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GUIDELINES FOR WOUND MANAGEMENT AND HEMORRHAGE CONTROL

Abstract

Anyone can find themselves in a situation requiring life-saving actions, and a rapid, appropriate response can save the injured person's life. Providing first aid is one of the key skills everyone should possess. Therefore, it is so important that as many people as possible know its principles and can respond effectively until qualified medical personnel arrive. The aim of this study is to present systematized, specialized knowledge of procedures for proper hemorrhage management in a first aid setting. a key element of this article is algorithms for managing bleeding, which facilitate identification of the injured person's condition, enable immediate implementation of appropriate actions, and organize the sequence of interventions. The article presents information on wound types, methods of management using both conventional and modern tactical dressings, and procedures in situations where specialized equipment is unavailable. The issue of protection against infectious materials during first aid is also addressed. The article is based on a review of literature on emergency and battlefield medicine, including current guidelines of the European Resuscitation Council (ERC, 2025) and Tactical Combat Casualty Care (TCCC), as well as the latest reports from the war in Ukraine.

Keywords

hemorrhage, hemorrhagic shock, bleeding control, tactical medicine, tourniquet

Introduction

Uncontrolled hemorrhage remains one of the leading causes of preventable death in both civilian and military trauma settings. Many deaths happen before the patient reaches the hospital, making early recognition and effective bleeding control a key factor for survival. Despite advances in emergency medicine, quickly identifying life-threatening bleeding and applying the right interventions remains difficult for both trained responders and ordinary bystanders.

Bleeding management depends on the situation. In civilian settings, care is typically guided by structured medical protocols. However, in tactical environments, intervention often must be performed under extreme conditions, such as limited supplies, ongoing danger, and delayed evacuation. These differences have led to the development of distinct approaches to hemorrhage control.

Recent years have seen a growing integration of battlefield medical experience into civilian trauma care, particularly in the area of rapid hemorrhage control. However, differences in training, access to equipment, and practical application of guidelines highlight the need for a clear and structured synthesis of current knowledge.

The aim of this review is to present a comprehensive overview of hemorrhage as a clinical and practical problem. It covers the types of wounds that cause severe bleeding, the underlying mechanisms of hemorrhagic shock, and current methods of bleeding control in both civilian and tactical settings. The review also seeks to organize existing approaches into a coherent framework that can support effective decision-making in high-stress, prehospital environments.

Methods

This narrative review is based on an analysis of international clinical guidelines, review articles, and original research concerning trauma care and combat casualty management. The search was conducted primarily within the 2015–2025 timeframe, using scientific databases such as PubMed and ScienceDirect, alongside official repositories of international medical organizations. Key search terms included "hemorrhage control", "tourniquet", "tactical medicine", and "hemorrhagic shock".

The review prioritizes the most recent recommendations from the European Resuscitation Council (ERC, 2025), the International Liaison Committee on Resuscitation (ILCOR), and the Tactical Combat Casualty Care (TCCC) guidelines. Sources were selected based on their scientific reliability and relevance to prehospital trauma care and hemorrhage control techniques. Due to the narrative nature of this study, a formal systematic meta-analysis protocol was not applied.

Wounds Classification and their Immediate Management

Understanding the mechanism and type of injury is essential for predicting its consequences, including the risk of hemorrhage. a wound is defined as a disruption in tissue continuity and may be classified according to multiple criteria. From the perspective of first aid and emergency medicine, the key division is based on the mechanism of formation and the extent of tissue damage:

Incised wounds

Incised wounds (vulnus scissum) are caused by a sharp object such as knives, glass, or sheet metal. They are characterized by smooth edges, often considerable bleeding (especially when larger vessels are involved), but a relatively small zone of tissue damage around the wound. The prognosis for healing is good, especially if hemorrhage is effectively controlled (Hotton et al., 2020, p. 409–410).

Immediate management:

- Scene Safety: Confirm that there is no further risk from a sharp object.
- Direct pressure: Apply firm, manual, and continuous pressure to the wound using sterile gauze or a clean cloth. If no medical supplies are available, use any clean fabric (e.g., a T-shirt).
- Wound Hygiene: Do not attempt to wash, disinfect, or irrigate the wound during active bleeding control, as this wastes critical time and may disrupt the clotting process.

- Elevation: if possible, raise the injured limb above the level of the heart to reduce the blood flow.
- Once bleeding slows, apply a firm bandage. Do not remove the first gauze if it is soaked. Add more layers on top. (Hotton et al., 2020, chap. 9)

Puncture Wounds

Puncture wounds (vulnus punctum) are caused by narrow, sharp objects like knives, nails, bayonets, or shrapnel fragments. Although the external skin opening is often small, these injuries pose a significant risk due to their depth and the potential for damage to deep structures such as major vessels, nerves, or internal organs. External bleeding may be minor, but there is a high risk of internal hemorrhage (Hotton et al., 2020, p. 409–410).

Immediate Management:

- Leave the object in place. Do not remove objects from the wound. It may be acting as a plug to stop deeper bleeding.
- Stabilization: Use thick dressings (e.g., roller bandages or towels) to immobilize the object and prevent movement.
- Indirect control: apply pressure around the object, not directly on it.
- Wound Hygiene: Do not flush or irrigate the puncture channel in the pre-hospital phase.
- Shock watch: watch for signs of internal bleeding (pale skin, weak pulse, altered mental status), even if the outside wound looks small (Hotton et al., 2020, chap. 9).

Lacerations

Lacerations (vulnus lacerum) are a result of blunt force trauma that tears tissues (e.g., crush injuries, bites, traffic accidents). They are characterized by irregular wound edges, devitalized tissue, and extensive soft-tissue destruction. These wounds are usually contaminated and bleeding, though often profuse, can be difficult to control due to the extent of the damage (Hotton et al., 2020, p. 409–410).

Immediate management:

- Basic Cleaning: remove loose, superficial debris. Do not try to clean the wound deep in the pre-hospital phase.
- Strong compression: Due to irregular edges, manual pressure must be firm and applied for at least 10 minutes. In the absence of bandages, use body weight to apply pressure through any available clean cloth.
- Wound packing: If the wound is deep, pack it tightly with gauze before applying a pressure bandage.
- Protection: cover the area with a clean, dry dressing after the bleeding is controlled (Hotton et al., 2020, chap. 9).

Gunshot wounds

Gunshot wounds (vulnus sclopetarium) are a wide, distinct category of wounds, particularly relevant in military and tactical medicine. Depending on the projectile characteristic, they may be perforating (with an entry and exit wound) or penetrating (with a retained bullet or fragment). The destructive effect depends on the projectile's kinetic energy. The injury zone is divided into the permanent cavity and the zone of secondary necrosis (tissue damaged from the shock wave). These wounds are frequently heavily contaminated, and accompanying vascular damage is often extensive, leading to massive hemorrhages (Stefanopoulos et al., 2025, p. 4).

Immediate Management (MARCH Protocol)

- MARCH Protocol Priority: Identify all wounds (entry and exit) and prioritize life-saving hemorrhage control over wound hygiene.
- Tourniquet: If the wound is on a limb and bleeding is massive, apply a tourniquet "high and tight.
- Improvisation: If no tourniquet is available, apply immediate and aggressive manual pressure with both hands directly on the bleeding site.
- Wound packing: for "junctional" wounds (groin, armpit, neck), pack the cavity with hemostatic gauze and press firmly for 3-5 minutes.
- Seal Chest wounds: if the wound is on the chest, use an airtight (occlusive) dressing to protect the lungs (Hotton et al., 2020, chap. 9).

Crush wounds

Crush wounds and traumatic amputation are a result of extreme mechanical forces such as industrial accidents, explosions, or the impact of heavy objects. They are characterized by complete tissue destruction, including bones and vessels. Bleeding from such a wound may paradoxically be less than from a clean arterial cut (due to crushed vessel walls), but the overall risk of hemorrhagic shock, crush syndrome, and subsequent organ failure remains extremely high (Osman et al., 2025).

Immediate Management:

- Immediate tourniquet: do not wait for massive bleeding. For amputations, apply a tourniquet above the injury site right away, even if the bleeding is not yet heavy.
- Improvised Tourniquet: If a commercial device is unavailable, use a wide strip of fabric (min. 5 cm) and a rigid windlass to create an improvised tourniquet. Do not use narrow wires or strings.
- Crush safety: if a limb has been trapped for more than 15 minutes, do not release it until medical teams are ready (due to the risk of "crush syndrome" toxins)
- Amputate part: wrap the severed limb in sterile gauze, place it in a plastic bag, and then put the bag on ice (avoid direct contact with water or ice)
- Heavy padding: Use large amounts of dressing material to cover crushed areas and maintain pressure (Hotton et al., 2020, chap. 9).

- Shock Evaluation: Systematically assess the patient's level of consciousness and radial pulse, as these patients are at extreme risk of rapid decompensation.

Regardless of the wound type, a key factor influencing further management is its degree of contamination. The presence of foreign bodies, soil, clothing fragments, and especially bacteria leads to the formation of a bacterial biofilm, which significantly hinders the healing process and poses a risk of systemic infection (Irizarry-Tardi et al., 2025, p. 1). Nevertheless, in the heat of the prehospital phase, especially during the initial management of severe trauma, cleaning the wound should not delay life-saving interventions. Both civilian and tactical guidelines are firm on this: stopping the bleed is always the priority. a rescuer's focus should remain entirely on direct pressure, wound packing, or tourniquet application until the hemorrhage is managed. Basic care, like clearing loose debris or applying a sterile cover, is only appropriate once the patient is stable and the bleeding has stopped. For those providing first aid, attempting to disinfect or deeply irrigate a wound is not recommended, as it wastes critical time that should be spent on hemorrhage control and rapid evacuation (ERC, 2025; TCCC, 2023; ZOSP RP, 2025).

Hemorrhage and Hemorrhagic Shock – pathophysiological aspects

Hemorrhage remains one of the leading preventable causes of death in both civilian trauma and combat-related injuries (ANZCOR, 2025; Charlton et al., 2020; Jarrassier et al., 2025, p. 2). The physiological response to blood loss is dynamic and primarily determined by the amount and rate of blood loss. As bleeding continues, it can result in hypovolemic (hemorrhagic) shock, a critical condition where the body tissues do not receive enough blood flow and oxygen delivery (TCCC, 2023, p. 10).

An average adult has a blood volume of around 5 litres. Even partial loss of this volume can initiate compensatory mechanisms aimed at maintaining perfusion of vital organs. When these mechanisms become insufficient, decompensation occurs, leading to systemic shock (TCCC, 2023, p. 12).

Types of Hemorrhage

There are two types of hemorrhage: arterial and venous. Each presents distinct characteristics, risks, and requires a different approach.

Arterial bleeding occurs when an artery, the vessel carrying oxygenated blood, is damaged.

- Flow characteristics: the blood flows in a strong, pulsating jet that synchronizes with the heartbeat. The color is bright red due to high oxygen saturation.
- Risk: Due to high internal pressure, this type of bleeding is the most life-threatening. It can lead to severe hemorrhagic shock and cardiac arrest within minutes if not controlled.
- Management. Apply firm, continuous direct pressure using sterile gauze. If ineffective, use a pressure dressing or a tourniquet for limb injuries. If no medical

supplies are available, use any clean fabric and apply maximum manual pressure using your body weight. Do not attempt to wash or disinfect the wound during active arterial bleeding, as the priority is immediate flow control.

Venous hemorrhage occurs when a vein, a vessel carrying oxygenated blood, is damaged.

- Flow characteristics: Blood flows steadily and uniformly, without the pulsating spurts seen in arterial injuries. The color is typically dark red.
- Risk: when the pressure is lower, damage to major veins (e.g., femoral or jugular) can still lead to rapid and fatal blood loss.
- Management. Direct manual pressure and pressure dressings are the primary treatments. Elevating the injured limb above the heart level can help reduce blood flow. If no medical supplies are available, use a clean cloth or clothing to maintain constant pressure for at least 10 minutes. Do not irrigate the wound during the acute phase to avoid disrupting the primary clot.

Pathophysiology of Hemorrhagic Shock

Hemorrhagic shock is a specific form of hypovolemic shock resulting directly from acute bleeding. Similar hemodynamic consequences may also arise from significant fluid loss due to burns, vomiting, diarrhea, or heat stroke. The core problem in hemorrhagic shock is reduced circulating blood volume, leading to decreased venous return, lowered cardiac output, and impaired tissue oxygenation (TCCC, 2023, p. 12).

One of the earliest physiological responses to blood loss is centralization of circulation. Blood flow is redirected toward vital organs such as the heart, lungs, and brain, at the expense of peripheral tissues. As a result, reduced perfusion of the skin, gastrointestinal tract, and skeletal muscles leads to observable clinical signs like pale, cold, and sweaty skin. These symptoms frequently appear before a drop in blood pressure and are crucial early indicators of shock (TCCC, 2023, p. 14).

Practical Patient Evaluation without Specialized Equipment

In scenarios where medical monitoring is unavailable, the rescuer must rely on rapid clinical markers to assess the severity of blood loss:

- Mental status: agitation, confusion, or lack of response to verbal commands are early indicators of cerebral hypoxia and severe internal bleeding.
- Radial Pulse: The presence or absence of a radial pulse (at the wrist) is a critical threshold. a palpable radial pulse generally correlates with a systolic blood pressure above 80–90 mmHg. Conversely, a weak, rapid, or absent radial pulse, especially when the carotid pulse remains present, is a definitive sign of decompensated shock.
- Skin and respiration: Pale, cool, and clammy skin, combined with a respiratory rate exceeding 30 breaths per minute, are definitive signs of the body's compensatory effort during massive hemorrhage.

Patient Evaluation in the field and Combat Medicine

Accurate estimation of blood loss outside a hospital or on the battlefield is often difficult. Visual assessment of external bleeding is unreliable, particularly in the presence of absorbent clothing, environmental contamination, or internal hemorrhage. For that reason, clinical evaluation of hemorrhagic shock depends on the patient's physical state, rather than absolute blood volume measurements (TCCC, 2023, p. 15).

In tactical and emergency medicine, attention should be paid to the following key indicators:

- level of consciousness
- Presence and quality of radial pulse
- Heart rate and its character
- Respiratory rate (Zachaj, Hajnus, 2025, p. 86; TCCC, 2024)

Mental status is a sensitive marker of cerebral perfusion. Altered mental status can indicate severe blood loss, lack of oxygen, or a combination of both. The radial pulse provides quick insight into blood pressure. If the radial pulse is palpable, systolic pressure is typically above 80-90 mmHg, while a missing radial pulse may indicate severe shock (TCCC, 2023, p. 14). Recent examinations of the conflict in Ukraine further emphasize that these pro-simple indicators remain the most reliable tools in high-stress tactical environments where advanced monitoring is unavailable (European Values Center for Security Policy, 2023).

Stages of Blood Loss and Associated Clinical Manifestations

To support decision-making, blood loss can be categorized into stages based on approximate volumes lost (TCCC, 2023; Szczeklik, 2025).

A loss of about 0,5 liters is usually well managed by a healthy person. Patients might show mild restlessness or anxiety. The radial pulse remains strong and palpable, with a normal or slightly increased heart rate. Respiratory rate is generally unaffected. Death is unlikely if hemorrhage is controlled.

With a loss of around 1 liter, patients remain conscious but agitated. a rapid heart rate over 100 beats per minute is common; the respiratory rate might be normal or mildly elevated. Even with these changes, the mortality rate is still low with proper care (Skallsjö et al., 2025, p. 7).

Blood loss of approximately 1,5 liters signals the beginning of system failure. Patients often exhibit significant anxiety and restlessness. The radial pulse is weak and hard to locate; the heart rate remains elevated above 100, and the respiratory rate increases to around 30 breaths per minute. While survival is still possible, the risk of rapid decline is high without rapid hemorrhage control and resuscitation.

A loss of about 2 liters can lead to severe hemorrhagic shock. Mental status commonly ranges from confusion to lethargy. The radial pulse may be barely detectable or absent. Tachycardia exceeds 120 beats per minute, and the respiratory rate is often over 35 breaths per minute. At this stage, the risk of death is high, even with medical intervention.

Blood loss of 2.5 liters or more may rapidly become fatal. Patients typically lose consciousness, exhibit profound tachycardia exceeding 140 beats per minute, and have severe breathing difficulty. The absence of a radial pulse indicates critically low blood pressure. Death in this stage is highly probable (TCCC, 2023, p. 12–14).

Practical implications

In high-pressure environments like combat or disasters, it is important to remember that a fast heart rate and rapid breathing can also be caused by physical exertion or extreme psychological stress. These signs should always be assessed alongside the patient's mental status and the quality of their pulse (TCCC, 2023, p. 14). Early recognition of hemorrhagic shock and swift control of bleeding remain fundamental to improving survival outcomes (TCCC, 2023, p. 16).

Nosebleeds (Epistaxis) and Their Immediate Management

Epistaxis is a common form of hemorrhage in civilian settings. It often requires immediate first aid to prevent blood aspiration or airway obstruction. It is usually not fatal, but it is worth knowing how to manage it effectively.

Immediate Management

- Posture: The patient should sit upright, leaning slightly forward. This position prevents the blood from flowing into the throat, which may cause nausea or irritate the airway.
- Direct compression: Firm and continuous pressure should be applied by pinching the soft part of the nose (the nostrils).
- Duration: Compression should be maintained without interruption for at least 10-15 minutes.
- Improvisation. If no medical supplies are available, the patient or rescuer should use any clean cloth or tissue to absorb the blood while applying pressure.
- Wound hygiene: do not irrigate the nasal cavity or pack the nostrils with absorbent material, such as loose cotton wool, as this may disrupt the primary clot upon removal.
- Escalation: If bleeding persists after 20 minutes of uninterrupted pressure or occurs after a significant head injury, emergency medical services (EMS) should be contacted immediately. (Trentzsch et al., 2025, p. 92)

Massive Hemorrhage in Tactical Medicine

Uncontrolled Hemorrhage remains the most important preventable cause of death in modern battlefield and other combat environments. Analyses of casualties from recent conflicts, including Iraq, Afghanistan, and the ongoing war in Ukraine, consistently show that a significant number of casualties occur in the pre-hospital phase, before the injured individual reaches advanced medical care (Zachaj, Hajnus, 2025; Skalski et al., 2024). In a large proportion of these cases, death results from rapid blood loss, particularly from extremity wounds (TCCC, 2023; Trentzsch et al., 2025). These findings have led to a fundamental shift in tactical medicine doctrine, prioritizing immediate hemorrhage control as the first step in the management of combat casualties.

This principle is reflected in the MARCH algorithm (Massive hemorrhage, Airway, Respiration, Circulation, Head Injury/Hypothermia), which deliberately prioritizes control of life-threatening bleeding over airway management and other resuscitative interventions (ERC, 2025; TCCC, 2023). The rationale for this prioritization is that severe external bleeding may lead to death within minutes, whereas airway compromise or respiratory failure often develops over a comparatively longer period, allowing slightly more time for intervention (ERC, 2025; TCCC, 2023, p. 8).

Tactical Combat Casualty Care guidelines further divide battlefield medical response into three operational phases: care under fire (CUF), Tactical Field Care (TFC), and Tactical Evacuation Care (TACEVAC) (TCCC, 2023, p. 6). During the Care under Fire phase, when both the casualty and the responder remain exposed to hostile fire, medical interventions must be limited to the most essential measures. The primary medical intervention recommended is the rapid application of a tourniquet to control life-threatening extremity hemorrhage. In this setting, treatment priorities are influenced not only by medical factors but also by ongoing tactical threats, limited resources, and environmental conditions.

During the subsequent Tactical Field Care phase, when the casualty and rescuer are no longer under direct hostile fire, a more comprehensive assessment can be performed. At this stage, previously applied tourniquets should be reassessed, and additional hemorrhage control may be implemented. These include wound packing using hemostatic dressings, the application of pressure bandages, and the elevation of potential bleeding from junctional areas that cannot be managed with conventional tourniquets (ANZCOR, 2025; TCCC, 2023). Current evidence-based guidelines emphasize that if a tourniquet is applied during the CUF phase, it must be checked for effectiveness (by assessing distal pulse absence) and, if possible, replaced with less restrictive methods if the situation and wound type allow (Trentzsch et al., 2025; Djarv et al., 2025). Additional adjunctive methods, such as junctional tourniquets or mechanical wound closure devices, may also be considered depending on the location and severity of the wound. These advanced tools are particularly vital when standard limb tourniquets are ineffective or cannot be applied due to the injury's proximal location (Day, 2016, p. 46).

Recent experiences from the war in Ukraine have further confirmed the effectiveness of systematic hemorrhage control training and the routine distribution of tourniquets to combat personnel. Evidence suggests that early self-application or buddy-application of tourniquets has significantly reduced mortality from extremity hemorrhage in frontline conditions (Zachaj, Hajnus, 2025; Skalski et al., 2024). Data from the ongoing conflict emphasize that the availability of high-quality, certified tourniquets and the muscle memory developed through repetitive training are the most critical factors in surviving massive limb trauma (TCCC, 2023; Zachaj, Hajnus, 2025). These findings show the importance of integrating standardized tactical medical protocols with appropriate equipment and systematic training programs. Together, these elements form the foundation for improving survival outcomes among casualties in contemporary combat operations.

Methods of External Hemorrhage Control – Review and Hierarchy

The modern approach to external hemorrhage control is based on a simple hierarchy of actions. In battlefield conditions, it was formalized in the MARCH algorithm (Massive hemorrhage, Airway, Respiration, Circulation, Head Injury/Hypothermia), which focuses on the most immediate life-threatening conditions (TCCC, 2023; Bento, 2025, pp. 5, 7). Similarly, civilian ERC, 2025 guidelines emphasize a sequential approach, often referred to as the "hemostatic ladder," starting with the simplest, least invasive methods and progressing to more advanced ones if the initial steps are ineffective (ERC, 2025; Djarv et al., 2025).

Direct Pressure and Simple Dressings

In civilian first aid, bystanders must act quickly and follow a well-defined approach suited to the situation. Before addressing the wound, the rescuer should make a rapid basic assessment. The main steps include:

1. Scene Safety: The rescuer must first confirm that the environment is safe for both themselves and the injured person before proceeding.
2. Initial Assessment and Pulse Check: Check consciousness by gently shaking the victim's shoulders and asking loudly: "Are you okay?" This tests both sound and touch reactions. If there is no response, the person is considered unconscious. Next, assess the pulse. Use the radial artery (wrist) in conscious patients, or the carotid artery (neck) in unconscious patients, to quickly evaluate circulation and the severity of blood loss.
3. Call for help: Emergency medical services (EMS) should be called immediately.
4. Immediate Bleeding control: If a massive, life-threatening hemorrhage is obvious, address it even before a full assessment.

When the assessment is complete, the main rule is to act quickly with what is at hand. The rescuer should apply constant, direct pressure to the wound. This can be done with hands, clothing, or any nearby absorbent material. Pressure should be applied for at least 10 minutes to allow the body's natural clotting mechanisms to work effectively (ZOSP RP, 2025). In cases of simple bleeding, this method may be effective and sufficient.

Specialized devices like tourniquets are preferable. If they are unavailable, use any item to apply pressure – do not wait to start manual compression. Campaigns such as "Stop the Bleed" show that people without medical training can stop life-threatening bleeding.(ERC, 2025; ZOSP RP, 2025; TCCC, 2023).

In civilian settings, direct pressure is considered the gold standard for most external bleeds and should be attempted before moving to more restrictive measures (ANZCOR, 2025). However, the military approach (TCCC) often bypasses this step for life-threatening limb hemorrhage. While a civilian rescuer is encouraged to start with pressure, a tactical responder in a "Care Under Fire" scenario will immediately apply a tourniquet, as the tactical environment makes maintaining 10 minutes of manual pressure impossible and dangerous (TCCC, 2023; Zachaj, Hajnus, 2025).

Hemostatic Dressings

When direct pressure is ineffective, and the hemorrhage originates from a wound where a tourniquet cannot be applied (e.g., the neck, groin, or junctional areas), hemostatic dressings are used (ANZCOR, 2025). Their role is to accelerate the clotting process through active ingredients (e.g., chitosan, mineral zeolites, kaolin) (ZOSP RP, 2025). The method involves tightly packing the wound with the dressing, followed by applying pressure for a specified time (TCCC, 2023; Djarv et al., 2025). Several studies have demonstrated their effectiveness in controlling hemorrhages in junctional zones where tourniquets cannot be placed. The 2025 ILCOR guidelines recommend their use as an option for uncontrollable hemorrhages unresponsive to simple pressure (Djarv et al., 2025).

Tourniquets

Tourniquets are the gold standard for controlling massive hemorrhages. Its operating principle is simple – circumferential compression of the limb, with sufficient force to occlude the arterial lumen and stop all blood flow distal to the application site (TCCC, 2023; Djarv et al., 2025). Current guidelines are clear and consistent:

When to apply? Immediately, in the case of massive, life-threatening hemorrhage from a limb, especially in tactical conditions (battlefield, mass casualty incident), the priority is set on rapid cessation of blood loss (Zachaj, Hajnus, 2025; European Values Center for Security Policy, 2023).

How to apply? In the Care Under Fire (CUF) phase, the tourniquet is applied "high and tight" – meaning as high as possible on the limb, above the wound, and tightened until bleeding stops. In battlefield conditions, time is not wasted on precise placement a few centimeters above the wound. Speed and responder safety are the priority (TCCC, 2023, p. 11; Skalski et al., 2024). Modern tourniquets (e.g., Combat Application Tourniquet – CAT, SOF, Tactical Tourniquet – SOFTT) are designed for one-handed application (including self-application).

When to apply a targeted tourniquet: in conditions where time and tactical situation permit (e.g., in the Tactical Field Care – TFC zone), the goal is to place the tourniquet approximately 5-7 cm above the wound, avoiding joints, to increase effectiveness and minimize tissue damage (TCCC, 2023; ERC, 2025). Dedicated devices for specific areas are also used, such as the JETT (junctional emergency treatment tool) for controlling hemorrhages from the groin or axilla (Day, 2016, p. 47).

Risk and conversion: prolonged (over 2 hours) tourniquet use carries the risk of ischemia and nerve and muscle damage. Therefore, as soon as possible (after hemorrhage control and in hospital or pre-hospital settings with long transport times), conversion of the tourniquet to a hemostatic dressing or another less invasive method should be attempted. However, the conversion procedure carries a risk of re-bleeding and requires experience and access to hemostatic agents (TCCC, 2023; Zachaj, Hajnus, 2025).

Experiences from Ukraine confirm that equipping soldiers with tourniquets and training them in their use (as part of basic and advanced courses) has significantly reduced mortality from hemorrhages (European Values Center for Security Policy, 2023; Zachaj, Hajnus, 2025; Skalski et al., 2024).

Devices Aiding Hemorrhage Control

Recent technological developments have introduced several devices designed to assist in hemorrhage control. An example is the ITClamp – a device that mechanically closes wound edges, creating a temporary cavity where blood accumulates, and rapid clot formation occurs. According to the International Legion Medical Service document, its use is recommended at an advanced (JCM) level (Day, 2016; Zachaj, Hajnus, 2025). Another example is the Combat Ready Clamp (CRoC), which provides direct pressure over a junctional wound. Its effectiveness was demonstrated in a swine model of a femoral artery injury, where, after application, no arterial flow was visible distal to the device on Doppler and computerized tomography (Day, 2016, p. 46).

Limitations of Current Hemorrhage Control – Review and Hierarchy

Despite significant progress in trauma care and widespread adoption of standardized hemorrhage protocols, several limitations continue to influence patient outcomes. Although modern guidelines emphasize rapid control of bleeding through direct pressure, hemostatic dressings, and tourniquets, realworld conditions often reduce the effectiveness of these interventions (ERC, 2025; ANZCOR, 2025).

Early recognition of lifethreatening bleeding remains a fundamental challenge in prehospital settings, where rescuers rely on clinical signs rather than advanced monitoring (ERC, 2025; ZOSP RP, 2025). Visual estimation of blood loss is highly inaccurate, especially when bleeding is obscured by clothing, equipment, or poor visibility. Internal bleeding in the abdomen, chest, or pelvis may remain unnoticed until advanced stages of hypovolemic shock, leading to underestimation of injury severity (Djarv et al., 2025; TCCC, 2023, p. 14).

Proper execution of bleeding control techniques also poses challenges. Although tourniquet use and wound packing are conceptually simple, they require appropriate training and repeated practice. Incorrect tourniquet placement, insufficient tightening, or delayed application significantly reduce effectiveness (TCCC, 2023, p. 14; Zachaj, Hajnus, 2025). In civilian settings, bystanders may be reluctant to use aggressive bleeding control measures out of fear of causing harm. Initiatives such as *Stop the Bleed* have sought to address this, but implementation remains uneven (ZOSP RP, 2025; Djarv et al., 2025).

Tourniquets, while considered the gold standard for massive limb hemorrhage, carry physiological drawbacks. Prolonged application may lead to ischemic damage, compartment syndrome, and permanent limb injury (TCCC, 2023; Day, 2016, p. 46). Current recommendations emphasize minimizing tourniquet duration when possible (Djarv et al., 2025; Trentzsch et al., 2025), though this may not be feasible during prolonged evacuation in remote or military settings. Furthermore, tourniquets are ineffective in junctional areas such as the groin, axilla, and neck (Day, 2016, p. 46; TCCC, 2023).

To address these anatomical limitations, modern trauma care incorporates hemostatic dressings and junctional devices. Although successful in controlled trials, their realworld use may be complicated by wound complexity, contamination, and limited visibility. Deep wounds may require extensive packing, and hemostatic agents must directly contact the bleeding surface to be effective (Djarv et al., 2025).

Environmental and operational factors impose substantial limitations in tactical settings. During the Care Under Fire phase, interventions are often limited to rapid tourniquet application, with priority given to tactical safety and casualty extraction (TCCC, 2023). Comprehensive assessment and advanced bleeding control may be delayed until a safer area is reached. Similar challenges exist in civilian masscasualty incidents, natural disasters, and remote environments.

Another important limitation involves traumainduced coagulopathy. Major bleeding often coincides with hypothermia, acidosis, and coagulation disorders—collectively termed the “lethal triad of trauma”—which impair the body’s ability to form stable clots and may reduce the effectiveness of mechanical hemorrhage control (ERC, 2025; Djarv et al., 2025). In such cases, local control must be supplemented with systemic interventions such as fluid resuscitation and tranexamic acid, which are often unavailable in the early prehospital phase.

Finally, training, equipment availability, and systemlevel factors continue to influence success. Although many military and emergency medical systems have incorporated bleeding control instruction into curricula, gaps in resource distribution and readiness persist (Skalski et al., 2024, p. 96). Experiences from recent conflicts, including the war in Ukraine, highlight that widespread distribution of tourniquets and systematic training significantly improve survival, though these measures require coordinated implementation and ongoing reinforcement (European Values Center for Security Policy, 2023; Zachaj, Hajnus, 2025).

In summary, while contemporary hemorrhage control strategies have significantly improved survival, their effectiveness remains limited by challenges related to early recognition, anatomical constraints, operational conditions, traumainduced coagulopathy, and variability in training and resources.

Future Directions in Hemorrhage Control

Uncontrolled bleeding remains a significant cause of preventable mortality worldwide, driving current research to improve both the effectiveness and accessibility of hemorrhage control strategies, particularly in prehospital and austere environments (Djarv et al., 2025; ANZCOR, 2025).

Advancements in hemostatic materials and wound dressings represent a key area of development. Modern products based on kaolin or chitosan have demonstrated superior clotpromoting properties compared with traditional gauze (Day, 2016; Djarv et al., 2025). Ongoing research focuses on improving blood absorption, activating the clotting cascade, and enhancing efficacy in contaminated wounds, while maintaining biocompatibility and minimizing tissue damage (ANZCOR, 2025; Djarv et al., 2025).

The development of advanced mechanical devices for hemorrhage control is another promising direction, particularly in junctional areas where traditional tourniquets cannot be applied (Trentzsch et al., 2025, p. 12). Junctional tourniquets and mechanical wound closure systems have shown promise, though further improvements are needed to facilitate broader adoption.

Technological innovation also includes automated or assisted hemorrhage control systems. Pneumatic or CO_2powered tourniquets provide more consistent compression than manually applied devices and may reduce the risk of incorrect application, particularly among less experienced users (Trentzsch et al., 2025, p. 14). Future devices may incorporate feedback mechanisms to verify adequate pressure for arterial flow cessation (Trentzsch et al., 2025, p. 15).

Pharmacology represents another important area. Early administration of tranexamic acid (TXA) has been incorporated into many trauma protocols following studies demonstrating reduced mortality when given within the first hours after injury (Center for Army Lessons Learned, 2025, p. 12). Current research focuses on optimal dosing, alternative routes of administration, and integration of antifibrinolytic therapy into earlier prehospital care (AHA, 2025, p. e15).

Systemlevel improvements in training and preparedness are also essential. Programs such as *Stop the Bleed* have demonstrated that basic hemorrhage control skills can be successfully taught to the general public (ZOSP RP, 2025, p. 12). Expanding these initiatives and ensuring widespread availability of bleeding control kits in public spaces may substantially improve survival in civilian trauma (ILCOR, 2025, p. 1112).

Recent experiences from modern armed conflicts highlight the importance of integrating military medicine lessons into civilian trauma systems. Techniques such as rapid tourniquet application, wound packing with hemostatic dressings, and structured tactical casualty care have already influenced emergency medical services worldwide (TCCC, 2023, p. 1215). Continued cooperation between military and civilian research communities will likely support further advances (Zachaj, Hajnus, 2025, p. 8688).

Finally, the future of hemorrhage management may increasingly rely on technologysupported clinical decision making. Wearable monitors, portable ultrasound, and artificial intelligencebased tools may allow earlier identification of severe bleeding and shock in prehospital environments (Palmer, 2022).

Although current hemorrhage control strategies have significantly improved trauma survival, further progress is needed to address existing limitations. Future advances in hemostatic biomaterials, mechanical devices, and early pharmacological interventions, integrated into both civilian and tactical medical systems, have the potential to further reduce preventable deaths from traumatic bleeding (ILCOR, 2025, p. 1820; ERC, 2025, p. 42).

Conclusion

External hemorrhage remains a major cause of preventable death in both civilian trauma and military medicine. This review confirms that effective management rests on three most important pillars: rapid recognition, decisive action, and knowledge of the method hierarchy.

- Recognition: It is a crucial ability to be able to recognize hemorrhagic shock using simple clinical signs like mental status, radial pulse, and respiratory rate, rather than laboratory tests (TCCC, 2023, p. 8). It should be noted that tachycardia and tachypnea can be symptoms of stress, but in combination with altered mental status, they are an alarm signal.
- Action: the sequence of actions in case of massive hemorrhage must be automatic, rapid, and well-practiced. For limbs, tourniquets should be used “high and tight” (TCCC, 2023, p. 22). For wounds in junctional zones, wounds should be packed with a hemostatic dressing and pressure (Zachaj, Hajnus, 2025, p. 87). These interventions, according to the MARCH algorithm, therefore represent essential components of training programs for personnel at risk of traumatic injury (Zachaj, Hajnus, 2025). Practical experience from recent high-intensity conflicts further emphasizes that proficiency in these life-saving techniques is the most critical factor in reducing preventable combat deaths (Víchová et al., 2023, p. 14).
- Training and equipment. Experiences from armed conflicts prove that it is not enough to merely equip services with modern gear (tourniquets, hemostatic dressings, ITClamp). Systematic, repeated training is crucial to overcoming the natural barrier of stress and developing ingrained habits. It is necessary to differentiate training levels – basic (for all personnel) and advanced (for designated medics and personnel), according to the model proposed by the Ukrainian side (Víchová et al., 2023, p. 15). Integration of these military-proven training standards into civilian emergency systems is key to increasing the effectiveness of life-saving interventions in mass casualty incidents (Zachaj, Hajnus, 2025, p. 89).

In conclusion, the fight against hemorrhage is a race against time. Knowledge of pathophysiology, wound types, and hemorrhage control methods, supported by practical skills, is the most effective weapon in the hands of any rescuer, whether they operate in an ambulance, on the battlefield, or at the scene of a traffic accident.

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