

- **Start the initial or primary survey** to detect life-threatening injuries and, if any, apply therapeutic measures, such as exsanguinating haemorrhage control, protection or opening of the airway with cervical spine control.

- **Evaluate extraction and immobilization with other first responders and transfer the victims to a safe area for healthcare.** Sometimes analgesia is necessary and even a face screen can be placed to avoid facial wounds when retrieving victims.

- **If time permits, start a secondary assessment:** evaluation of the whole body to discover and solve, if appropriate, any injury not found in the primary evaluation.

- **Stabilize and transport** victim to a health facility capable of treating potential injuries.

- **Report the relevant information** to the other first responders, the coordinating centre and receiving hospital.

Horizontal, simultaneous action is characteristic of multidisciplinary teams, and therefore leadership is necessary to collect and report the information from the scene and the staff, to ensure identification of those most seriously injured, their stabilization and priority in transfer. This leadership does not imply having all the knowledge or skills, but the ability to direct the intervention, whilst being aware of personal and the team's skills, the available resources, context and to show receptiveness to the team and other first responder's feedback.

Scene safety is the responsibility of everyone involved and starts before the event occurs.

Remember that what was safe before can become dangerous, for example, when moving structures, cutting the vehicle, etc.

Universal precautions

Protective measures and PPE should be adapted to the existing risks, without posing any additional risk. They must adapt to the existing conditions on the scene, be ergonomic and compatible with each other, that is, several can be used at the same time[10,11].

In the care of patients with major trauma, the use of PPE is essential to safeguard staff from any incident during care. It is recommended to use appropriate clothing and footwear, double nitrile gloves (the first glove layer in case of dirt or bleeding), protective glasses or face shield and helmet when required.

You arrive at the scene and the firefighters who have arrived before you provide the following assessment:

- The co-pilot is dead.
- The driver is outside the vehicle on a spinal board. He is pale, with a frontal wound, conscious and confused. His heart rate (HR) is 125 beats per minute (bpm), deformities in both femurs, a weak central pulse and absent radial pulse, an O_2 peripheral pulse oximetry of 85% and a respiratory rate (RR) of 40 breaths per minute (rpm).
- Firefighters are extracting a victim out of the back of the vehicle, who is conscious, and complaining of pain in the pelvis and knees. He has a weak radial pulse and the following vitar signs: Saturation O_2: 93%, HR 125 bpm, RR 30 rpm and systolic blood pressure (SBP) 95 mmHg.
- Another victim, now sitting, with obvious shoulder dislocation, complains of pain and asks about the others.

You make a primary survey of the situation. What priorities of care would you assign to the patients? What initial therapeutic measures are you going to take? Who would you transfer first? Are you going to ask for more resources? Are you going to mobilize a helicopter? How can the other first responders help?

THE PRIMARY SURVEY

The Primary survey is the cornerstone of clinical management in major trauma. Its purpose is to detect life-threatening injuries of the patient and start treatment immediately. It is performed in a short time (less than 3 minutes). As the evolution of injuries is dynamic, the primary evaluation must be repeated, especially if there are acute changes in the patient's clinical condition or after an intervention (for example, tracheal and medication-assisted intubation, fluid infusion, and after patient transfer).

In recent years, following the experience of war medicine, an initial X component has been incorporated into the classic ABCDE system of primary evaluation, to include the detection of a catastrophic, potentially exsanguinating haemorrhage that requires immediate attention, becoming the XABCDE. There are other acronyms such as MARCH (Massive Haemorrhage, Airway, Respiration, Circulation, Hypothermia, Head and spine injury) with similar meaning[12]. In this article, we use the nomenclature XABCDE (Figure 1).

This implies that a massive haemorrhage is the priority of the rescuer if an amputation is involved, or a direct vascular injury that may require the application of a tourniquet.

Each element of the primary assessment is detailed below.

Exsanguinating haemorrhage [X]

Key: Do I have to stop any massive and active bleeding? Is there any limb amputation?

The initial assessment emphasizes the importance of controlling massive external bleeding that threatens the patient's life, placing the X before the traditional ABCDE.

Exsanguinating haemorrhage, usually arterial, may lead to complete or almost complete blood loss in a relatively short time.

Consider:

- Arterial bleeding may present as "non-pulsatile" rapid bleeding.
- Amputated limbs often bleed less than wounds with partial arterial section.
- Bleeding can be hidden under the patient's clothes.
- A scalp laceration may cause exsanguination.

Figure 1. Primary Assessment.

		TIME DEPENDENT	SUSPECT	THERAPEUTIC ACTIONS
M*	**X Exsanguinating haemorrhage**	Vascular injury Amputation		Direct pressure, indirect Haemostatic packing Tourniquet Sutures
A	**A Airway**	Unconscious Obstruction Risk Cervical spine control	Oedema/swelling Burns Tracheal injury Assess AVPU to verify ability to maintain airwa	O2 at 15 l/min Cervical control Mandibular traction Nasal/oro pharyngeal cannula Supraglottic airway devices I-Gel®/LMA BVM OTI FONA
R	**B "Breathing" ventilation**	RR<8 o > 20/min Reduced saturation Respiratory distress Chest trauma	Open pneumothorax Tension pneumothorax Cardiac tamponade Hemothorax Flail chest	Digital/ Needle thoracotomy Drainage Analgesia Chest seal BVM NIMV RSI Protective ventilation
C	**C Circulation**	Confusion/ Reduced Glasgow Capillary filling time >3 seconds Absent radial pulse or >120 l/min Evidence of internal bleeding	Hypotension not responsive to fluids Internal bleeding (chest, abdomen, long bones, pelvis, retroperitoneum, floor)	Re-evaluate X (compression/ tourniquet) Pelvic strap Control temperature Permissive hypotension (except severe HI) Tranexamic ac. (< 3 hours)
H	**D Disability**	Glasgow Coma Scale Low Neurological focality Neurogenic shock	Blood-glucose level Neurological deficit ICP (herniation) Priapism Bradycardia	O2/ventilation Immobilize/splint Appropriate centre Neuroprotection
	E Exposure	Other undetected injuries Burns	Back, perineum, armpits, skin folds	Analgesia Temperature control Protocol for burns

MARCH: [M : Massive Bleeding) A : Airway R : Respiration C: Circulation H: Hypothermia + Head + Spine]. AVPU: [A: alert V: responsive to verbal stimuli D: to painful stimuli N: not responsive to stimuli]. RR: Respiratory Rate. LMA: Laryngeal Mask Airway. BMV:Bag-Valve-Mask ventilation. OTI: Orotracheal Intubation. FONA: Frot of Neck Access NIMV: Non-invasive Mechanical Ventilation. RSI: Rapid Sequence Intubation. HI: Head Injury IH: OCP: IntraCranial Pressure.

The steps in the management of external bleeding include:

- Direct pressure to the wound (manually and later with the application of a compressive dressing).
- Haemostatic agents.
- Tourniquet.
- Sutures.
- Alignment, reduction, and stabilization of fractures.

Direct pressure

Attempt to be as precise as possible at the point of compression, sometimes a couple of fingers are enough to get the bleeding to stop. If the gauze or dressing used for direct pressure becomes soaked with blood, add more dressing on top without removing the other. If it persists, you can compress the artery proximal to the wound or move on to another measure.

Haemostatic agents

You can use gauze soaked in haemostatic agents (Appendix 1). It is important to "pack the wound", that is, insert the gauze into the base of the wound and fill up the wound completely. Once the wound has been packed, direct compression should be performed for a minimum of 3 minutes if we use gauze with haemostatic agents (or the time indicated by the manufacturer) and 10 minutes if we use normal gauze[13].

This task involves the use of at least two hands. If you need to help with another task and free both hands, we can apply a compressive bandage, which can be performed with more simple gauze and elastic bandage placed on top of the wound already pre-packed, with the cuff of the sphygmomanometer or with some specific dressing (Israeli bandage).

To handle bleeding caused by embedded objects should be done by compressing on its sides and never on the object itslef. The removal of the object must be carried out at the hospital, immobilizing the object as best as possible.

Direct compression of considerable bleeding has priority over attempting to obtain intravenous access and resuscitation with liquids. For volume management, the concept of "permissive hypotension" will be applied, which is assessed in section C.

Limb elevation and compression at pressure points (proximal to the bleeding site) are not indicated as they have not shown effectiveness and therefore should not be performed[14,15].

The primary survey consists of asking yourself in an orderly manner what is threatening the patient's life. Follow the XABCDE sequence and act horizontally distributing the tasks in the team

Assure, communicate and if in doubt, ask

Tourniquet

If the external bleeding of a limb cannot be controlled by direct pressure, apply a tourniquet16. Data from studies during the Iraq and Afghanistan wars, suggest that correctly placed tourniquets could have prevented 7 out of 100 combat deaths[17,18].

Apply a tourniquet as proximal as possible (near the groin or armpit), tightening it until the haemorrhage ceases (a tourniquet that occludes only the venous outflow can produce an increase in haemorrhage). If the bleeding does not stop or the distal pulse is still present, fasten the tourniquet even more, or consider placing another tourniquet proximal to the first one.

Once the tourniquet has been placed, leave it in plain sight and note down the time of application. In general, it is recommended to keep it until arrival at the hospital without having to loosen it every 10-15 minutes as previously recommended[19].

There are different commercial tourniquets available (Appendix 1), although a tourniquet can be improvised (eg: belt, bandage and makeshift windlass).

If you place a tourniquet, consider the administration of analgesia. Fentanyl is a good option due to its speed of action, analgesic potency, and stable hemodynamic effects.

Junctional torniquets

In areas such as the groin, armpit, shoulder, neck, scalp and back where it is impossible to place a tourniquet, the management of exsanguinating haemorrhages can be done with clamps or junctional torniquets (Annex 1).

Airway with cervical spine control [A]

Key: Do I have to protect the airway right now?

Airway management is a priority in the patient with major trauma[20,21].

Make a quick overall assessment by asking the patient his name, how he feels or what has happened. An oriented and coherent response implies that the airway is open and permeable, and that both breathing and cerebral perfusion are adequate (see AVPU scale in section D).

- Approach the patient from the front, to avoid neck movements and perform C-spine control from the first moment.
- Initially this control will be done bimanually by a second rescuer. The restriction of cervical movement can be accompanied by immobilization with a rigid cervical collar, although this does not completely limit cervical movements, so manual immobilization must continue to be performed or apply head blocks, tape, or a vacuum mattress of suitable size.
- In case of head trauma, and if the patient needs intubation and neuroprotective anaesthesia, the collar can be released and manual stabilization can be used, to improve cerebral venous drainage and reduce intracranial pressure (ICP).
- Inspection of the airway includes assessing the head and neck, to rule out (current or potential) injury.
- Simultaneously, look at the chest and abdomen to assess breathing rhythm. If the airway is permeable, it is usually associated with a normal pattern of thoracic and abdominal movement, although there may be an increase in respiratory rate, use of accessory muscles, intercostal or tracheal tugging.

Look for:

- Penetrating neck injuries, as well as vascular lesions or oedema. Assess the presence (or possible development) of expansive cervical hematoma.
- Maxillofacial/mandibular injuries, deformities, or fractures.
- Inhalation injuries or burns.
- Tracheal displacement or tugging, crepitus, or subcutaneous emphysema.
- Presence of foreign bodies in the airway (blood, vomit, dental pieces).

Hypoxia in the initial stages can cause anxiety, so consider it in aggressive or agitated patients. Anxiety is not synonymous with intoxication, even less in patients with major trauma.

If the victim does not answer or the answer is not appropriate:

- Look for signs of airway obstruction. The presence of snoring, stridency, hoarseness, or voice changes indicate partial obstruction.
- The absence of breathing noises implies complete obstruction of the airway.
- Listen for breathing sounds. The noises can be inspiratory stridency (obstruction at the laryngeal level or higher), expiratory wheezing (obstruction in the lower airway), gurgling (liquid or semisolid in the upper airway) or snoring (pharynx occluded by the tongue and palate).
- Observe chest and abdominal movements. Look for paradoxical movement between the chest and abdomen, respiratory sounds when auscultating, and absence of airflow in the mouth or nose.
- In case of apnoea, keep the airway open and immediately start ventilation with a bag-valve-mask.
- If the victim is in cardiorespiratory arrest, cardiopulmonary resuscitation will be started following the relevant resuscitation algorithms2, taking into account the specific features of management[65].
- Opening of the airway:

  It is contraindicated to perform the forehead-chin manoeuvre in the patient with major trauma. Apply mandibular traction or chin elevation, to avoid cervical spine hyperextension, and stabilize the cervical spine bimanually.

- Cleaning the airway:

  There are several devices to extract secretions or foreign bodies in the airway.

  - Secretions can be suctioned using flexible or rigid catheters (Yankauer) connected to a suction system. Rigid catheters allow for more directed suctioning. Flexible catheters permit suctioning through other devices such as oropharyngeal cannulas or endotracheal tubes (you can use a soft aspiration catheter with a calibre twice the size of the tube, for example, use a size 16 catheter if the endotracheal tube is 8).

» Do not suction for more than 15 seconds at a time.

» Foreign bodies can be removed with Magill forceps. Do not insert any fingers in the patient's mouth or perform blind digital sweeps without direct vision.

- Airway permeabilization:

» The introduction of an oropharyngeal cannula (Guedel) prevents obstruction caused by displacement of the tongue or soft palate.

» The nasotracheal cannula is indicated in patients who have mandibular deformities or trismus, or who do not tolerate the oropharyngeal cannula. Once lubricated, insert it through one nostril. Do not apply it in case of suspected skull base fracture or of the cribriform plate, due to a possible insertion into the skull. It is not recommended in cases of haemorrhagic diathesis (or when taking anticoagulants).

» None of these devices isolate the airway, so they do not prevent the risk of bronchoaspiration. You can place the patient in the reverse Trendelenburg position to decrease the risk of aspiration and reduce abdominal pressure on the chest.

- Oxygen administration:

All patients with MT should be monitored with pulse oximetry and receive high-concentration oxygen. The goal is to maintain a saturation of $O2 \geq 90\%$. Oxygenation may be compromised in steps A, B, C (haemorrhage) or D (high spinal cord injury).

Passive oxygenation

In patients with adequate respiratory effort, if the airway is permeable. These devices can be applied:

» Mask with Venturi effect: It can administer an oxygen concentration of between 24 and 50% with an oxygen flow (12-15 l/min). With this type of mask, a more precise control of the FiO is achieved$_2$.

» Non-rebreather mask: A non-rebreather oxygen mask can deliver a concentration of 80-85% inspired oxygen with flows of 10-15 l/min. The oxygen flow should be adjusted above 10-15 l/min to avoid collapse of the non-rebreather bag mask.

Active oxygenation

If ventilation support is need, active oxygen should be administered.

» Use a bag-mask connected to a non-rebreather mask and with 100% oxygen.

» Good sealing of the mask must be ensured, and if possible, this technique should be performed by two people. One of them is responsible for sealing, and the other for ventilation. Difficulty in bag-mask ventilation may itself be a predictor of difficulty for laryngoscopy and/or intubation. Patients with beards, maxillofacial traumas, bone fractures or instability of facial structures can pose a challenge when it comes to achieving a good sealing of the face mask[6].

» The patient can also be oxygenated by performing non-invasive mechanical ventilation with a ventilator.

» It is advisable to carry out ventilations with low respiratory volumes and frequencies to avoid the excessive passage of air into the stomach. Many of these patients may benefit from an advanced airway (supraglottic device / endotracheal tube / surgical airway) depending on the skills of the professional and the urgency.

The placement of the endotracheal tube provides a definitive airway (Appendix 2).

Ventilation and breathing [B]

Key: Do I have to decompress the chest? Are there any open wounds in the chest?

There are several aspects to evaluate:

- Symmetrical motion of both left and right hemi thoraces. Presence of respiratory effort, tugging or use of accessory muscles, as well as the presence of abdominal breathing.
- Presence of pain with light palpation, as well as the presence of lacerations, wounds, bruises, crepitus or deformities.
- Respiratory rate (RR). Respiratory pattern and depth of respiratory movements.
- Gross bilateral ventilation, and auscultation of respiratory noises and their symmetry.
- Cardiac auscultation, ruling out the presence of muffled heart tones. Cardiac and respiratory auscultation can be difficult in the prehospital environment due to noise in the ambience.
- Additionally, we can use pulse oximetry and capnography. Low prehospital levels of CO2 at the end of expiration (EtCO2) have a poor prognostic value in major trauma.

Injuries to be ruled out in B:

- Tension pneumothorax.
  - » The diagnosis is clinical. Consider it in a patient with a rapid deterioration in ventilation with tachypnoea, respiratory effort and tachycardia. Crepitus and subcutaneous emphysema may also appear. Mediastinal and tracheal displacement to the opposite side and jugular ingurgitation may appear in late phases.

Treat tension pneumothorax by inserting a thick needle (14 G), with subsequent connection to a Heimlich valve, preferably in the 2nd intercostal space (clavicular midline) or the 5th intercostal space (axillary midline), where there are no large blood vessels, and the chest wall is thinner. In the prehospital field, the puncture in the latter location (and especially its correctly placed maintenance) can be complicated, since it can interfere with the resuscitation manoeuvres, with the observation of the patient, the placement of the vacuum mattress, and with the movements of the emergency team inside the ambulance cabin, where space is already limited in itself[22].

There are commercial devices (Annex 1) that provide greater safety, prevent the catheter from bending, and with larger diameter preventing obstruction and facilitating the verification of needle penetration into the pleural space. Alternatively finger thoracostomy can be applied.

In case of persistent hemodynamic or respiratory instability, a pleural drainage system or a chest tube may be placed.

A recurrence of tension pneumothorax may occur after initial chest decompression, so the patient should be closely monitored (potential bleeding from intercostal vessels, local hematoma, occlusion or catheter bending).

- Massive hemothorax.

  Like tension pneumothorax, it causes the rapid onset of a shock (hypovolemic) situation, which usually precedes respiratory compromise. The diagnosis is clinical and may initially be difficult to differentiate from tension pneumothorax in the prehospital setting. The presence of dullness to percussion instead of tympany supports the diagnosis. The initial management does not differ from the one discussed for tension pneumothorax (thoracic puncture), although simultaneous treatment of hypovolemia should also start, since it turns out to be a problem in C.

- Open pneumothorax.

These are "wounds that breathe". Treatment of open pneumothorax consists in closing the wound with a valve mechanism. The valve prevents the development of a tension pneumothorax. Be aware that the patient may develop a tension pneumothorax after occlusion of the wound, sometimes even the valve may become clogged with blood.

  - » There are commercial chest seals available that contain a one-way valve (Appendix 1).
  - » If no commercial seal is available, alternatively a Vaseline gauze can be applied to the wound taping three of its four sides, leaving one free to allow for a one-way valve mechanism that to permit the exit of air on expiration and prevent air entering the pleural space during inspiration.
  - » In case of large open pneumothorax accompanied by respiratory failure, drug-assisted intubation and positive pressure ventilation should be considered.

- Flail chest

  Deformities and crepitus in the chest wall are usually observed and may co-exist with pneumothorax, pulmonary contusion or haemothorax.

  It can cause acute respiratory failure and its management includes adequate oxygenation and ventilation and analgesia. There is no evidence that securing the segment with your hand, or other device can improve breathing. Contrarily, it may even impede ventilation.

- Other considerations.
  - » In closed thoracic trauma, especially if associated with rib fractures, pain should be treated aggressively, as it greatly conditions respiratory mechanics.
  - » Ventilation may be compromised due to airway obstruction (previous section), alteration of ventilatory mechanics, central nervous system injury, or poisoning.
  - » Spinal cord injuries at the upper cervical level cause rapid deterioration of respiratory mechanics and must also be handled aggressively, generally requiring ventilatory assistance, intubation, and mechanical ventilation.
  - » Consider that cyanosis is a late sign.

Circulation and haemorrhage control [C]

Question: Is the patient in shock? Where is the patient bleeding? Does the patient need blood?

Patients in shock should be promptly identified, bleeding detected (external and obvious or internal and hidden), blood losses minimized and if possible, other types of shock, cardiogenic (intrinsic, obstructive), and distributive (neurogenic), should be considered[4,23,24].

Identifying Shock

La identificación del shock es un diagnóstico clínico e idealmente se debe reconocer antes de que se desarrolle la hipotensión (shock descompensado) por lo cual no podemos dejar de insistir en la importancia de reevaluar al paciente.

Para valorar el estado hemodinámico y/o la presencia de shock en un paciente disponemos de:

- Signs and symptoms of compensation mechanisms (sympathomimetics):
  - Tachycardia: Frequent, although not always present, but may be caused by pain or anxiety. In the case of neurogenic shock, there may be bradycardia.
  - Coldness and pallor of extremities (due to vasoconstriction).
  - Changes in skin colour (pallor, cyanosis).
  - Weak pulse.
  - Initial tachypnoea (in late stages there may be bradypnea) which reflects compensation by metabolic acidosis.
  - Elongated capillary filling > 2 seconds (low value): while at the peripheral level it would be reduced in a cold environment, a central capillary filling may be more useful applying thumb pressure on the forehead or chest of the patient and assessing the time between pallor and returning to the normal state.
  - Decrease in pulse pressure (25 mmHg).
  - Hypotension: the absence of a radial pulse indicates an SBP <80 mmHg or vascular involvement of the limb. Hypotension should not be considered synonymous with shock since hypotension appears in a late phase (decompensated).
  - Shock Index (SI): ratio between HR and SBP. This score is useful and easy to calculate for diagnosing hypovolemia, even with normal HR and BP values. Its normal range is between 0.5 and 0.7. A shock index >0.8 correlates with poorer outcomes, while an index >0.95 correlates with the need for massive transfusion[14,24,25].
- Use of ultrasound (ECO-FAST): if available, it is a useful tool to detect free fluid in cavities, hemopericardium or pneumothorax[26,27].
- Signs and symptoms of organ dysfunction: a decrease in the level of consciousness (CNS disorder) may indicate cranial injury or hypoxia, but in trauma, bleeding should always be considered.
- Gasometry if available (increase in lactate, deficiency of bases, calcium).

Confounding factors

The physiological changes of **elderly patients** and the effects of the medication they take (for example, beta-blockers) may decrease their ability to compensate, which implies that they may have a decrease in BP, no tachycardia and may lose the radial pulse with 15% blood loss. On the contrary, children compensate very well at the expense of increasing their HR and maintain normal BP until they lose 45% of their blood volume. Athletes have greater compensatory power and may not have tachycardia in the initial moments of shock. In case of **pregnancy**, the normal increase in cardiac output, blood volume and HR contribute to signs of shock not appearing until there is blood loss of 30%, even though there is foetal distress. Moreover, during the third trimester the compression of the gravid uterus on the large vessels that occurs in the supine position can result in a decrease in preload and generate obstructive shock. Previous illnesses and **comorbidities** can contribute to a decrease in cardiopulmonary reserves in patients with advanced lung (COPD) or heart disease. **Consider medication** (antihypertensives, antiaggregant, anticoagulants, etc.) and the presence of **devices** such as a pacemaker.

Management of the patient in haemorrhagic shock

Haemorrhage (hypovolemic shock) is the main cause of shock in major trauma, and classically it should be sought in 6 areas: chest, abdomen, pelvis, retroperitoneum, long bones, and the floor. Shock may be compensated by the release of catecholamine and blood pressure is usually normal.

The management strategy for patients with severe haemorrhagic trauma is called Damage Control Resuscitation (DCR)[28-30]. DCR is a balanced resuscitation strategy accepting permissive hypotension, restricted use of crystalloids and massive transfusion. Its purpose is to avoid or reverse hypothermia, avoid coagulopathy, minimize bleeding with early measures during transport and initial evaluation, administering drugs to promote haemostasis[29,31,32].

- Bleeding areas and performance

  External:

  It is usually easy to diagnose. Starting with the X approach, prior to assessment of the patient's circulatory state. Remember to re-evaluate the measures taken.

  Internal:

  » **Chest:** Suspected haemothorax by physical examination, the clinical symptoms of respiratory failure and signs of shock, having to limit the time on the scene. Consider having a chest tube inserted if there is acute respiratory failure, no ventilation in a hemithorax, and signs of shock.

  » **Abdomen:** even though the sensitivity and specificity of the clinical symptoms is very small, in the case of a patient with MT in shock, the abdomen should be considered. If available, use the ultrasound to detect free liquid provided the transfer is not delayed.

  » **Pelvis-retroperitoneum:** suspect through the mechanism of injury (falls, precipitation, ejection from vehicles, etc.) along with signs and symptoms. Palpation to assess the stability of the pelvic ring should be avoided at all costs, due to its low specificity and sensitivity and the possibility of increasing bleeding. Place a pelvic binder (pelvic sheet or pelvic belt (Appendix 1) to minimize bleeding.

  » **Long bones (femur):** if injury is suspected, perform aligned immobilization of the limb.

- Identify and minimize blood loss (definitive/temporary control of bleeding).

  In patients with both external and internal bleeding in the prehospital setting, the priority is its control or reduction. In most cases, definitive bleeding control can only be done in a hospital centre.

  Classically, to estimate blood loss, the four degrees proposed by ATLS course been classically referred to[4]. However, after an analysis of patients included in trauma records, some authors question the use of this ATLS classification and advocate a physiological classification (Table 1), according to the response of the patient with hypotension to judicious fluid replacement, cardiac/circulatory reserve and microcirculation[33,34]. It is important to know if the patient is receiving anticoagulant and/or antiaggregant treatment: drugs, last dose, INR, etc.

- Restore blood volume if necessary and improve tissue oxygen perfusion.

  The challenge of permissive hypotension consists in restricting the administration of crystalloids or blood derivatives and maintaining a mean arterial pressure (MAP) of 50 mmHg. Although lower than normal, it maintains adequate organ perfusion. It is not recommended in cases of severe TBI, spinal cord injury and hypertensive elderly patients[29].

  This hypotension could decrease the incidence of haemodilution coagulopathy and prevent the displacement of an unstable but recent thrombus over a vascular lesion ("pop the clot" effect) when the intravascular pressure increases[30].

Table 1. Physiological classification of haemorrhagic shock (adapted from Bonano F.)[34]

Group A	Group B
Stable Compensated hypotension	Stage I Mild/stable: some skin signs. (Pallor, prolonged capillary filling), tachycardia. Stage II Moderate/stabilized: shock responds to fluid replenishment.
Unstable severe shock	Stage III Shock and hypotension with temporary fluid response (<20-30 minutes) or Shock with hypotension that does not respond to replenishment with 500 mL x 2.
Critical hypotension Imminent cardiac arrest	Stage IV Shock with signs of cardiac or cerebral ischemia or ≥40% total volume loss.
Cardiac arrest Exsanguination	Stage V Cardiac arrest.

Objectives

- **Non-elderly patients, with penetrating injury, in haemorrhagic shock without severe head injury (HI) or spinal cord injury (SCI)[29]:** give fluids until bleeding is controlled to keep the patient conscious (correct cerebral perfusion) despite the loss of radial pulse. MAP about 60 mmHg..

- **Non-elderly patient, without penetrating injury, in haemorrhagic shock without severe HI or SCI:** administer fluids until bleeding is controlled to keep the patient conscious (correct cerebral perfusion) and maintaining the radial pulse (SBP around 90 mmHg). MAP 60-70 mmHg.

- **Patient in haemorrhagic shock with severe HI or SCI or elderly:** supply of fluids and vasoactive drugs to maintain SBP around 100-110 mmHg (MAP 80 mmHg) ensuring adequate cerebral perfusion pressure to avoid secondary injuries or further neuronal damage[29,35].

An excessive volume intake is harmful because it worsens coagulation due to haemodilution of clotting factors, increases pressure at the bleeding site favouring it, exacerbates hypothermia after the infusion of cold liquids, worsens acidosis due to alterations in pH and increases interstitial oedema due to endothelial injury that favours capillary leakage[31,35].

Therefore, major trauma patients with signs of shock should be treated with a restricted supply of intravenous fluids (for example, an initial bolus of 250 mL of crystalloids in a patient without a radial pulse) increasing the response to achieve the objectives of haemostatic resuscitation (permissive hypotension). Repeated boluses should be administered when the infused liquid volumes exceed 500 mL while evaluating the patient's response (e.g. mental state, presence and quality of pulse, RR, HR, AP, etc.). Continue monitoring, particularly during prolonged transfer, and administer additional intravenous fluid boluses if necessary. If the desired MAP is reached, the infusion rate should be reduced to maintenance. The fluid supply should be limited to 1500 mL until definitive bleeding control (excluding haemodialysis).

Type of fluids

- **Warm crystalloid solutions**
  Plasmalyte® and Ringer's lactate. Physiological serum with 0.9% sodium chloride may have a risk of producing hyperchloremic acidosis, lower renal perfusion, and lower survival. In contrast, balanced solutions have physiological concentrations or almost chlorine levels that provide benefits. Ringer's Lactate is hypotonic with respect to plasma and should be avoided as a resuscitation fluid in patients with moderate to severe HI (risk of cerebral oedema).

- **Hypertonic solutions**
  (7.5% hypertonic saline, preparation for 100 mL: remove 35 mL from a 100-mL container of physiological serum 0.9% and fill with 35 mL of ClNa 20%), only use in two situations and always prior to the administration of isotonic crystalloids: (1) Administration of more than 1000 mL of crystalloids and hemodynamic instability; and (2) MT patient with haemorrhagic shock and severe HI associated with signs of increased intracranial pressure (ICP). Dosage: 1 - 1.5 mL/kg in bolus. Danger: hypernatremia in case of repeated doses.

- **Vasoactive drugs**
  There are no human studies to support the use of vasoactive drugs (vasopressors such as norepinephrine) in the resuscitation of patients with MT shock. Its early use in the treatment of haemorrhagic shock can be harmful and is still under discussion[36,37].

- **Massive transfusion**
  Identify those patients who are candidates for massive transfusion to alert the receiving centre and activate the protocol. Several scales have been proposed to help identify these patients, 3 of which can be useful at the prehospital level:

  ◊ Shock Index (SI): HR/SBP.
  If it is ≥0.9 consider severe injury with severe bleeding, increased mortality, possibility of hypotension after endotracheal intubation. If the SI is ≥1, there is a need for massive transfusion. Its limitation in the elderly must be considered and that a normal value does not rule out serious bleeding[33,38,39].

Identify a person to direct and coordinate the intervention

Take advantage of the teachable moment to explain important prevention measures

◊ Assessment of Blood Consumption (ABC)[40,41]
It is based on 4 parameters that can be determined upon arrival at the hospital and even at the pre-hospital stage:
1) Penetrating mechanism of injury.
2) Positive ECOFAST examination.
3) SBP ≤90 mmHg.
4) HR ≥120 bpm (Table 2).

A score of 2 or more predicts the need for a massive transfusion with a sensitivity of 75% and a specificity of 86%.

Table 2. Assessment of Blood Consumption (ABC).

Blood Consumption Scale (ABC)	Yes	No
SBP ≤ 90 mmHg	1	0
HR ≥120 bpm (on arrival)	1	0
Penetrating mechanism	1	0
ECO-FAST + free liquid	1	0

◊ Red Code[42]
Based on three parameters:
1) Suspicion or evidence of active bleeding.
2) SBP ≤90 mmHg.
3) Lack of response of the AP to a bolus of intravenous fluid.
91% of the patients who met any of these criteria ended up receiving blood transfusions and 40% of them required massive transfusion.

In any case, it is important not to rely on a single index or defined numbers, but on the clinical evaluation of the patient.

- Use of blood products

Administration as early as possible seems logical, but its use is not yet widespread at the prehospital level since the conservation of blood products, the products half-life and the logistics involved are complex and expensive[29,31,43]. The administration of red blood cells, plasma, and platelets in equal proportions (1:1:1) improves the results and should be started even in the prehospital setting whenever possible[23,32,45].

- Intravenous (IV) and intraosseous (IO) access

Whenever possible, obtain access for fluid resuscitation through a large bore cannula (not always 2) in the forearm. Avoid cannulating injured limbs.

Secure the intravenous line before moving the patient.

If peripheral intravenous access is difficult or impossible, consider intraosseous access (IO)[46]. Any drug, fluid or blood product can be administered. Apply 1 mL of lidocaine before to avoid pain on administration. There are different devices available, each with its specific characteristics (manual needle, electrical, specific sternal devices) (Appendix 1). It is recommendable to administer a bolus of 5-10 mL of physiological serum after each drug to ensure correct infusion.

Note: if the patient has significant injuries on the lower extremities or pelvis, you can use the upper extremities, or sternum.

Scene safety is the responsibility of all responders

Deadly triad

Classically formed by **acidosis, hypothermia, and coagulopathy**, which if not recognized and reverse, can cause exsanguination and death. With the addition of hypoxia and hyperglycaemia, they form the deadly pentad[32].

- Acidosis due to injury and tissue hypoperfusion (shock).

  » Management includes correction of hemodynamic status alterations, balanced blood transfusion of blood products in equal proportions 1:1:1 (red blood cells: plasma: platelets), and control of bleeding.

  » The monitoring of the evolution of base deficit and lactate levels can be used to evaluate our resuscitation efforts as vital signs alone are poor indicators of tissue perfusion.

  » The so-called lethal diamond associates hypocalcaemia and the deadly triad in patients with severe haemorrhage and the need for massive transfusion and may justify the administration of calcium in these patients. While the association between hypocalcaemia and mortality is significant, there are few studies to differentiate whether hypocalcaemia is a cause or predictor of mortality, and to establish clear pre-hospital administration protocols.

  » In case of open fracture, consider the prophylactic administration of antibiotics (according to local protocol) as soon as possible and within the first hour after the event, without this delaying patient transfer.

- Hypothermia:
  - » Hypothermia can be caused by exposure to cold at the time of injury, during transport and patient examination, and aggravated by the administration of cold liquids. Almost two-thirds of traumatized patients have a temperature below 36°C at the time of being examined.
  - The effect of hypothermia on coagulation includes hypocoagulability.
  - Sometimes major trauma is associated with the consumption of alcohol and drugs that exacerbate the loss of heat.

Avoid prolonged exposure of the patient in the primary survey, maintain or reheat the patient from the torso before limbs to prevent greater hypotension and acidosis due to peripheral vasodilation. You can use passive techniques (remove wet and cold clothes, use warm blankets, warm temperature in the ambulance) or active methods (warm liquids or blood products, humidified and hot oxygen)[30].

- Coagulopathy.

  There are two main causes:

  - Trauma-induced coagulopathy (TIC).
  - Secondary to hypothermia and haemodilution by aggressive volume replenishment[30].

Drug treatment

Tranexamic acid acts by decreasing hyperfibrinolysis observed in acute coagulopathy of major trauma. The greatest benefit is obtained when administered within the first hour of the injury (margin up to 3 h, after which it presents doubtful efficacy or may be harmful)[47,48].

Tranexamic acid is administered as an initial intravenous bolus of 1 gram over 15 minutes, followed with an additional 1 gram infused over 8 hours. The paediatric dose is 15 mg/kg (max. 1 g) followed by 2 mg/kg/h. May cause hypotension if given too quickly[49].

Other types of shock[4,21]

- Cardiogenic shock
  - *Intrinsic*

    It is due to a blunt or penetrating cardiac trauma, with impaired contractility, accompanied by arrhythmias (suspect if there is chest trauma + de novo arrhythmia) and mechanical complications (ventricular or valve rupture suspected with new onset murmur). Management: support treatment and monitoring and transfer.

  - *Extrinsic*

    Caused by no cardiac filling due to increased intrathoracic or intrapericardial pressure.

Injuries that can cause it include:

- Tension pneumothorax (TPT):

  See section B. After treatment of TPT, ventilation and hemodynamic status should improve. If neither of the two improves, the needle may not have reached the chest cavity. Consider finger thoracostomy or chest tube. If only breathing improves, consider other causes of shock.

  The most frequent cause of TPT is mechanical ventilation (at positive pressure) or pressure changes (helitransport) in patients with previous chest trauma. Hence the importance of continuously evaluating B and C.

- Cardiac tamponade

  More frequent in penetrating trauma. ECOFAST or immediate echocardiography can provide a quick, early and accurate diagnosis.

Prevention and control of the deadly triad (acidosis, hypoxia and hypothermia) improves the patient's prognosis

What was safe can become dangerous

Prioritize the safety of the team, victims, and bystanders, in this order

Pericardiocentesis is **only** performed if pericardial tamponade is suspected (hypotensive patient who worsens despite intensive resuscitation with volume), the best treatment being open thoracotomy. During resuscitation, keep in mind that drug-assisted intubation and positive pressure ventilation can further compromise hemodynamic function.

» **Compression of the gravid uterus on the lower aorta.**

In case of a pregnant patient is more than 20-24 weeks' pregnant and in the supine position with signs of shock, move the uterus to the left manually or tilt the full patient 15 degrees to the left. Check if the signs of shock disappear and the patient improves).

- Neurogenic shock

SCI is associated with upper cervical or thoracic lesions (above T5).

Initially consider the mechanism of injury and clinical examination: relative hypovolemia (hypotension), often associated with bradycardia (confounding factor), and hot flushed skin.

Patients with SCI may present with other types of associated shock (especially if there is high energy transfer) such as haemorrhagic or extrinsic cardiogenic shock, so the priority is to rule out and initiate treatment of other types of shock, mainly haemorrhagic shock, immobilize and transfer the patient as early as possible, maintaining adequate spinal perfusion[12,50].

It is important to maintain an adequate MAP to ensure a correct perfusion of the injured spinal cord and therefore limit secondary injury. Although with scarce supporting empirical data, the guidelines currently recommend maintaining a MAP of at least 85-90 mmHg, with intravenous isotonic crystalloids (avoid Ringer's lactate and other hypotonic fluids that favour oedema)[30]. Bradycardia may require external stimulation or the administration of atropine.

Neurological Assessment [D: Disability]

Key: Is there neurological impairment? How is the patient's mental status?

At this point, the level of consciousness and pupils should be assessed, as well as signs of lateralization or focal deficit.

To assess the level of consciousness, two scales are available:

The AVPU Scale (alert, responsive to verbal stimuli, to painful stimuli, not responsive to stimuli): simpler, faster, and easier to apply

The Glasgow Coma Score51 (GCS) (Table 3): evaluates three aspects (motor response, verbal response and ocular opening) and provides information on the brain function and prognosis of the patient, also serving to classify HI.

The neurological status of a MT patient with HI can vary within a few minutes, which is why it is necessary to carry out the neurological evaluation early and regularly to detect changes in the level of consciousness. Changes in GCS between prehospital attention and the emergency centre arrival is predictive of severe injury. The motor component of the GCS is the most important, as predictive of severe injury, as the full scale with a score of less than 6 points ("the patient does not obey simple orders")[52,53].

An alteration in the level of consciousness may be a direct consequence of HI, but other causes must be ruled out, such as hypoxia due to problems in ventilation and/or perfusion (especially hypovolemia), drug or alcohol intoxication, metabolic problems (hypoglycaemia), or seizures, among others.

Assess the size of the pupils, their reactivity and symmetry. Anisocoria, with unilateral mydriasis, associated with a decrease in the level of consciousness, makes one suspect the presence of cerebral herniation and increased ICP. The presence of anisocoric pupils in a patient with a normal level of consciousness is not an indicator of cerebral herniation or an increase in ICP.

Table 3. Glasgow Coma Scale (GCS)[51]

Response	1	2	3	4	5	6
Eye opening	Closes	With painful stimulation	With verbal stimulation	Spontaneously		
Verbal	No sounds	No words	Inappropriate	Confusing	Normal	
Motor	None	Position (extension)	Position (flexion)	Withdrawal after painful stimulus	Localizes pain	Obeys orders

Minimum score: 3 (deep coma). Maximum score: 15 (normal). Head trauma: mild 13-14. Moderate 9-12. Severe 3-8.

For primary brain injuries (fractures, contusions, cerebral laceration, and diffuse axonal injury), there is no possible therapeutic action to apply once the impact has occurred; not so for secondary brain injuries (hematomas, intracranial haemorrhages, cerebral oedema, cerebral ischemia, and infections), which are potentially avoidable. So, our efforts in the emergency should focus on the prevention of secondary brain injury, and the detection and treatment of suspected increased intracranial pressure (ICP).

The causes of secondary brain injury, which should be avoided and treated in case of suspicion include:

- Hypoxia
- Hypotension
- Anaemia
- Hypovolemia
- Hypo and hyperventilation
- Hypo- and hyperglycaemia
- Seizure
- Intracranial hypertension

Management

Ensure correct oxygen supply to reach the brain. To do so, in case of GCS < 9 points, the airway is preferably protected through endotracheal intubation while protecting the cervical spine. Drug-assisted intubation reduces the negative effects of direct laryngoscopy on ICP.

Once the airway is protected, the patient should be "normoventilated" without producing hypo- or hypercapnia. Hyperventilation with mild hypocapnia is reserved for cases of IH in which other therapeutic measures have failed. Hypocapnia produces cerebral vasoconstriction, increasing cerebral vascular resistance with less blood flow to the brain and a consequent decrease in ICP, although with a risk of cerebral ischemia.

Attempt to maintain euvolemia (minimizing bleeding, under the premise that "every red blood cell counts") and avoid arterial hypotension. In polytraumatized patients with hypotension due to the concomitant presence of shock (of any type), compensation mechanisms fail, so the combination of ICP and arterial hypotension can lead to poor prognosis for the patient.

In the management of patients with severe HI, both hypo and hyperglycaemia should be avoided. Therefore, in the initial fluid therapy, the glucose-based solutions should be avoided (unless there is hypoglycaemia).

ICP is suspected in a patient with severe TBI with symptoms such as decreased level of consciousness, vomiting, Cushing's phenomenon (arterial hypertension and bradycardia), which may be absent if hypovolemic shock coexists, irregular breathing (due to compression of the brain stem), mydriasis with anisocoria (due to compression of the III pair) or decorticate and decerebrate posturing.

Apply these measures in this order:

1. Loosen or remove the cervical collar to improve venous return and decrease cerebral venous congestion.
2. If possible, place the stretcher in the reverse Trendelenburg position at about 15-30º. Do not raise solely the headboard of the stretcher, to maintain full spine alignment.
3. Optimize sedation, analgesia and muscle relaxation since pain, agitation or maladaptation to the respirator can increase ICP. Provide adequate analgesia with fentanyl or morphic chloride; use midazolam as a sedative, and rocuronium or cisatracurium as muscle relaxants.
4. Administer hyperosmolar agents:
   - Mannitol 20%: 0.25-1 g/kg. Useful in patients with hemodynamic stability and presenting signs of herniation or progressive neurological deterioration not attributable to extracranial causes. 250 mL (50 g mannitol) is administered in 15 minutes[54].

Exposure [E]

Key: Are there injuries that have not been detected? How can we avoid hypothermia?

At the end of the primary survey, remove all the patient's clothing to detect injuries that may have gone unnoticed, including the patient's back, armpits and perineum, moving the whole patient in a coordinated way to avoid aggravating possible injuries. Remember that injuries are found under the clothing. Once assessed, cover the patient to preserve body heat with appropriate material and prevent hypothermia[47].

SECONDARY ASSESSMENT

After performing the primary survey and stabilizing the victim, you can carry out a quick but complete assessment of the entire body. Its objective is to discover and resolve, if appropriate, any injury not found in the primary evaluation.

The classic system for secondary assessment is "from head to toe without forgetting the back" in search of non-vital injuries. Remember that life-threatening injuries must be detected and treated at the initial assessment. The secondary assessment includes revaluating the vital signs: HR, AP, O2 saturation, RR and temperature, monitoring pain, blood glucose, and capnography if appropriate[55].

In addition, if the patient's condition allows, you can now make a brief medical history, to obtain information about what happened, allergies, symptoms, current medication (especially anticoagulant therapy), medical and/ or surgical history. It is important to detect if there was a medical factor triggering the accident.

Monitoring

During the transfer, patients should be continuously monitored and re-evaluated for signs of deterioration. This includes pulse oximetry with HR, non-invasive AP, and electrocardiography. Ventilation-assisted patients should have continuous EtCO2 monitoring.

The evidence of the use of ultrasound (ECOFAST/Point of Care Ultrasonography, POCUS) at the prehospital level is scarce but growing, and it can be a useful tool to rule out life-threatening injuries. It requires training and skill and can be carried out on site or during transport[26,27,56].

In no case should the transfer of a patient with evidence of severe injury be delayed by carrying out extraordinary measures, or by attempting to ensure excessive stabilization.

ANALGESIA

The goal is to reduce pain at least to a tolerable level, without causing major adverse effects. Scales can be applied for pain assessment [0 = no pain and 10 = worst pain][50]. Pain relief improves the hemodynamic condition and respiratory rate and allows the transfer of the patient and immobilization and alignment of fractures. Communication with the patient relieves anxiety associated with pain. Aligning and immobilizing fractures also reduces pain. The use of opiates is considered safe because the effects on cardiovascular stability and excessive sedation are not common. In addition, naloxone is available as an antidote, which quickly reverses the opioid effect. Fentanyl (ampoules 150 mcg/3 mL;) can be safely administered in the prehospital setting intravenously (1-3 mcg/kg), intramuscularly, intranasally (2 mcg/kg) or subcutaneously[57,58].

Morphine (10 mg/mL ampoules) can be used but, unlike fentanyl, its effect lasts longer and can produce more hypotension and respiratory depression. It is advisable to start with a dose of 4 mg and add 2 mg in 2 mg up to 15 mg if necessary.

Ketamine is increasingly used at the prehospital level (ampoules of 500 mg/10mL) intravenously (0.5 mg/kg), intranasally (1 mg/kg), intramuscularly (3 mg/kg)[59], alone or in combination with opioids and seems to show better results[60].

In cases of major trauma, apply a strategy of permissive hypotension. Excessive volume intake is harmful

The advantages of ketamine are that it does not produce respiratory depression or, according to the available evidence, does not increase ICP, but can produce disorientation as an adverse effect[61,62].

EXTRICATION AND IMMOBILIZATION

Extrication implies the collaboration between technical and health responders, fluid communication and dynamic planning. On arrival, there may be citizens, companions, witnesses, bystanders and other first responders such as the police, or firemen who can provide different degrees of information regarding the event and the patient's clinical condition. It is important to interpret the information they provide to what is relevant in terms of the safety and clinical condition of the victims. Extrication involves an assessment of the safety of the scene, stabilization of the vehicle, removal of glass debris and dangerous objects, creation of space and full access to the victims. Local health care teams sometimes arrive before the rescue team and therefore must have previous training in scene safety. In case of doubt or if any danger is detected, you should contact the coordinating centre and wait for technical assistance. If there is a need for more resources, the relevant details and priorities should be reported to the rescue team when they arrive. This allows an extrication plan to be implemented based on the severity detected in case of several victims, which can be immediate, fast (5 minutes) or urgent (20 minutes).

Ideally there should be complete access to the patient, who is to be extracted at an aligned and at a zero angle. Usually, the patient is extracted on a long spinal board, although other devices such as the spinal splint (for example, the Kendrick Extraction Device) may be useful in some circumstances.

Spinal immobilization

Spine immobilization is routine practice in MT care. Manoeuvres and material include the use of the cervical collar, head blocks, fastening straps, spine board, arched back stretcher, etc. Despite the benefits of protection and stabilization, immobilization is not without risks. It can delay the start of definitive treatment, increase intracranial pressure, increase the risk of aspiration, limit ventilatory effort and be uncomfortable for the patient. Sometimes it is even applied when not indicated or when neither the mechanism of injury nor the clinical findings indicate this measure.

The trend regarding prehospital immobilization has changed from generalized to selective immobilization. In the consensus of the Royal College of Surgeons of Edinburgh, after reviewing the evidence on spinal immobilization[55,59] in the prehospital setting, the recommendations are based on expert opinion and on protocols of long historical use not always based on evidence, which in the prehospital setting is difficult to obtain.

The NEXUS rule[45,63] identifies 5 criteria that, if met, rule out injury and the need for spinal immobilization without considering the mechanism of injury:

- No midline spinal pain.
- No neurologic deficit.
- Patient conscious, normal.
- No signs of intoxication.
- No painful injury distracting the patient's attention.

The Canadian Rule of the Cervical Spine[63,64] uses low and high-risk factors:

- High-risk (age ≥65 years, paraesthesia, high-energy mechanisms).
- Low risk in range of motion (rear-end collision), sitting in the ER, walking at any time, late onset of pain, absence of spinal pain).
- Posibilidad de rotar el cuello 45°.

Although there are other algorithms, the injury mechanism is a predictor of injury. The level of consciousness also influences the decision to immobilize. In any case, the priority is to follow the primary survey (XABCDE), whether the patient is conscious or not. In the conscious patient there are more possibilities to count on patient collaboration and to obtain information, and to even delay immobilization until the evaluation is completed if the patient can stay still.

In the case of non-health responders, recommendations should tend to focus on exceeding care or triage. Based on healthcare criteria, immobilization can be adapted to the patient's condition.

Remember that, in case of suspected pelvic fracture, immobilization with a pelvic binder must be performed before placing the patient on the spinal hardboard. It is important to avoid unnecessary movements of the patient, and orchestrate movements from the head of the patient.

For an urgent short-distance transfer (up to 10 minutes), it is not necessary to remove the board since it does not offer any clinical advantage and even delays the transfer. For prolonged transfer (more than 10 minutes) the vacuum mattress is recommended, which in our setting is the one that is most used in both prolonged and short trips based on the primary evaluation, clinical suspicion, and injury mechanism.

ALERT AND PATIENT TRANSFER

Before or during the transfer, it is important to alert the receiving centre about the incident, the transfer of the victims and their clinical condition for the safety and definitive management. A pre-alert facilitates the preparation of receiving team in the Emergency Room and alerting other related services (traumatology, anaesthesia, surgery, intensive medicine, haematology) accordingly[4,21].

Upon arrival at the Emergency Room there are two transfers: 1) the patient and material, and 2) the information.

1 The physical transfer to the emergency stretcher must be directed from the heath care oriovider at the head of the patient's. Consider that the patient is to me moved along with other material equipment (such as the ventilator, monitor, tubing, vacuum mattress, i.v. lines, etc.) which must be controlled by sufficient assisting personnel.

Verify that the transfer can proceed by asking: 'Is anyone not ready?', and count down loudly "3,2,1" and perform the transfer.

2 The other transfer involves delivering relevant clinical information to the appropriate receptor, summarized below.

Critical information

- Mechanism of injury
- Findings from the latest primary survey
- Vital signs (latest and trend)
- Level of consciousness
- IV/IO access available
- Interventions

Additional information

- Mechanism details (photos of the scene, weapon/knife type, SDI, vehicle intrusion, position in the vehicle, etc.)
- Number of victims
- Medical or surgical history, medication, allergies
- Possible medical trigger

The last patient has been transferred and you have finished this incident:

- The co-pilot is dead.
- The driver was intubated and during the transfer he developed a tension pneumothorax resolved after drainage and improving saturation and ventilatory situation. He arrived alive at the referral hospital (with a SBP of 95 mmHg). The massive transfusion protocol was activated after a full body CT scan showed cerebral haemorrhagic contusions, pneumothorax that required a chest drain, and a bleeding liver that required surgical intervention. The patient is in the Intensive Care unit in critical condition.
- Another patient suffered a bilateral femoral fracture, and improved after analgesia, immobilization, and restricted volume administration, arriving in stable condition at the hospital,
- The last victim suffered an anterior dislocation of the shoulder and abrasions on the arms.
- They all tested positive for alcohol.

After the incident, you carry out a team debriefing regarding the intervention, reviewing individual and team performance, based on the actions taken contrasted with the guidelines presented in this article, and your experience.

What has been done properly? Were all the first responders coordinated? Have we taken care of our safety and that of the victims? Did we have enough resources? What was missing? Have we had to report the event to family or friends?

How do I feel after dealing with the tragedy? Do I need to talk to someone or the rest of the team? Does anyone on my team need me? What interventions have worked well for us?

What concrete actions should we train or review?

Let's restock material and then have something to eat... It's been along morning.

Well done.

Findings

Understanding the mechanisms of injury helps us to interpret the scene of the accident and to anticipate the possible injuries that the victims may suffer.

Healthcare intervention in major trauma improves when a multidisciplinary team knows and applies unified criteria under a leader.

The responders should know the methodology of the primary survey and actively look for life-threatening injuries

Active communication makes it possible to streamline the management and coordination of relevant actions at each stage to guarantee the safety of rescuers and victims.

Annex 1
Some references of marketed products

Haemostatic products

- Chitogauze®
- ChitoSAM®
- Celox gauze®
- Combat gauze®

Tourniquet

- Combat Application Tourniquet (C-A-T®)
- SAM® XT Tourniquet

Clamps and Junctional torniquets

- IT-Clamp®
- Combat Ready Clamp (CRoC)®
- Junctional Emergency Treatment Tool (JETT)®
- SAM Junctional Tourniquet (SJT)®

Pneumothorax management

- Air Release System (ARS) ®
- Simplified Pneumothorax Emergency Air Release (SPEAR)®

Pelvic stabilizer

- T-POD®
- PelvicBinder®
- SAM® Pelvic Sling

Intraosseous route

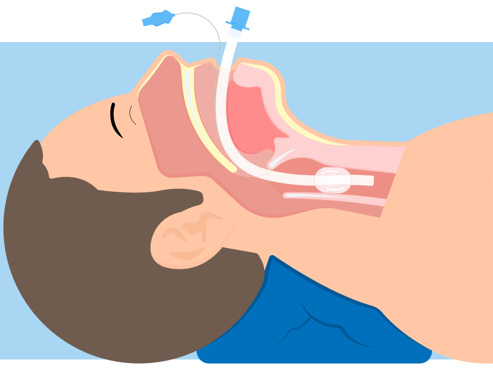
Intraosseous route

- EZ-IO® intraosseous
- Bone Injection Gun

Specific sternal intraosseous devices

- FAST Responder ™ esternal
- Cook Medical® Dieckmann Manual Needle

Appendix 2 Tracheal Intubation checklist



Planning and preparation

- Identification of difficult airway predictors (below).
- Initial plan and assignment of team roles.
- Alternatives to the initial plan.
- Multi-parameter monitoring.
- Localization and palpation of the cricothyroid membrane.
- Preparation and checking of material.
- Venous/intraosseous access.
- Ideal weight according to patient height.

Difficult airway predictors identified

Plan A:
- Medication
- Direct laryngoscopy / video laryngoscopy
- Bougie / Frova®

Plan B
- Bag/PEEP valve mask ventilation
- Supraglottic device

Plan C (no puedo oxigenar, no puedo ventilar)
- FONA (front of neck access)
- Bougie - endotracheal tube - scalpel

Difficult airway predictors (HEAVEN)[1,2]
- **H**ypoxemia
- **S**ize
- **A**natomical obstruction or difficulty
- **V**omiting / blood/ fluids
- **E**xsanguination
- Neurological injury/Neck mobilization (**N**eck)

Pre-oxygenation

Saturation target n >95%

- Non-rebreather mask
- PEEP valve mask-bag (2-operator technique)
- Supraglottic device
- Non-invasive ventilation / CPAP
- Delayed sequence intubation

Pre-medication

Adjust dose in case of hypotension or intracranial hypertension

- Fentanyl
- Atropine
- Vasopressors
- Fluids
- Other: ....

Induction

Adjust dose in case of hypotension or intracranial hypertension

- Etomidate
- Midazolam
- Ketamine
- Propofol

Relaxation

Adjust dose in case of hypotension or intracranial hypertension

- Succinylcholine
- Rocuronium

Intubation in optimal position and airway protection

- Head and neck placement
- Reverse Trendelenburg position (if necessary)
- Cervical immobilization
- BURP manoeuver
- Apneic oxygenation

Post-intubation care

- Check: direct view, auscultation, pulse oximetry, EtCO2, etc.
- Capnography
- Fasten the tube
- Mechanical ventilation (transport/ standard)
- Monitor and repeat primary evaluation
- Analgesia, sedation and relaxation, humidification
- Nasogastric catheterization
- Gasometry if available
- Ventilation adjustments
  - FiO2: ....
  - Tidal volume (6-8 ml/kg) (Ideal weight according to height)
  - Respiratory rate
  - PEEP

Material

- Oxygen
- Nasal cannula
- Non-rebreather mask
- Face mask
- PEEP Valve
- Viral Filter
- Oropharyngeal cannula
- Nasopharyngeal cannula
- Suction working
- Yankauer catheter
- Flexible catheter
- Magill forceps
- Laryngoscope
- Curved blade
- Straight blade
- Endotracheal tube
- Video laryngoscope
- 10cc syringe
- Lubricant
- TET fastening device/tape
- Guide rod
- Insertion device (Bougie/Frova)
- Supraglottic airway device
- Cricothyroidotomy set
- Monitor
- Pulse Oximetry
- Capnography
- Ventilator
- Tubing
- Perfusion pump
- Nasogastric catheter
- Batteries
- Stethoscope

1. Nausheen F, Niknafs NP, MacLean DJ, et al. The HEAVEN criteria predict laryngoscopic view and intubation success for both direct and video laryngoscopy: A cohort analysis. Scand J Trauma Resusc Emerg Med. 2019;27(1):1-9. https://doi.org/10.1186/s13049-019-0614-6

2. Olvera D, Lauria MJ, Noce J, Weir WB. Compliance and Attitudes of Critical Care Transport Providers Regarding a Prehospital Rapid Sequence Intubation Checklist. Air Med J. 2022;41(1):82-87. https://doi.org/10.1016/j.amj.2021.10.007

ENLARGE VIEW

References

1. Alberdi F, García I, Atutxa L, Zabarte M. Epidemiología del trauma grave. *Med Intensiva*. 2014;38(9):580-588. https://doi.org/10.1016/j.medin.2014.06.012

2. Croswell J, Shin YR. Prevention of falls in community-dwelling older adults. Am Fam Physician. 2012;86(12):1135-1136. https://doi.org/10.1056/nejmcp1903252

3. Cohen DJ, Clark EC, Lawson PJ, Casucci BA, Flocke SA. Identifying teachable moments for health behavior counseling in primary care. *Patient Educ Couns*. 2011;85(2):e8-e15. https://doi.org/10.1016/j.pec.2010.11.009

4. NAEMT (National Association of Emergency Medical Technicians). *PHTLS Soporte Vital de Trauma Prehospitalario*; 2019.

5. Díez DR, Otano TB, Bermejo Fraile B, Louis CJ, Ramírez JR, Sucunza AE. Use of a structural deformity index as a predictor of severity among trauma victims in motor vehicle crashes. *J Emerg Med*. 2012;43(1):19-28. https://doi.org/10.1016/j.jemermed.2010.01.017

6. Belzunegui Otano T, Castro González E, Fortún Moral M, Reyero Díez D, Teijeira Álvarez R. Implantado en Navarra el primer registro de politraumatizados de base poblacional en España TT - Implementation of the first Spanish population-based register for multiple-injury cases in Navarre. *Emergencias (Sant Vicenç dels Horts)*. 2013:196-200.

7. Ali Ali B, Brinck T, Handolin L, Belzunegui Otano T. Severe head injury in elderly: 6-year comparison of treatment and outcome between southern Finland and Navarra (Spain). *Eur J Trauma Emerg Surg*. 2021;47(5):1429-1436. https://doi.org/10.1007/s00068-019-01091-8

8. Gérvas J GJ. Multicausalidad de las caídas y papel de los medicamentos. *Boletín Inf Farmacoter Navarra*. 2013:1-8. http://www.navarra.es/home_es/Temas/Portal+de+la+Salud/Profesionales/Documentacion+y+publicaciones/Publicaciones+tematicas/Medicamento/BIT/Vol+21/BIT+Vol+21+n+2.htm

9. Reid C, Brindley P, Hicks C, et al. Zero point survey: A multidisciplinary idea to STEP UP resuscitation effectiveness. *Clin Exp Emerg Med*. 2018;5(3):139-143. https://doi.org/10.15441/ceem.17.269

10. Real Decreto 773/1997, de 30 de mayo, sobre disposiciones mínimas de seguridad y salud relativas a la utilización por los trabajadores de equipos de protección individual. https://www.boe.es/eli/es/rd/1997/05/30/773/com

11. Reglamento (UE) 2016/425 del Parlamento Europeo y del Consejo, de 9 de marzo de 2016, relativo a los equipos de protección individual y por el que se deroga la Directiva 89/686/CEE del Consejo. *D Of la Unión Eur*. 2016;93(81, de 31 de marzo):51 a 98. https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:32016R0425&from=LT.

12. The ATACC Group. *Anaesthesia, Trauma and Critical Care Course Manual 2014. 8th Edition.*; 2014.

13. Littlejohn LF, Devlin JJ, Kircher SS, Lueken R, Melia MR, Johnson AS. Comparison of Celox-A, Chitoflex, WoundStat, and combat gauze hemostatic agents versus standard gauze dressing in control of hemorrhage in a swine model of penetrating trauma. *Acad Emerg Med*. 2011;18(4):340-350. https://doi.org/10.1111/j.1553-2712.2011.01036.x

14. Zideman DA, Singletary EM, Borra V, et al. European Resuscitation Council Guidelines 2021: First aid. *Resuscitation*. 2021;161:270-290. https://doi.org/10.1016/j.resuscitation.2021.02.013

15. Swan KG, Wright DS, Barbagiovanni SS, Swan BC, Swan KG. Tourniquets revisited. *J Trauma - Inj Infect Crit Care*. 2009;66(3):672-675. https://doi.org/10.1097/TA.0b013e3181986959

16. Passos E, Dingley B, Smith A, et al. Tourniquet use for peripheral vascular injuries in the civilian setting. *Injury*. 2014;45(3). https://doi.org/10.1016/j.injury.2013.11.03

17. Doyle GS, Taillac PP. Tourniquets: A review of current use with proposals for expanded prehospital use. *Prehospital Emerg Care*. 2008;12(2). https://doi.org/10.1080/10903120801907570

18. Beekley AC, Sebesta JA, Blackbourne LH, et al. Prehospital tourniquet use in Operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma*. 2008;64(2 Suppl). https://doi.org/10.1097/ta.0b013e318160937e

19. Lakstein D, Blumenfeld A, Sokolov T, et al. Tourniquets for hemorrhage control on the battlefield: a 4-year accumulated experience. *J Trauma*. 2003;54(5 Suppl):S221-5. https://doi.org/10.1097/01.TA.0000047227.33395.49

20. Brown CA, Sakles JC, Mick NW. *The Walls Manual of Emergency Airway Management*; 2018.

21. Koyfman A, Long B. *The Emergency Medicine Trauma Handbook.*; 2019. https://doi.org/10.1017/9781108647397

22. Clemency BM, Tanski CT, Rosenberg M, May PR, Consiglio JD, Lindstrom HA. Sufficient Catheter Length for Pneumothorax Needle Decompression: A Meta-Analysis. *Prehosp Disaster Med*. 2015;30(3):249-253. https://doi.org/10.1017/S1049023X15004653

23. Standl T, Annecke T, Cascorbi I, Heller AR, Sabashnikov A, Teske W. The Nomenclature, Definition and Distinction of Types of Shock. *Dtsch Arztebl Int*. 2018;115(45):757-767. https://doi.org/10.3238/arztebl.2018.0757

24. Rosell-Ortiz F, Escalada-Roig X, Fernández del Valle P, et al. Out-of-hospital cardiac arrest (OHCA) attended by mobile emergency teams with a physician on board. Results of the Spanish OHCA Registry (OSHCAR). *Resuscitation*. 2017. https://doi.org/10.1016/j.resuscitation.2017.01.029

25. Campos-Serra A, Montmany-Vioque S, Rebasa-Cladera P, et al. The use of the Shock Index as a predictor of active bleeding in trauma patients. *Cir Esp*. 2018;96(8):494-500. https://doi.org/10.1016/j.ciresp.2018.04.004

26. Bøtker MT, Jacobsen L, Rudolph SS, Knudsen L. The role of point of care ultrasound in prehospital critical care: A systematic review. *Scand J Trauma Resusc Emerg Med*. 2018;26(1). https://doi.org/10.1186/s13049-018-0518-x

27. Ramsingh D, Mangunta VR. The Use of Point-of-Care Ultrasonography in Trauma Anesthesia. *Anesthesiol Clin*. 2019;37(1):93-106. https://doi.org/10.1016/j.anclin.2018.09.011

28. Pohlman TH, Walsh M, Aversa J, Hutchison EM, Olsen KP, Lawrence Reed R. Damage control resuscitation. *Blood Rev*. 2015;29(4). https://doi.org/10.1016/j.blre.2014.12.006

29. Cannon JW. Prehospital Damage-Control Resuscitation. *N Engl J Med*. 2018;379(4). https://doi.org/10.1056/nejme1805705

30. Kaafarani HMA, Velmahos GC. Damage control resuscitation in trauma. *Scand J Surg*. 2014;103(2):81-88. https://doi.org/10.1177/1457496914524388

31. Cantle PM, Cotton BA. Balanced Resuscitation in Trauma Management. *Surg Clin North Am*. 2017;97(5). https://doi.org/10.1016/j.suc.2017.06.002

32. Egea-Guerrero JJ, Freire-Aragón MD, Serrano-Lázaro A, Quintana-Díaz M. Objetivos y nuevas estrategias de resucitación en el paciente traumatizado grave. *Med Intensiva*. 2014;38(8):502-512. https://doi.org/10.1016/j.medin.2014.06.003

33. Moffat B, Vogt KN, Inaba K. The Shock Index: Is it ready for primetime? *Crit Care*. 2013;17(5):2-3. https://doi.org/10.1186/cc13040

34. Bonanno FG. The need for a physiological classification of hemorrhagic shock. *J Emergencies, Trauma Shock*. 2020;13(3). https://doi.org/10.4103/JETS.JETS_153_19

35. Weingart S, Meyers CM. *Thoughts on the Resuscitation of the Critically Ill Trauma Patient*; 2008.

36. Gupta B, Garg N, Ramachandran R. Vasopressors: Do they have any role in hemorrhagic shock? *J Anaesthesiol Clin Pharmacol*. 2017;33(1):3-8. https://doi.org/10.4103/0970-9185.202185

37. Gauss T, Gayat E, Harrois A, et al. Effect of early use of noradrenaline on in-hospital mortality in haemorrhagic shock after major trauma: a propensity-score analysis. *Br J Anaesth*. 2018;120(6):1237-1244. https://doi.org/10.1016/j.bja.2018.02.032

38. Rau CS, Wu SC, Kuo SCH, et al. Prediction of massive transfusion in trauma patients with shock index, modified shock index, and age shock index. *Int J Environ Res Public Health*. 2016;13(7):1-11. https://doi.org/10.3390/ijerph13070683

39. Pariente Juste L, Koo Gómez M, Bonet Burguera A, Reyes García R, Pérez García L, Macía Tejada I. Índices de shock prehospitalario y hospitalario como predictores de transfusión masiva en la atención inicial del paciente politraumático. *Emergencias (Sant Vicenç dels Horts)*. 2021;33(1):29-34.

40. Nunez TC, Voskresensky I V, Dossett LA, Shinall R, Dutton WD, Cotton BA. Early Prediction of Massive Transfusion in Trauma : Simple as ABC (Assessment of Blood Consumption)? 2009;(February). https://doi.org/10.1097/TA.0b013e3181961c35

41. Cotton BA, Dossett LA, Haut ER, Shafi S. Multicenter Validation of a Simplified Score to Predict Massive. 2010;69(1):33-39. https://doi.org/10.1097/TA.0b013e3181e42411

42. Código Trauma. SaludNavarra. Atención a las urgencias tiempo-dependientes. http://www.navarra.es/home_es/Temas/Portal+de+la+Salud/Ciudadania/Nuevo+Modelo+asistencial/Plan+Salud+Navarra/Plan+de+Salud+de+Navarra+2014-2020+Profesionales/Estrategias+y+Programas/Atencion+urgencias/Codigos+activacion.htm. Accessed June 24, 2022

43. Sperry JL, Guyette FX, Brown JB, et al. Prehospital Plasma during Air Medical Transport in Trauma Patients at Risk for Hemorrhagic Shock. *N Engl J Med*. 2018;379(4):315-326. https://doi.org/10.1056/nejmoa1802345

44. Mizushima Y, Nakao S, Idoguchi K, Matsuoka T. Fluid resuscitation of trauma patients: How much fluid is enough to determine the patient's response? *Am J Emerg Med*. 2017;35(6):842-845. https://doi.org/10.1016/j.ajem.2017.01.038

45. Brown J, Sajankila N, Claridge JA. Prehospital Assessment of Trauma. *Surg Clin North Am*. 2017;97(5):961-983. https://doi.org/10.1016/j.suc.2017.06.007

46. Olaussen A, Williams B. Intraosseous access in the prehospital setting: Literature review. *Prehosp Disaster Med*. 2012;27(5). https://doi.org/10.1017/S1049023X12001124

47. Binz S, McCollester J, Thomas S, et al. CRASH-2 Study of Tranexamic Acid to Treat Bleeding in Trauma Patients: A Controversy Fueled by Science and Social Media. *J Blood Transfus*. 2015;2015. https://doi.org/10.1155/2015/874920

48. Wafaisade A, Lefering R, Bouillon B, Böhmer AB, Gäßler M, Ruppert M. Prehospital administration of tranexamic acid in trauma patients. *Crit Care*. 2016;20(1). https://doi.org/10.1186/s13054-016-1322-5

49. Tranexamic acid: Drug information. In: *UpToDate*. Waltham, MA: Post TW (Ed), UpToDate. https://www.uptodate.com/contents/tranexamic-acid-drug-information Accessed June 24, 2022.

50. Galeiras Vázquez R, Ferreiro Velasco ME, Mourelo Fariña M, Montoto Marqués A, Salvador de la Barrera S. Actualización en lesión medular aguda postraumática. Parte 1. *Med Intensiva*. 2017;41(4):237-247. https://doi.org/10.1016/j.medin.2016.11.002

51. Brain Trauma Foundation. Guidelines for Prehospital Management of TBI, 2nd Ed.

52. Healey C, Osler TM, Rogers FB, et al. Improving the glasgow coma scale score: Motor score alone is a better predictor. *J Trauma*. 2003;54(4). https://doi.org/10.1097/01.TA.0000058130.30490.5D

53. Kupas DF, Melnychuk EM, Young AJ. Glasgow Coma Scale Motor Component ("Patient Does Not Follow Commands") Performs Similarly to Total Glasgow Coma Scale in Predicting Severe Injury in Trauma Patients. *Ann Emerg Med*. 2016;68(6). https://doi.org/10.1016/j.annemergmed.2016.06.017

54. Smith ER, Amin-Hanjani S. Evaluation and management of elevated intracranial pressure in adults. In: *UpToDate*. Waltham, MA: Post TW (Ed), UpToDate. https://www.uptodate.com/contents/evaluation-and-management-of-elevated-intracranial-pressure-in-adults . Accessed June 24, 2022.

55. Christ M. Pain – the fifth vital sign. *Swiss Med Wkly*. 2020;150. https://doi.org/10.4414/smw.2020.20215

56. van der Weide L, Popal Z, Terra M, et al. Prehospital ultrasound in the management of trauma patients: Systematic review of the literature. *Injury*. 2019;50(12):2167-2175. https://doi.org/10.1016/j.injury.2019.09.034

57. Soriya GC, McVaney KE, Liao MM, et al. Safety of prehospital intravenous fentanyl for adult trauma patients. *J Trauma Acute Care Surg*. 2012;72(3). https://doi.org/10.1097/TA.0b013e31823c4444

58. Fentanyl: Drug information. In: *UpToDate*. Waltham, MA: Post TW (Ed), UpToDate. https://www.uptodate.com/contents/fentanyl-drug-information. Accessed June 24, 2022.

59. Ketamine: Drug information. In: *UpToDate*. Waltham, MA: Post TW (Ed), UpToDate. https://www.uptodate.com/contents/ketamine-drug-information. Accessed June 24, 2022.

60. Yousefifard M, Askarian-Amiri S, Rafiei Alavi SN, et al. The Efficacy of Ketamine Administration in Prehospital Pain Management of Trauma Patients; a Systematic Review and Meta-Analysis. *Arch Acad Emerg Med*. 2020;8(1):1-11. https://doi.org/10.22037/aaem.v8i1.479

61. Gregers MCT, Mikkelsen S, Lindvig KP, Brøchner AC. Ketamine as an Anesthetic for Patients with Acute Brain Injury: A Systematic Review. *Neurocrit Care*. 2020;33(1). https://doi.org/10.1007/s12028-020-00975-7

62. Bar-Joseph G, Guilburd Y, Tamir A, Guilburd JN. Effectiveness of ketamine in decreasing intracranial pressure in children with intracranial hypertension: Clinical article. *J Neurosurg Pediatr*. 2009;4(1). https://doi.org/10.3171/2009.1.PEDS08319

63. Michaleff ZA, Maher CG, Verhagen AP, Rebbeck T, Lin CWC. Accuracy of the Canadian C-spine rule and NEXUS to screen for clinically important cervical spine injury in patients following blunt trauma: A systematic review. *Cmaj*. 2012;184(16):867-876. https://doi.org/10.1503/cmaj.120675

64. Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA*. 2001;286(15):1841-1848. https://doi.org/10.1001/jama.286.15.1841

65. Lott C, Truhlář A, Alfonzo A, et al. European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances [published correction appears in Resuscitation. 2021 Oct;167:91-92]. Resuscitation. 2021;161:152-219. https://doi.org/10.1016/j.resuscitation.2021.02.011

66. Wray JP, Bridwell RE, Schauer SG, et al. The diamond of death: Hypocalcemia in trauma and resuscitation. Am J Emerg Med. 2021;41:104-109. https://doi.org/10.1016/j.ajem.2020.12.065

67. Vasudeva M, Mathew JK, Groombridge C, et al. Hypocalcemia in trauma patients: A systematic review. J Trauma Acute Care Surg. 2021;90(2):396-402. https://doi.org/10.1097/TA.0000000000003027

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