

# **Penetrating wounds**

**Treating gunshots and stabbings as a paramedic – a literature review**

LAB University of Applied Sciences  
Bachelor of Health Care, Paramedic Nurse  
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Cian Carroll, Eerika Helttula

## Abstract

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Abstract		
<p>As violent encounters in society are on the rise, there is a correlating increase in shootings and stabbings. Furthermore, violent crime and suicides are getting more frequent. For paramedics, penetrating wounds are not as common as are for example cardiac patients or sprains and broken bones. Therefore, it is important to keep up to date on treatment protocols in these types of injuries, to ensure the best possible outcomes for patients, as penetrating wounds can be difficult to treat and are often life threatening.</p> <p>This thesis discusses about injury mechanisms in penetrating injuries, the most common complications and systematic treatment of these. We will focus on the initial assessment phase and move on to treatment and transport of patients. We did not include patients from special groups, such as paediatric patients and pregnant patients.</p> <p>The thesis method is a literature review, using current data from books and online materials. The aim was to compile a useful information package for medical professionals and students to use in school and working life. Which is why the assumption is that the basic anatomy and treatment methods are familiar to the reader.</p>		
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wound care, emergency care, penetrating wounds, gunshot wounds, stabbings, paramedicine, paramedic		

## Tiivistelmä

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<p>Väkivalta lisääntyy jatkuvasti, ja sen myötä myös puukotukset ja ampumiset. Ensihoitajille lävistävät vammat eivät ole arkipäivää, kuten esimerkiksi yleistilan lasku-, tai sydäninfarktipotilaat. Tämän vuoksi on tärkeää muistaa ja pitää mielessä hoitoprotokollat lävistävien vammojen hoidossa, jotta saadaan paras mahdollinen hoitotulos. Lävistävän vamman saanut potilas on yleisesti haastava hoidettava ensihoidossa.</p> <p>Tässä opinnäytetyössä käymme läpi lävistävien vammojen vammamekanismit, yleisimmät komplikaatiot ja systemaattisen tutkinnan kautta hoitotoimenpiteet. Painotamme alkuarvion ja vamman tekotavan selvittämistä ja etenemme aina potilaan kuljetukseen asti. Tässä opinnäytetyössä jätimme ulkopuolelle potilaiden erityisryhmät, kuten lapset ja raskaana olevat.</p> <p>Teimme työn kirjallisuuskatsauksena käyttäen erilaisia tutkimuskantoja. Tutkimme materiaaleja ja kokosimme niistä kattavan yleisen kirjallisuusmateriaalipaketin. Kohderyhmänä meillä on terveydenalan ammattilaiset, jonka vuoksi emme kattaneet anatomiaa perusteellisesti, vaan lähdimme oletuksesta, että se on jo tuttu.</p>		

# Contents

1	Introduction.....	1
2	Background .....	2
2.1	Definition of penetrating wound mechanism .....	2
2.1.1	Low impact mechanism .....	2
2.1.2	High impact mechanism .....	3
2.1.3	Penetrating wounds in different areas of the body .....	4
2.2	Safety and TECC .....	5
2.3	Initial assessment.....	6
2.4	Systematic examination.....	7
2.5	Pain management .....	9
3	The purpose of the thesis, aim and questions to be answered.....	10
4	Method .....	11
4.1	Literature review.....	11
4.2	Data search and collection .....	11
4.3	Analysis method.....	12
5	Data selection.....	14
6	Results .....	17
6.1	How to recognise the injury mechanism .....	17
6.2	How to treat different types of piercing wounds in the field .....	18
6.2.1	Bleeding and extremity injuries .....	18
6.2.2	Torso and chest injuries.....	19
6.2.3	Cranial and spinal injuries.....	20
6.2.4	Heart injuries .....	21
6.3	How to improve your patient's chances of survival .....	21
7	Discussion .....	22
8	Ethics.....	23
9	Conclusions .....	24
	References .....	26

Appendix 1. Studies included in the literature review

## 1 Introduction

Shootings and stabbings are not common in Finland, compared to the rest of the world at least (Afriproedu 2024). However, according to recent studies, they have increased significantly in the past few years (Haapakangas & Kaakinen 2023). Stabbings and gunshot wounds are not injuries that are seen every day in the healthcare field (Barner-Rasmussen et al. 2016). Although, considering the latest statistics, these incidents will probably increase in the future, especially amongst younger demographics (Haapakangas & Kaakinen 2023).

Around 40% of violent crimes involve a sharp blade (Rikoksentorjunta 2024). Sharp blades are knives, ice picks or anything that can be used as a piercing weapon. There are approximately 400 gunshot incidents per year in Finland. About half of these are self-inflicted, the other half are caused by violence and mass casualty situations. (Barner-Rasmussen et al. 2016). Examples in Finland are Jokela's school shooting in 2007 and the 2017 Turku terrorist attack (knife as a weapon). More recent incidents are the Viertola school shooting in Vantaa in April 2024 and the two separate stabbings in Oulu on the 13<sup>th</sup> of June 2024. Knowledge about the treatment in these types of situations is vital.

This thesis consists of the mechanism of piercing wounds and the treatment of them. The topic is divided into low-, and high impact wounds and specifically to gunshot wounds and piercing wounds made with a sharp object. The aim was to gather current and accurate information on the treatment of these kinds of injuries and to compile them into a literature review. The topic is important, since it is vital for paramedics to have the most up to date information and knowledge on treating piercing wounds. The mortality rate in these types of injuries is typically high. Treating wounds made with a sharp blade or a bullet are taught in the paramedicine program, but only briefly. The purpose of the thesis is to give the reader knowledge of the pathophysiology of the wound, treatment and transportation of the patient.

## 2 Background

### 2.1 Definition of penetrating wound mechanism

Trauma results from the exchange of energy between an object and the human body.

*Kinetics: "The extent of injury from penetrating trauma is proportional to the amount of kinetic energy (KE) that is lost by the missile. -- the kinetic energy of an object is equal to its mass times the square of its velocity, all divided by 2. It should be noted that doubling the mass only doubles the energy, whereas doubling the velocity quadruples the energy. Therefore, a small caliber bullet traveling at a high speed will produce more serious of an injury than a large caliber bullet with less velocity."* (Northwestern medicine 2019.)

Piercing injury can cause damage in the bones, tissues, nerves, and vascular structures. A penetrating wound is defined as an injury which is made by a sharp object breaking or piercing the skin, which lacerates or contuses adjacent tissue, creating an open wound. *"Tissue and organ trauma result from the permanent wound cavity caused by direct destruction by the bullet, and also from radial stretching of surrounding tissues causing a temporary wound cavity."* (Maiden 2009.) This thesis studies the most serious types of penetrating wounds.

High water density tissues, such as the liver or spleen, are more prone to permanent cavitation as well as solid density tissues, such as bones. (Northwestern medicine 2019.) The kinetic energy of the impact directly correlates to the effect of the injury.

A penetrating wound is always a dirty wound. The penetrating object is usually unclean and filled with bacteria. Dirt from the surroundings, such as pieces of clothing often get inside the wound, since the object that penetrates the patient rips the clothing and takes fibres and fragments with it to the wound cavity. (Barner-Rasmussen, et al. 2016.)

#### 2.1.1 Low impact mechanism

Low energy impact piercing wounds are wounds made with a knife or a similar sharp object. Wounds made with shotgun or handgun projectiles can also be low energy, if the calibre of the bullet is small and it is shot from a long enough distance. With a shotgun the injury energy is low, if the shot was made from further than 10 meters away. (National library of medicine 2015.) Usually, the low energy wounds are made with a piercing object. The size of the object affects the mechanism of the injury as well. A large chef's knife does more

damage than a small butter knife. Both are low impact wounds but can be greatly different on the risk level. (Northwestern Medicine 2019.)

The area of impact affects the outcome of care greatly. For example, stabbing wound in the chest is a greater risk than a higher number of stabbing wounds in the extremities. This is important to acknowledge when coming up with a treatment plan. It is not always the number of the wounds that is important, the body part and the energy of the wound plays a great part as well. When it comes to multiple injuries, the patient needs to be considered as a “whole”, not an injury by injury. (Northwestern Medicine 2019.)

Stabbing wounds follow a direct path, since the injury is usually inflicted with a straight object. This results in an injury, where the damage is localized (In.Gov. 2024). Knowing the depth of the wound helps to estimate the severity. One way to estimate the depth of the wound is to put two fingers inside the cavity, and if they fit, the wound is approximately 10cm deep. Low impact gunshot wounds crush the tissues but limitedly, versus to high impact gunshot wounds. (Kuisma et al. 2021, 549.)

### 2.1.2 High impact mechanism

High impact penetrating wounds are often caused by bullets or other ballistic projectiles. The injury mechanism in these types of wounds is caused by a phenomenon called “cavitation”, this occurs when the projectile travels at high speed through tissue and creates a pressure wave, which expands outward of the bullets path, damaging the tissue as it travels. (Barner-Rasmussen et al. 2016.)

Larger calibre bullets, such as rifle rounds are designed to continue straight through the body, usually causing an entry and exit wound, while smaller bullets can bounce around in the body and stay lodged, creating extensive damage. The greater the speed of penetration, the greater the injury usually is. (Northwestern medicine 2019.)

The severity of damage in high impact projectiles injuries varies greatly, based on many factors, including the area of impact. A high energy missile can for example travel through muscle tissue, severe veins and arteries, pierce critical organs such as the heart or lungs, break bones, or even destroy the spinal column. The best prognosis for survival is in trough-and-trough injuries of the extremities, while high velocity impacts to the brain are most often deadly. (Barner-Rasmussen et al. 2016.)

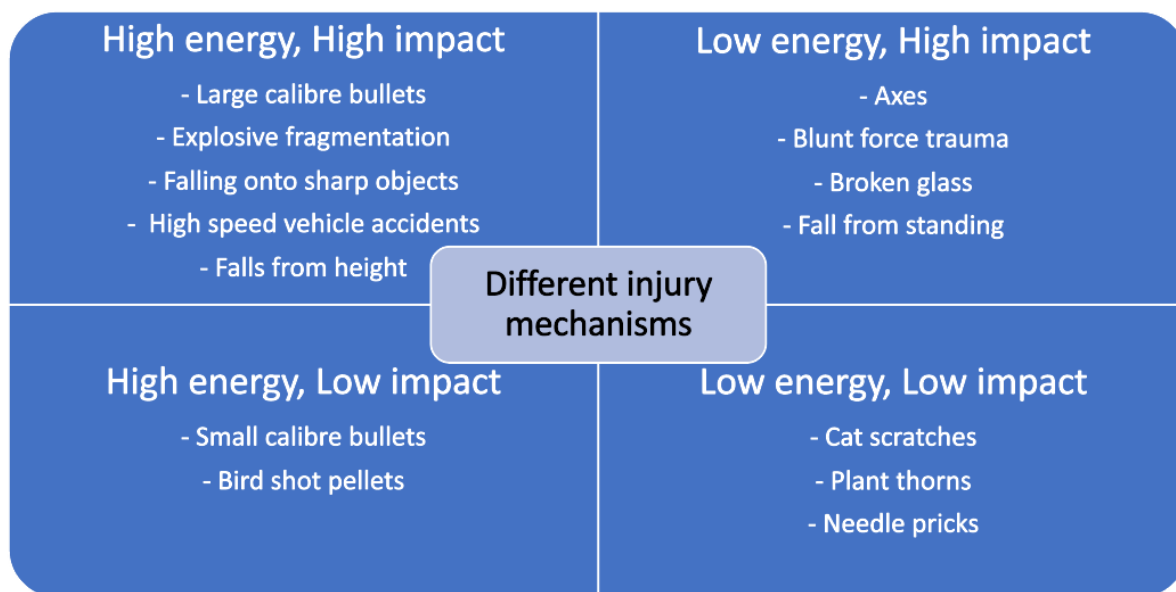


Figure 1. Different injury mechanisms

### 2.1.3 Penetrating wounds in different areas of the body

Head region stabbings have a high mortality rate (Kazim et al. 2011). The brain controls all the systems the human body requires to stay alive. When damaged, it can cause problems in different regions, like the motor skills and senses. The brain is fragile but protected by the skull, although a sharp object to the head usually penetrates the skull and damages the brain. (Hari 2018.) The neck contains different structures, like the spinal cord and column, jugular veins, carotid and vertebral arteries, trachea and oesophagus. Penetrating trauma to the neck can cause breathing and/or neurological problems as well as different levels of bleeding. (Roesch & Tadi 2023.)

Penetrating injuries to the chest area can vary greatly, because of the size of the thoracic cavity. Contained within are the lungs, oesophagus, diaphragm, major blood vessels and the heart. When it comes to the heart, pericardial tamponade is often common as well as injuries to the aorta, superior vena cava and pulmonary vessels. Lung traumas usually result in pneumothorax, tension pneumothorax or haemothorax. Tracheobronchial injuries can happen but are rare. Diaphragmatic injuries happen often, more specifically 45% of gunshot wounds and 15% of stab wounds to the torso injure the diaphragm. (Cook & Gleason 2009, 798-820.)

Two body cavities that contain many organs and structures are the abdomen and pelvis. Penetrating wound to these areas can be lethal, depending on the injury mechanism. Once

again, the most damaging are gunshot wounds. The pelvis can bleed internally for up to 1 litre which is a risk factor for haemodynamic shock. (Kuisma et al. 2021, 636.)

Penetrating wounds to the extremities are common, but usually not deadly. Extremities are made from bones, muscles, tendons, ligaments, nerves and blood vessels. The wound can become deadly, when a great blood vessel is compromised. All the areas affected can lead to lifelong disabilities, so even if the situation doesn't seem deadly, it is still considered a high-risk wound. (Sisley & Chiu 2024.)

## 2.2 Safety and TECC

Before arriving to the scene of gunshot or stabbing related incidences, the safety of paramedics must be guaranteed. In Finland, in violent incidence's such as these the police patrol unit is always attached to the mission. They try to make the scene as safe as possible for fire and rescue services before their arrival. Paramedics communicate with police, emergency centre and direct supervisors about a safe area to stage and wait, until the scene is secured. While waiting for this confirmation, paramedics prepare by putting on personal protective equipment, such as helmets and bullet proof vests and start gathering supplies that are most likely needed on scene. (Jama 2024.)

Once permission is granted, the unit moves up to the scene where a final "window assessment" is done. As the name suggests, this is done by scanning the scene through the ambulance window. There is a useful mnemonic device for this: PENMAN. The words letters formulate from; Personal/personnel safety – Is the scene safe for yourself and everyone else involved? Environmental hazards – for example traffic, aggressive people, smoke. Number of Victim's. Mechanism of injury. Additional resources – Do you need more units than initially was thought? And the last N stands for "Need for outside agencies, which is most likely not needed at this stage as we are going through the situation in this thesis where the victim is alone. (Jama 2024.)

TECC – tactical emergency casualty care comes initially from the TCCC – tactical combat casualty care system, which is used in the military. TECC is adapted from this military model. The TECC -model is used in police lead situations and in threat situations. For example, an active shooter or suspected stabbing. The model is used to maximise patients' survival outcome and to promote professional safety. In TECC there's three parts: the direct threat area, the undirect threat are and the evacuation area. (Jama 2024.)

The basic idea behind TECC is fast evacuation of the patient, and minimizing the treatments compared to the threat. In the direct threat zone, the main objective is to stop the bleeding and open the airways. In this area only specially trained person can operate, like the police

or a TEMS paramedic. Only the life supporting treatments are done here. In the indirect threat area, you can do more, like placing a chest seal for example. Every other necessary treatment is done in the safe zone – the evacuation zone. (Jama 2024.)

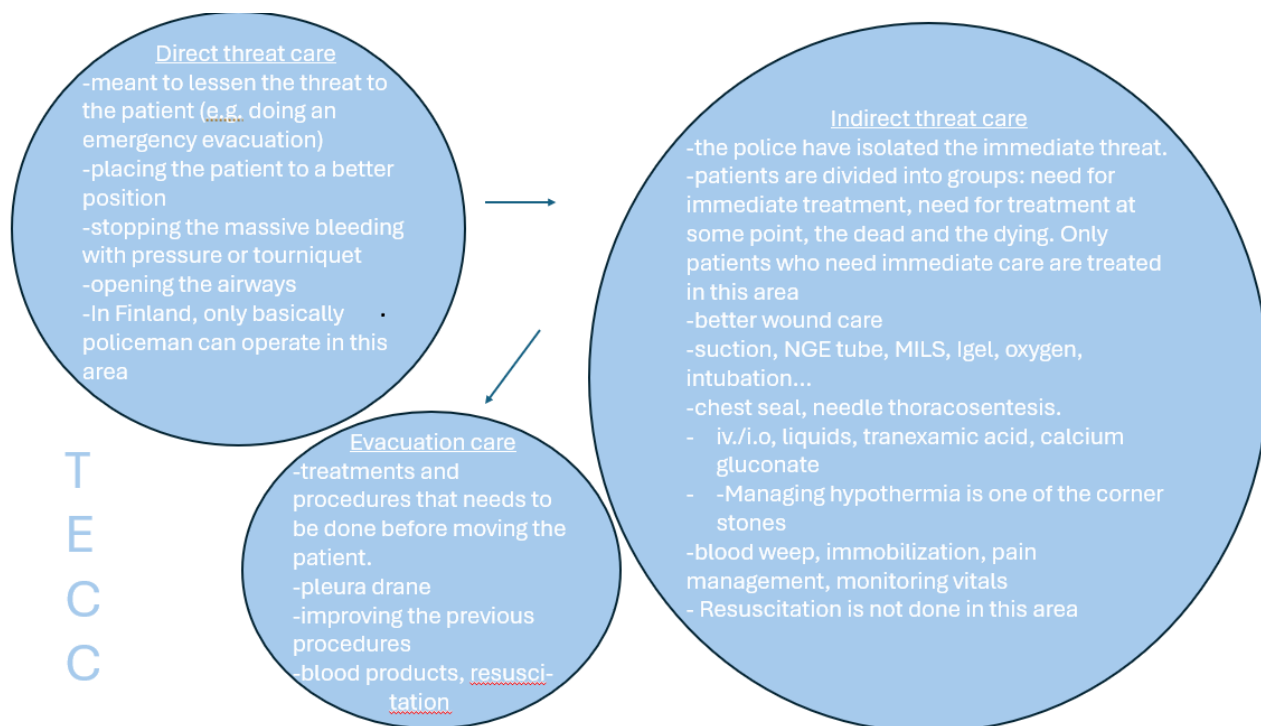


Figure 2. TECC

### 2.3 Initial assessment

As well as in any event, when examining a penetrating injury trauma patient, the initial assessment is very important. It is done rapidly and systematically. Ideally it takes only 30 seconds and no equipment is used. The main point is to stabilize the patient. Normally patient examination starts with an ABC assessment, airways, breathing and circulation. With trauma patient there is a “c” in the memory rule before the ABC, c standing for catastrophic bleeding. When going forward, you want to take care of each area before moving on to the next one. So first, we take care of the catastrophic bleeding, then the airways and so on. (Zane & Raja 2024.)

First, the catastrophic bleeding is taken care of. Usually with a CAT tourniquet on extremities, or with a pressure bandage like an Israeli bandage. A blood sweep to the patient is performed to find any other bleeds. Cavities are packed with a bandage, preferably a haemostatic gauze, and pressure is applied. Airways are secured next. This is basically done

with a jaw thrust and stabilizing the neck. Supraglottic airway may be necessary to keep the airway open. The goal is to establish an airway. (Zane & Raja 2024.)

If there are some major complications with breathing, these are taken care of in the initial assessment as well as for example tension pneumothorax or an open chest wound. Open chest wound is managed with a chest seal and tension pneumothorax is dealt with needle thoracocentesis. (Zane & Raja 2024.) Next on the list is circulation. In the initial assessment the main point is to establish whether the pulse is palpable. (Kuisma et al. 2021.)

In the initial assessment it is important to recognise the life-threatening conditions and act on those. When there no longer is an immediate threat to life, one can proceed to the systematic examination. (Zane & Raja 2024.)

## 2.4 Systematic examination

When the initial assessment is done and the immediate life-saving measures have been taken, systematic and more precise examinations come next. At this point the patient is ideally already being moved to the emergency vehicle. In trauma patients, this is done by backboard or with the scoop bar. If the patient is obviously load & go, (stab wound to the chest for example) time is not wasted on scoop bars or back boards, the patient is rapidly moved to the stretchers and into the ambulance. If there is a need for further immobilization, a vacuum mattress is a great device for trauma patients. The heat economy is important to consider as well. Space blankets and ready-heat blankets are efficient for maintaining the heat economy. (Parker & Magnusson 2016.)

Systematic examination includes the whole ABCDE -method. With penetrating wounds, time is of the essence. Stabilizing the patient's condition before starting transport is vital. If the patient is stable, more precise examination is performed on route. If not, it is done on scene. Stabbing wounds and gunshot wounds usually need surgical care, so there is not much a paramedic can do. The Load and Go -tactic is the best one, when the bleeding has been managed. Especially when the injury is on the torso, the load & go tactic is the one to use. (Parker & Magnusson 2016.)

**Airways:** Airway obstruction is always a medical emergency, that must be treated immediately. Loss of airways leads to hypoxia, which causes brain damage, liver damage, heart failure and ultimately death. Signs of airway obstruction are complete loss of breathing, paradoxical chest movements and use of the accessory muscles of breathing. In partial

obstructions air entry is laboured and noisy. The first step of airway management is physically inspecting and clearing the airway. This can be done by suctioning the airways and inserting an oropharyngeal or nasogastric tube. (Resuscitation council UK 2024.)

**Breathing:** Once the airway of the patient is secured, ensure breathing and oxygen levels (SpO<sub>2</sub>%). Record the patient's respiratory rate and get the SpO<sub>2</sub>% - reading with a pulse oximeter. In trauma patients with blood loss, respiratory rate is usually high and SpO<sub>2</sub>% dramatically lowered, due to loss of oxygen-carrying red blood cells. (Beckerman 2022.) Abnormal breathing sounds indicate ventilation issues. EtCo<sub>2</sub> reading, the carbon dioxide measured from the expiration point to the efficiency of the breathing. Pressured ventilation (CPAP) may be necessary. Supplemental oxygen is given with the appropriate mask and volume, based on initial findings. (Resuscitation council UK 2024.)

**Circulation:** The next step in the system is ensuring circulation. In traumatic injuries such as stabbings and gunshot wounds, hypovolemia is almost always present and a major risk factor. Locate all entry and exit wounds and stop the bleeding. After this is done the patient's blood pressure is measured and an intravenous cannula is inserted for fluid and medicine administration. Tranexamic acid is standard to be given to bleeding trauma patients. Start a bolus of crystalloid solution to improve circulation and heart rate. The aimed systolic blood pressure level for trauma patient is 100mmHg, but if the patient has multiple injuries, the level is 90mmHg. When presented with multiple injuries and a head trauma, the target level of the systolic pressure is 120mmHg. Inotropic medication, such as Noradrenalin infusion could be of use. In most traumatic bleeds the standard procedure is to stop the bleed and get the patient to hospital as fast as possible, so after the above-mentioned steps have been taken, transportation is started. (Resuscitation council UK 2024.)

**Disability:** This step focuses on the consciousness level of the patient. It is worthwhile to go through steps ABC again and then ascertain the consciousness level using the AVPU method. Is the patient Alert, responding to Verbal stimuli, responding to Pain or Unconscious. The Glasgow coma scale should be recorded for future reference for staff at the hospital. Blood sugar is measured at this point and the neurologic status is assessed using the FAST (face, arms, speech, time) exam. (Resuscitation council UK 2024.)

**Exposure:** This step focuses on examining the patient from head to toe for secondary injuries or other damage, check the skin for bruising, swelling or other signs of injury. Hypovolemia causes the body temperature to drop, so measuring the temperature is important. (Resuscitation council UK 2024.) A more precise blood sweep, using the RiVaLAiSeR -method can be performed again in the ambulance with better lighting. RiVaLAiSeR stands for Rinta

(chest), Vatsa (stomach), Lantio (pelvis), Aivot (brain), Selkä (back) and Raajat (extremities). So basically, it tells us in which order the body is checked for bleeding. First you start pressing on the chest area and then checking your gloves for blood. Then moving on to the stomach, pelvis, head, back and lastly the extremities. This is ideally done after cutting the clothes off. (Kuisma et al. 2021.)

## 2.5 Pain management

Pain management is important in all trauma cases. Pain relief medication and sedatives are considered based on patients' state. S-Ketamine is great for patients with low blood pressure and Midazolam is greatly used as a sedative. Fentanyl, Morphine and Oxycodone are also widely used in Finland. Efficient pain management lowers the blood pressure and heart rate decreasing the possible bleed. It also lowers the oxygen consumption. The fear of the adverse effects of pain medications cannot be in the way of proper pain management. (Björkman et al. 2023.)

### **3 The purpose of the thesis, aim and questions to be answered**

The purpose of this thesis is to prevent delayed treatments caused by penetrating wounds and prevent unnecessary deaths by improving the knowledge of the mechanisms of those. By listing the most common risks and medical conditions linked to penetrating wounds the hope is that this thesis serves as a useful guide to healthcare workers.

The aim of this thesis was to research and gather information related to gunshot and penetrating wound injuries and to compile a useful literature review on the subject. During the research for this thesis subject, the matter seemed interesting and a similar literature review, in English, could not be found in the databases searched. The aim is to educate as well as remind healthcare workers on the different mechanisms on penetrating wounds and the ways to start the initial treatment of those.

The questions answered in this thesis are:

1. How to recognise the injury mechanism of the patient?
2. How to treat the different types of piercing wounds in the field?
3. How to improve your patient's chances of survival?

## 4 Method

### 4.1 Literature review

The method of this thesis is literature review. This means compiling data regarding the topic and reviewing those. From this gathered information a compact informational package is written, especially for healthcare workers as a reminder on how to treat penetrating wounds. Furthermore, the aim is to gather and present new information to professionals and students and from there to improve the treatment of these types of wounds. (Grant & Booth 2008, 97.)

Traditional narrative literature review is a method in which a group of sources related to the same topic are gathered using the inclusion and exclusion criteria that has been selected. In narrative review the topic is recognised from the selected sources and then presented and interpreted from the point of view of the research questions. (Sukhera 2022.)

### 4.2 Data search and collection

The data for the review was compiled from academic sources, such as: Cochrane library, Cinahl, Pubmed and current care guidelines. For key concepts and medical information, topical books were used. As sources, Finnish-, and international sources were used. Different regions have varied guidelines on treatments, from these the most recent and well justified published data was selected.

Search words used were wounds, penetrating wounds, emergency care, gunshots, wound care, and stabbings. As an exclusion criterion no older than a decade old material regarding wound care and emergency protocols was used. The sources that managed our exclusion criteria's and were on point when regarding our topic were included. In total 10 articles were chosen.

Inclusion criteria	Exclusion criteria
Finnish or English Language	Language other than Finnish or English
Publication between 2014 - 2024	Publications before 2014
Free or accessible through LAB/LUT institutional logins publications or articles	Behind a paywall
Full text available	Only abstract or summary available
Peer reviewed	Non peer reviewed

Table 1. Exclusion and inclusion criteria

### 4.3 Analysis method

As an analysing method thematic analysis was chosen. Thematic analysis is a qualitative method of analysing data. It is widely used in different fields. It means that the data is read and analysed through the mindset of searching patterns and wanted themes regarding the research question. *“It is a method for identifying, analysing, organizing, describing and reporting themes found within a data set.”* (Braun & Clarke 2006, 77-101.) Based on this method answers to the research questions were searched.

First, chosen articles were briefly looked through and divided into groups based on their themes. The themes formulated from the article's main topics. After that the articles were analysed and further divided into groups based on the research questions. This helped analysing the results with the specific questions in mind. Below is a chart showing part of the analysis method.

Themes	Codes
Different types of penetrating wounds	<ul style="list-style-type: none"> <li>• Different kinds of sharp objects</li> <li>• Weapons and the damage they can make</li> <li>• Bullet types</li> </ul>

Recognising the injury mechanism	<ul style="list-style-type: none"> <li>• Distance affecting the force of the penetration</li> <li>• Speed and force</li> <li>• Kinetic force playing a role in the formation of the injury</li> </ul>
Treating wounds made with a sharp object or a bullet	<ul style="list-style-type: none"> <li>• First aid of penetrating wound</li> <li>• Transport being the key</li> <li>• Cavitation and wound packing</li> </ul>
Treatment based on the area of the injury	<ul style="list-style-type: none"> <li>• Head</li> <li>• Heart</li> <li>• Torso</li> <li>• Breathing</li> <li>• Extremities</li> </ul>

Table 2. Example of the analysis method

## 5 Data selection

Data selection for this traditional narrative literature review was done by using various sources. Search terms related to the thesis topic were used and the results were restricted based on the inclusion and exclusion criteria. Some search terms yielded results in various databases; in which case those were recorded to the table in order of appearance.

Database	Search terms used	Other search parameters	Search results	Articles selected for thesis
Pubmed	Paramedic AND stabbing	between 2014-2024, free full text available	3	0
Pubmed	paramedic AND gunshot	between 2014-2024, free full text available	5	1
Pubmed	Emergency care AND penetrating wound	between 2014-2024, free full text available	740	1
Pubmed	Penetrating wound AND treatment	between 2014-2024, free full	2145	2

		text available		
EBESCOhost	Wound care and penetrating injury	between 2014-2024, free full text available	6	1
CINAHL	Gunshot wounds AND emergency care	between 2014-2024, free full text available	11	1
CINAHL	Penetrating wound AND emergency care	between 2014-2024, free full text available	8	1
Duodecim	Ampumava-mmat	between 2014-2024, free full text available	14	1
NCBI	bleeding AND treatment AND trauma	between 2014-2024, free full	914	1

		text available		
Duodecim	Trauma- potilaan tutkiminen	between 2014- 2024, free full text available	3	1

## 6 Results

10 articles were selected for the thesis. Two of these dealt with the first research question: how to recognise the injury mechanism of the patient. To the second question: how to treat the different types of piercing wounds in the field 7 articles were found. How to improve your patients' chances of survival, the third research question, was answered in 2 articles. Some of the articles answered more than one of our questions.

### 6.1 How to recognise the injury mechanism

It is important to recognise the injury mechanism so the treatment can be as effective as possible. Understanding the ballistics of a gunshot wound is crucial. In the emergency care it is enough to know about the firearm type, whether it is a rifle or a handgun, when treating a gunshot victim. The bullets are different, so they inflict different kinds of damage. The bullets kinetic energy is depending on the weight and speed of the bullet. The higher the kinetic energy, the more it does tissue damage. If the bullet is structurally weak, it does more damage as it fractures into smaller pieces on impact. (Barner-Rasmussen et al. 2016.)

The bullet either crushes the tissue or expands it. Small energy bullet does more of a crush damage, and a larger bullet leaves an expanding tissue injury. The expanding tissue damage always creates a wound cavity, with negative pressure, which suctions small fragments into the wound, making it a dirty wound. The energy of the bullet drops correlating to the distance travelled. Although it is important to know the firearm and the distance from where the shot has been made, it is more crucial to understand that even one small kinetic energy wound is more damaging to a vital organ, than one or more large kinetic energy wounds to a non-crucial tissue. (Barner-Rasmussen et al. 2016.)

Other penetrating wound type is usually stabbings with a knife, pipe or other piercing sharp object. When thinking about this type of penetrating injury mechanism, it is important to inquire information about the blade. The size and shape have a big role regarding to the severity of the wound, as well as the energy of the stabbing. The location is as vital as the mechanism the injury was made with. (Springer et al. 2023.)

Paramedics can go a long way with just understanding that the larger the kinetic energy of the object the penetrating wound was made with, the more destruction it does. The distance, the objects size and weight, the speed and the location of the injury are the things that need to be acknowledged when treating a patient with a piercing wound. (Barner-Rasmussen et al. 2016.)

## 6.2 How to treat different types of piercing wounds in the field

### 6.2.1 Bleeding and extremity injuries

Uncontrolled post-traumatic bleeding is still the leading cause of potentially preventable death among injured patients (Ball 2015). First, assess the patient fully using the cABCDE – method. In the case of critical bleeding, which is usually present in the case of gunshot or stabbing wounds, the primary step taken is haemorrhage control. This is initially done by applying direct pressure to the wound by hand, with or without a bandage. While direct pressure can reduce or even temporarily stop bleeding, this alone is not sufficient. Tranexamic acid is administered to all bleeding trauma patients, starting with 1g infusion which can be administered again, if the first dose seems not to be sufficient. (Ball 2015.)

The next step is to pack the wound to start the coagulation process. This is done by inserting a haemostatic dressing (celox) into the wound cavity and dressing the area with a bandage. Giving the patient fluids, isotonic crystalloids such as Ringer is crucial also in a bleeding situation, to replace the lost blood volume and help uphold blood pressure. Inotropes (medications that affect the heart muscles contractions) can be used to maintain or elevate the blood pressure (Noradrenalin). Although it needs to be kept in mind that in bleeding trauma patients 70mmHg systolic pressure is sufficient, without a head trauma. Too high blood pressure can exacerbate the bleed. (Gurney et al. 2024.)

Blood products can also be necessary, especially when there is massive haemorrhage. Frozen plasma and red blood cells are the standard products, which in Finland are carried by separate emergency care doctor units, such as FinnHEMS. In some areas in Finland the field manager in primary care carries blood products as well. (Ångerman 2019, 200-205.)

For catastrophic bleeds in the extremities a tourniquet is effective for controlling the bleed. Tourniquets are applied above the wound, on the affected limb, and they work by cutting off circulation to the whole extremity. The time of application of the tourniquet must be recorded, as prolonged use of these devices (>2h) can lead to complications such as nerve damage, ischemia and blood clots. Hospital and surgical staff need to know how long a tourniquet has been on the patient, to help in decision making regarding advanced care in hospital. (Melendez-Lugo et al. 2020.)

### 6.2.2 Torso and chest injuries

When the injury has impacted the torso and chest area, it is a load and go situation. Stab wounds usually damage the liver, diaphragm, small bowel or the colon. The injury is low energy and causes tissue damage to the tract that has been in contact with the sharp object. Gunshot wounds can impact the small bowel, colon, liver or vascular structures. These are more severe cases, because of the high energy of the bullet. The affect is also usually more widespread. (Gurney et al. 2024.)

In penetrating torso injuries, fluids may not be necessary, so a clot dislodgment does not happen. Slight hypotension is more preferred in a situation like this. When the bleeding has been taken care of, the evaluation and treatment goes as in other trauma evaluation and treatment: ABCD. The background information that we are interested in is the type of the weapon, and the amount of the blood on the scene, as well as the timeline. If the injury is a gunshot wound, we are also interested in the number of shots and distance they have been shot from. (Krammel et al. 2024.)

While inspecting the patient, we need to search for the exit wounds. Complete removal of the clothes is necessary to see if there's "hidden" wounds as well. Stabbings can be through and through, as well as a gunshot wound, or the bullet can still be inside the patient. Gunshot wounds can have multiple exit wounds. When doing the inspection, the patients' temperature must be considered to prevent hypothermia. Warming blankets are good to maintain the optimal body temperature, as well as increasing the heat inside the ambulance. (Cakmak et al. 2022.)

The chest area wounds usually cause pneumothorax and / or tension pneumothorax. Haemothorax is also possible. These must be treated immediately. Keep an eye on dyspnoea, chest pain, tachypnoea, reduced breath sounds and deviation of the trachea. First aid treatment for tension pneumothorax is needle decompression, which is done between the second and the third rib. Pneumothorax can be treated with a chest seal. This lets the blood to come out but allows the oxygenation in the lung. Haemothorax and pneumothorax can situationally be managed with a thoracostomy out in the field. Chest tube is necessary as well usually in these situations. (Gurney et al. 2024.)

Supplemental oxygen is standard for low saturation values and to aid in laboured breathing. If this is not enough, in chest trauma patient's positive airway pressure is not ideal but can be exploited, especially if the patient has flail chest. If the patient is unconscious, endotracheal tube or Igel are used. If the breathing is non-existent, intubation is necessary. (Cakmak et al. 2022.)

Spine immobilization can do more harm than good. If there's back or neck pain related to the injury, or the NEXUS criteria is fulfilled, then it must be done. As previously stated, the wound is packed, and the bleeding stopped. The transportation cannot be delayed. Penetrating torso and abdominal traumas are always treated at the hospital, there is not much that can be done on the field without ultrasounds and imaging tools, such as CT scans. Often chest tubes, laparostomies and other invasive procedures are needed. The role of paramedics is to transport the patient to hospital, while upholding life supporting mechanisms. (Krammel et al. 2024.)

### 6.2.3 Cranial and spinal injuries

Penetrating injury to the head is one of the most severe and deadly areas of injury on the body. Penetrating head injury means an injury that penetrates the skull and reaches the brain matter. As the brain is the centre of nervous activity in the body, any injury to it will always induce major complications. Penetrating head trauma is the most lethal form of cranial injury, up to 70-90% of patients die on the way to hospital, and a further 50% of patients that reach the hospital die in the emergency department. (Titilola et al. 2024.)

After the initial assessment and securing of patient's airways, the paramedics must try to obtain as much information of the injury as possible. Time of injury, weapon or projectile type, neurologic symptoms (seizures, loss of consciousness) that might have occurred. Signs of intercranial pressure are critical to assess. Look for signs of cerebrospinal fluid, blood or brain parenchyma oozing from the wound, the ears, eyes or from the nose. Check the pupils for dilation and deviation. In the case of gunshot wounds, the entry and possible exit wound must be found. As projectiles can change direction on impact, the whole body should be inspected. For neurological status, perform the Glasgow Coma Scale evaluation. A GCS score of 8 or less is a significant indicator of decreased survivability and an indicator for intubation. (Melendez-Lugo et al. 2020.)

The main objective of pre-hospital care is resuscitation, wound management and prevention of further injuries. No surgery is / or should be performed in the ambulance. For example, any foreign object that may be stuck in the wound, should not be removed, but rather stabilized in place. For prevention of further brain injury, oxygenation, controlling intercranial pressure with proper blood pressure levels and with position therapy, elevation of the head of the bed >30 degrees. Mannitol is one option for a medication to lower the blood pressure, if the systolic pressure is more than 200mmHg. Avoiding hypotension is critical. As in most

cases involving penetrating injury, rapid transport to an advanced care facility is paramount. (Titilola et al. 2024.)

#### 6.2.4 Heart injuries

Half of all cardiac injury patients expire at the scene and further 30% die during transport. Statistically heart injuries are more likely resulted by stabbings than gunshot wounds. Severe shock, tamponade and right atrium issues are the most common outcomes from a cardiac injury. Sternotomy or thoracotomy in operating rooms are usually the treatments for severe cardiac injury, and these cannot be done in the field. (González-Hadad et al. 2021.)

Cardiac cases are treated in the ambulance the same as all trauma cases. The cABC first, and if there is time, the secondary assessment. When there is a hole in the chest, the wound is packed and then pressure is applied if there is an active bleed. Ventilation is taken care of and then circulation. What can be done, is open an intravenous line, or intraosseous line and administer fluids and inotropic agents such as Noradrenalin to maintain cardiac output. Ventilation with positive airway pressure should be delayed as long as possible and alternative airway management performed, since positive pressure decreases the venous return and can lead to tamponade or cardiac arrest. Supplemental oxygen with a mask is an option. (Lee et al. 2022.) Paramedics cannot do much about cardiac injuries. Rapid transport to a facility with heart and trauma surgeon and a comprehensive pre-arrival notification to the hospital are significant.

### 6.3 How to improve your patient's chances of survival

As often stated above, the key to improving outcomes of critically injured patients is management of life-threatening conditions and rapid transport to advanced care facilities. In the case of penetrating injuries, every minute spent on-scene correlates to about a 1% increase in mortality. Operating procedures and transport of patients is determined by the emergency call centre and chain of command, depending on various factors, such as severity of injuries and time of transport to hospital. In some cases, it is pertinent to use for example a medical helicopter instead of a ground ambulance unit. (Springer et al. 2023.) Following local operating procedures and a knowledge of care guidelines for various injury types is important to ensure the most effective care can be administered to patients. Always consult the emergency care doctor on duty and call additional units. This is standard procedure in all major trauma cases.

## 7 Discussion

This literature review is aimed mainly at paramedics and first responders, and students in this field. We wanted to review and compile a useful info package, for professionals and students to use and get up-to-date information on important lifesaving treatments on penetrating wounds. We reported the data on this thesis based on our wide research and personal experience. We ourselves learned a lot writing this and evaluating the articles, aiming for others to learn also.

Collecting the data and the search of the articles was quite difficult, since there are not many articles published on stabbings or gunshot wounds. Especially material in Finnish was minimal. This is most likely to the fact that shootings, other than self-inflicted are rare in Finland as well as stabbings, although those are more common. Material on treatment of gunshot wounds was more easily found in the international sources.

Sources on the injury mechanism theme were quite old. Physics have not changed, which is why we used a few older materials as sources regarding this theme. On the treatment part of this thesis, we were stricter about the publishing date of the article, due to rapid advancements in the health care field, where treatment guidelines change constantly.

As we were writing this thesis, it became even more clear that this is a current topic. During the year of 2024, there have been several shooting and stabbing incidents in Finland. To name a few; the Jokiranta school shooting, the shooting in Finnkino in central Helsinki, the shooting in Tampere city center and the two separate stabbings in Oulu on the 13<sup>th</sup> of June.

Moving on we think that health care professionals would benefit from training days focusing on gunshot wound treatments and how to deal with stab wounds. There are multi patient training days regarding mass shootings for paramedics, but not many focusing on single patient scenarios. Especially in areas where the distance to trauma centre is long, paramedics could benefit from these types of training days. In our opinion, the trauma education in paramedic program (AMK) is sufficient. Emphasizing on gunshot wound treatment in the future could be beneficial, as stated before, those incidents are increasing.

## 8 Ethics

As guidelines for ethical considerations in this literature review, the LAB University of Applied Sciences Thesis guidebook (1 September 2023) was used and the rectors conference of Finnish universities of applied sciences (Arene) document “Ethical recommendations for thesis writing at universities of applied sciences” released in 2020. TENK, The Finnish national board on research integrity’s guidelines were also used.

The trustworthiness and ethics of this thesis have been ensured by diligently researching and assessing the trustworthiness of the chosen referenced materials. As much current information as possible was used, and all information regarding treatment protocols is less than 10 years old. Some references regarding topics such as ballistics and injury mechanisms have not been updated for a long time, therefore materials on those topics are dated further back. To keep the sources reliable and understandable, both for us and the reader, Finnish and English language materials were the only ones used in the research.

The research was limited by a lack of available material on the topic and our lack of knowledge on the subject. However, while compiling this literature review and by using only reliable sources, these problems were minimized.

The main principles of TENK are accountability, reliability, honesty and respect. These were kept in mind while writing and searching for our articles. The chosen articles for this thesis were peer reviewed, to ensure accountability and respect. This helped to not rely only on our own inspection of the articles. For the chosen articles' honesty, we inspected the writers' sources and their origin. (TENK 2023.)

## 9 Conclusions

The thesis aims to expand awareness on shooting and stabbing incidents and treatment protocols for penetrating wounds. The focus is on adult patients leaving out special groups such as children and pregnant women. The chosen articles sufficiently answered the research questions. Most of them were not from the point of view of paramedics or emergency care done out in the field, which presented unique challenges.

This thesis is related to working life, as nurses and paramedics treat penetrating wounds as part of their jobs. As shootings and stabbings are becoming more common, understanding the mechanisms of those is relevant. A bullet wound might seem small, but the damage can be major. The bullet type determines whether it could have fragmented inside the body or remained intact. When it comes to stabbings, the force used in the penetration determines the damage and the depth, as well as the instruments size. (Northwestern medicine 2019.)

Part of the thesis was studying the injury mechanism and understanding the importance of what type of damage different kinds of bullets do, and what to consider when a patient has been stabbed. We emphasized the importance of the shooting distance and the force of impact. Different types of injury mechanisms leave different kinds of cavitation wounds and different numbers of exit wounds. Figuring out the caliber of the weapon gives an idea of how much damage there actually can be. Small caliber bullets with high speed have more kinetic energy than high caliber bullets with low velocity, for example. (Northwestern medicine 2019.)

The rest of the thesis covered the most common injuries in different areas of the body, and the first aid of those. Extremity bleeds should be dealt with a CAT tourniquet (Mendez-Lugo et al. 2020). Cavities should be packed with a hemostatic gauze (Zane & Raja 2024). Tranexamic acid is given to bleeding trauma patients (Ball 2015). Pressure bandages are used in areas where a CAT tourniquet is not helpful, such as in the neck, groin or torso area (Zane & Raja 2024). Fluids and inotropes are important to keep the blood pressure in desired level (Lee et al. 2022). Examining the breathing and opening the airways is the next vital thing to do after managing catastrophic bleeding (Resuscitation council UK 2024).

The main point in improving the chances of survival of the patient resulted from fast transport. Time is of the essence in trauma patients, therefore precious seconds are not wasted on scoop bars if the patients' spine and neck are not affected. Understanding the wound type and giving an efficient pre-arrival notification to the hospital resulted as being an improving factor as well. (Springer et al. 2023).

Considering future research, professionals in the healthcare field will benefit from more in-depth studies and articles regarding shooting and stab wounds. Information was rather difficult to find and very general in nature. Guidebooks and leaflets on these specific topics would be beneficial. Good theoretical knowledge remains the basis of all quality care. Furthermore, increasing the number of simulation-based training days with multi-professional co-operation will give everyone involved in saving human lives valuable knowledge and increase practical skills and confidence.

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## Appendix 1. Studies included in the literature review

Author, publication, year	Purpose of the study	Research design	Main results
<b>Ball, C. G.</b>  <b>Penetrating non-torso trauma: the head and the neck</b>  <b>2015</b>	The focus of this article is to deliver a concise and efficient diagnostic and initial management plan for patients with penetrating injuries to the head and neck.	Article.	Penetrating brain injuries are particularly lethal.  Airway management is critical,  Computer tomography is vital to assess damage within the skull.
<b>Ball, C. G.</b>  <b>Penetrating non-torso trauma: the extremities</b>  <b>2015</b>	To discuss and outline a logical and systematic approach to diagnosis and initial management of penetrating extremity trauma.	Article.	Treatment varies greatly depending on regional anatomy and clinical examination.  Immediate evaluation of the entire body is critical with patients who present with penetrating injuries.
<b>Barner-Rasmussen, I., Frisk, O., Handolin, L., Tukiainen, E.,</b>  <b>Ampumavammat</b>  <b>2016</b>	To give general knowledge of gunshot wounds and their effects	Review.	An understanding of ballistics is important for the treatment of gunshot wounds.  Most patients require surgery

			Gunshot wounds are always considered dirty wounds and must be treated as such.
<b>Cakmak, G., Cansun, F., Saracoglu, A., Saracoglu K.</b>  <b>Airway management in penetrating thoracic trauma.</b>  <b>2022</b>	To review and analyse thoracic injuries and their treatment protocols.	Article	Treatments vary largely based on extent of injury to the thoracic region.
<b>González-Hadad, A., Ordonez, C., Parra, M., Caicedo, Y., Padilla, N., Millán, M., García, A., Vidal-Carpio, J., Pino, L., Herrera, M., Quintero, L., Hernández, F., Flórez, G., Salcedo, A., Serna, J., Franco, M., Ferrada, R., Navsaria, P.</b>  <b>Damage control in penetrating cardiac trauma</b>  <b>2021</b>	To delineate experiences in surgical management of penetrating cardiac injuries and create a practical algorithm of principles of damage control surgery.	Synthesis of experiences.	Results vary based on findings in patients.  Comprehensive and efficient teamwork and communication between every party involved in care greatly improve outcomes.
<b>Gurney, O., Menaker, J.,</b>	To discuss the advances in patient	Article.	Penetrating torso trauma represents a

<p><b>Penetrating torso trauma</b></p> <p><b>2020</b></p>	<p>care regarding penetrating chest trauma</p>		<p>wide array of complex injury patterns, with many difficult therapeutic challenges</p> <p>Physicians need a clear and organized approach to identify patient's clinical needs.</p>
<p><b>Krammel, M., Frimmel, N., Hamp, T., Grassmann, D., Widhalm, H., Verdonck, P., Reisinger, C., Sulzgruber, C., Schnaubelt, S.</b></p> <p><b>Outcomes and potential for improvement in the pre-hospital treatment of penetrating chest injuries in a European metropolitan area: A retrospective analysis of 2009 - 2017</b></p> <p><b>2023</b></p>	<p>To look for data regarding penetrating chest trauma in high-resource settings in Austria. To benefit future training</p>	<p>Retrospective analysis</p>	<p>More education regarding the topic would be beneficial for paramedics and trauma surgeons</p>
<p><b>Lee, A., Hameed, S., Kaminsky, M., Ball, C.</b></p> <p><b>Penetrating cardiac trauma</b></p>	<p>To explore the comprehensive treatment of penetrating cardiac trauma</p>	<p>Article / Case study</p>	<p>Penetrating cardiac trauma presents complex challenges.</p>

2022			Experience and knowledge improve results in injury care
<p><b>Melendez-Lugo, J., Caicedo, Y., Guzmán-Rodriguez, M., Serna, J., Ordonez, J., Angamarca, E., García, A., Pino, L., Quintero, L., Parra, M., Ordonez, C.,</b></p> <p><b>Prehospital Damage Control: The Management of Volume, Temperature... and Bleeding!</b></p> <p>2020</p>	<p>To describe the pre-hospital attention principles regarding resuscitation and bleeding control.</p>	Article	<p>Early interventions without increasing transfer time to a hospital is critical to increase the success rate of saving patients.</p>
<p><b>Springer B, Repas S, Kretz E.</b></p> <p><b>EMS Trauma Stabilization and Transport: A Comprehensive Review.</b></p> <p>2023</p>	<p>A comprehensive review of the history and methods of emergency care transport</p>	Article / Review	<p>Expeditious treatment and rapid transport of trauma patients are of the highest priority for an EMS crew.</p>