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The Role of the Anesthetist in Combat Trauma Surgery: A Thematic Literature Review

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Abstract:

Combat anesthesia is a vital subspecialty that integrates anesthesiology, trauma care and resuscitation in war zones. Anesthetists in these environments face challenges such as austere conditions, poly trauma, limited resources and urgent decision making. The field has evolved from basic pain relief to advance strategies like damage control anesthesia, permissive hypotension and regional blocks. Their role now extends beyond the Operating room to include triage, resuscitation, and care during evacuation. Guided by Tactical Combat Causality Care (TCCC), combat anesthesia emphasizes early intervention, rapid stabilization and seamless evacuation-making anesthesia essential in the continuum of battlefield care.

Combat anesthesia is a highly specialized discipline of anesthesiology that addresses the needs of wounded soldiers and civilians in war zones and military operations. Unlike elective procedures in controlled civilian hospitals, combat anesthesia is delivered under conditions of unpredictability, limited resources, hostile environments, and constant risk of further attacks. The anesthetist in these situations is not merely a perioperative physician but a resuscitationist, intensivist, and trauma manager, often forced to improvise with whatever supplies are available.

Combat anesthesia must adapt to geographical extremes—from deserts of the Middle East to mountainous terrain in Afghanistan, from naval operations at sea to jungle conflicts. These settings not only limit mobility but also affect patient physiology (e.g., altitude-related hypoxia, heat stress, or hypothermia). Evacuation routes may involve helicopters, armored vehicles, or naval vessels, each posing additional challenges to maintaining airway control, ventilation, and analgesia.

The foremost challenge is the austere environment in which care must be provided. Makeshift operating theaters, tent hospitals, or even open fields replace sterile operating rooms. Electricity, oxygen, blood products, and advanced monitors may not be available. Anesthetists are required to make rapid, life-or-

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death decisions with minimal resources. Psychological stress, long working hours, and the constant threat of enemy action further compound the difficulties. Moreover, evacuation chains may be disrupted, meaning the anesthetist may need to manage critically injured patients for prolonged periods without reinforcements.

The injuries encountered in combat are different in both mechanism and severity compared to civilian trauma. High-velocity gunshot wounds, blast injuries from improvised explosive devices, shrapnel injuries, polytrauma, traumatic amputations, burns, and crush injuries are common. Many patients present with combined injuries involving the head, chest, abdomen, and limbs, alongside massive blood loss. This complex injury profile necessitates rapid anesthesia induction techniques, hemodynamic stabilization, and advanced pain control methods tailored to fragile physiology.

The concept of the "Golden Hour" emphasizes that survival is heavily time-dependent. Delays in bleeding control or airway stabilization significantly reduce the chances of survival. Combat anesthetists, therefore, play a pivotal role in damage-control resuscitation, focusing first on physiology—stopping hemorrhage, ensuring oxygenation, preventing hypothermia—before definitive surgical repair. Every minute saved through rapid triage, stabilization, and evacuation improves outcomes.

Historically, pain relief in wars was limited to morphine injections. Over the decades, lessons from World War II, Vietnam, Iraq, and Afghanistan transformed practice. Modern combat anesthesia employs ketamine [13] as the preferred induction and analgesic agent in shock, regional anesthesia to reduce opioid burden, balanced transfusion strategies with whole blood, ultrasound-guided interventions, and damage-control anesthesia (DCA)[14] focused on maintaining perfusion rather than depth of anesthesia. NATO and allied forces have formalized these lessons into Tactical Combat Casualty Care (TCCC) guidelines.

Initial Stabilization begins at the point of injury using the ABCDE framework:

- Airway: Securing patency, often with surgical cricothyrotomy in maxillofacial trauma.
- Breathing: needle decompression or chest seals for pneumothorax.
- Circulation: Immediate hemorrhage control with tourniquets, hemostatic dressings, and permissive hypotension.
- Disability: Rapid neurological assessment (GCS).
- Exposure: Complete examination while preventing hypothermia.

This primary survey identifies and treats life-threatening injuries immediately, followed by a secondary survey to assess hidden or less urgent injuries. Triage remains an essential principle when dealing with

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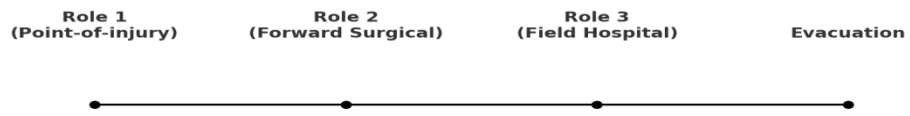
multiple casualties. Patients are categorized into immediate, delayed, minimal, or expectant based on survivability and urgency of intervention. The anesthetist is often a key triage officer, balancing the ethical burden of resource allocation with clinical judgment. This ensures that scarce supplies—blood, ventilators, surgical time—are directed to those most likely to survive.

In summary, combat anesthesia represents the convergence of anesthesia, trauma surgery, and intensive care medicine under some of the most hostile and resource-limited conditions. It has evolved into a physiology-driven discipline that prioritizes life-saving interventions, rapid stabilization, and safe evacuation. From initial triage to advanced resuscitation, the combat anesthetist is indispensable in ensuring survival and maintaining the chain of care from the battlefield to definitive hospitals.

Combat medical support is divided into rising tiers known as "Roles of Care," each of which outlines the breadth of clinical intervention, available resources, and the anesthetist's duties. This structured method ensures that the level of medical complexity gradually increases as wounded are evacuated from the battlefield to increasingly advanced hospitals (Figure 1).

Figure 1: A schematic of the *Roles of Care* (Role 1 → Role 2 → Role 3 → Evacuation) applying techniques to the operational context

Figure 1: Escalating Roles of Care in Combat Medicine



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Role 1 which corresponds to the point of injury and thus the inclusion of frontline care, which is often provided by combat medics or The First responders. The focus is on urgent life-saving procedures including but not limited to bleeding control, airway support, and quick evacuation, guided by Tactical Combat Casualty Care (TCCC) protocols[1]. TCCC has increased survivability in recent conflicts by standardizing procedures such as tourniquet application, needle decompression, and shock-safe analgesia (ketamine favored over morphine in unstable patients) [1, 2]

Role 2 facilities involve the Forward Surgical Teams (FSTs) which aim to provide additional capabilities for damage control resuscitation and limited surgery. At this echelon, anesthetists take on leadership roles in stabilizing physiology, including managing hemorrhagic shock, securing high-risk ("shock-safe") airways, and providing anesthesia for urgent damage-control surgery (DCS). Their work connects the tactical environment to definitive treatment, ensuring that wounded live long enough for higher-level operations.

Role 3 symbolizes a fully equipped combat support hospital with staff and resources to deliver definitive surgical procedures, advanced diagnostics, blood banking, ventilator support, and critical care. By this point, anesthetists are actively involved in trauma anesthesia, critical care management, and complex pain techniques. Patients are prepared for aeromedical evacuation, which requires secure airway care, sedation, analgesia, and hemodynamic stability [11].

Anesthetists in all disciplines work in harsh and resource-constrained circumstances, typically in battle zones. Their guiding idea is "physiology first, anesthesia second," which means that perfusion and hemostatic resuscitation are prioritized over definitive anesthetic depth. This perspective recognizes that, unlike civilian medicine, survival on the battlefield depends not just on technical anesthesia, but also on preserving physiology in the face of tremendous trauma.

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In summary, the tiered "Roles of Care" approach emphasizes combat anesthetists' developing and adaptive roles, which range from frontline stabilization (Role 1) to Resuscitation Physician and Surgical Anesthetist (Role 2), to Intensivist and Peri-evacuation Specialist (Role 3). This sequence describes that the role of anesthesiology in battle zones goes beyond operational anesthesia to include trauma resuscitation, physiological management, and continuity of care across the evacuation chain (Table 1).

Table 1: Roles of Care & Responsibilities of the Anesthetist

Role of Care	Key Functions of the Anesthetist
Role 1 (Point-of-Injury)	Immediate life-saving interventions: hemorrhage control, airway support, field analgesia, and application of TCCC protocols.
Role 2 (Forward Surgical Team)	Leadership in damage-control resuscitation, securing “shock-safe” airways, administering anesthesia for urgent surgery, and coordinating transfusion and resuscitation.
Role 3 (Field Hospital)	Comprehensive trauma anesthesia, ventilator support, intensive care, blood bank use, advanced pain management, and preparation for evacuation.
Evacuation (Aeromedical/Surface)	Packaging patients for safe transfer: airway securement, sedation and analgesia, maintaining hemodynamic stability en-route.

2. Damage-Control Resuscitation (DCR):

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Modern combat trauma care prioritizes damage-control resuscitation (DCR), an approach designed to avert the "lethal triad" of hypothermia, acidosis, and coagulopathy in exsanguinating patients [11]. This paradigm shift resulted from lessons learnt in both civilian and military trauma, where traditional resuscitation methods (large-volume crystalloids and delayed transfusion) frequently exacerbated coagulopathy and contributed to unnecessary mortality.

The main principles of DCR are:

- Early bleeding control via mechanical, surgical, and pharmaceutical treatments.
- Permissive hypotension is defined as maintaining systolic pressures sufficient for organ perfusion while keeping them low enough to decrease bleeding until definitive hemostasis is established.
- Crystalloids should be restricted because too much saline dilutes clotting factors and increases acidosis.
- Balanced transfusion techniques prioritize blood product resuscitation over crystalloids.

The Joint Trauma System (JTS) recommends low-titer type O whole blood (LTOWB) as the optimal resuscitation fluid for hemorrhagic shock due to its logistical ease and therapeutic superiority over component therapy [3]. Studies in both military and civilian trauma populations have indicated increased survival, reduced transfusion requirements, and lower incidence of coagulopathy when whole blood is used instead of isolated component therapy [4]. Spinella and colleagues in 2020 underline that whole blood provides volume expansion, coagulation factors, and oxygen-carrying ability in a single product, coinciding with battlefield needs for speedy and effective intervention [4].

Defense Health Ministry in 2019 suggested that when whole blood is not available, DCR methods substitute a 1:1:1 ratio of plasma, platelets, and red blood cells, reinforced with hemostatic adjuncts such as tranexamic acid (TXA) given within 3 hours of injury. Furthermore, it is critical to warm patients and fluids, detect coagulopathy early, and rectify metabolic acidosis. Importantly, massive transfusion techniques are initiated early, sometimes before hospitalization, based on clinical indicators of shock rather than scientific evidence. [3]

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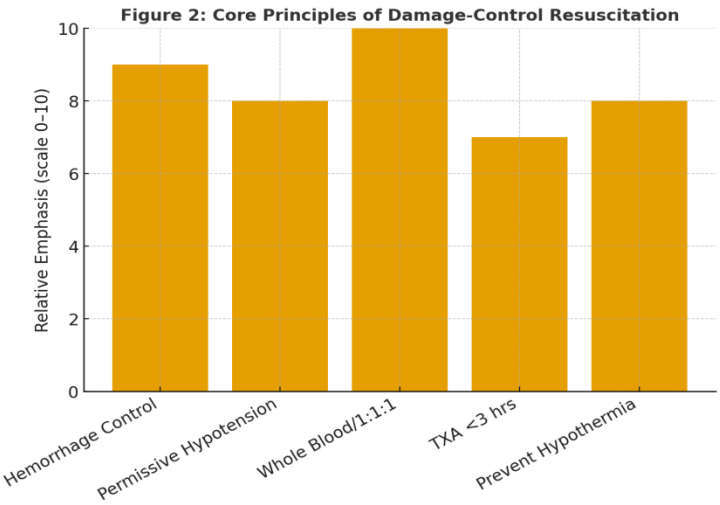
Modern military trauma care relies on a staged method elaborated by Rotondo and Zonies as a part of their article

The Damage Control Sequence and the Underlying Logic as early as 1997. Anesthetists collaborate closely with surgeons during damage-control surgery (DCS) – shortened treatments such as packing or vascular shunting aimed to stop bleeding and exsanguination, followed by deferred definitive repair once the patient is stabilized. [11]

In essence, DCR represents a paradigm shift: from treating metrics - blood pressure, hemoglobin to addressing trauma's underlying physiology - improving perfusion, maintaining coagulation, and preventing hypothermia. Its widespread use throughout U.S. and NATO troops as formalized in JTS Clinical Practice Guidelines [3] has been credited with considerably decreasing mortality in combat operations in Iraq and Afghanistan [1-4].

The anesthetist plays a crucial role in DCR. Combat anesthetists serve as "resuscitation physicians" leading transfusions, administering vasoactive agents, monitoring coagulation and perfusion, and anticipating difficulties throughout the intraoperative and postoperative phases. This combination of physiology-driven resuscitation and surgical intervention has transformed trauma anesthesia in modern combat.

The graph gives a visual representation of the varying degrees of importance of different strategies involved in damage control resuscitation with whole blood receiving the highest emphasis and tranexamic acid receiving the lowest amongst the different interventions mentioned in literature. (Figure 2).



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3. Airway and Ventilation Management

Airway control in battle trauma provides distinct issues, influenced by both environmental limitations and injury pattern variance observed in combat zone. The mechanisms of trauma are very variable inclusive of but not limited to blast injuries, penetrating trauma, and maxillofacial injuries. These are common patterns in combat zone but pose a fundamental shift of the routine patient management regimes. Thus, simple tasks like bag-mask ventilation or securing airway via endotracheal intubation become challenging and problematic. These injuries, combined with the complexity of hemorrhagic shock, limit the options for induction drugs as conventional anesthetics might cause circulatory collapse.

Keeping in view the need to avoid complicating shock further the Combat Anesthetists and trained medics prefer ketamine or etomidate for rapid sequence induction, as these agents preserve hemodynamic stability better than traditional hypnotics. [12]

Advanced airway adjuncts such as video laryngoscopes, bougies, and surgical cricothyrotomy kits are frequently used. The Tactical Combat Casualty Care (TCCC) guidelines advocate a low threshold for surgical airway institution in severe maxillofacial injuries due to the increased risk of worsening or loss of airway during evacuation. [2]

After the airway is secured, maintaining breathing becomes the next challenge. Combat conditions frequently lack ICU-grade ventilators; instead, anesthetists use portable transport ventilators or, in resource-constrained situations, manual ventilation using Mapleson's A, C or D type circuits. Ventilator techniques are modified to preserve oxygen while accommodating minimal levels of monitoring. Despite challenging conditions, patients with blast lung injury or pulmonary contusions are prioritized for instituting lung-protective ventilation strategies (low tidal volumes, permissive hypercapnia). Pulse oximetry, clinical examination, and portable capnography are commonly used for monitoring breathing component in these scenarios. Thus, anesthetists frequently rely on clinical surrogate markers such as chest rise, breath sounds, and patient responsiveness to determine ventilation adequacy.

Furthermore, the challenges are compounded by prolonged field care (PFC), including the possibility of portable ventilator batteries failing, oxygen rationing, and cautious sedation titration to avoid unintentional extubation. Dubose et al. identified occasions where providers resorted to rotating hand-ventilation shifts when mechanical devices failed, exemplifying the improvisation required under wartime conditions. [7]

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Overall, airway management in battle zones necessitates a mix of quick decision-making and resource rationing and flexibility. The goal is always to maintain a stable airway with minimal hemodynamic disruption, followed by adaptive breathing techniques matched to resource restrictions. Although video laryngoscopy and structured airway algorithms have increased first-pass success rates, airway management remains one of the riskiest tasks in combat anesthesia. [12]

4. Analgesics and Sedation

Effective pain management on the battlefield is both an ethical obligation and a therapeutic need, since untreated pain exacerbates physiological stress reactions, impedes evacuation, and increases morbidity.

The TCCC analgesia framework offers a systematic, tiered approach that is currently standard across NATO and allied forces.

1. Mild to moderate pain (functional soldiers): A Combat Wound Medication Pack contains oral medications such as acetaminophen and meloxicam.
2. Moderate to severe pain: Oral transmucosal fentanyl citrate (OTFC) lollipops are fast-acting, powerful, and convenient to deliver under field situations for patients in moderate to severe pain.
3. Severe pain in unstable patients: Ketamine- administered IV or IM- is the preferred treatment for severe pain in unstable or startled patients, providing potent analgesia while maintaining airway reflexes and cardiovascular stability. [2]

This triaged strategy has been found to reduce unnecessary deaths by avoiding opioid-induced respiratory depression in unstable trauma patients.

Beyond systemic drugs, anesthetists are increasingly using regional anesthesia (RA) procedures. Case series by Buckenmaier CC IIIet al 2012 and Clendenen et al in 2021 in Afghanistan and Iraq reveal the successful use of femoral, fascia iliaca, and brachial plexus blocks at Role 2 institutions, even under most challenging situations. [5,6] Regional anesthetic delivers opioid-free analgesia, keeps the patient awake (which is tactically favorable) and can be used for extended time with continuous nerve block catheters. Reports describe continuous peripheral nerve catheters maintaining analgesia during protracted evacuations, considerably enhancing comfort and minimizing systemic drug burden. [5]

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In battle trauma, sedation and analgesia are intimately linked. Sedation during evacuation or prolonged field care must be adequate yet light in order to avoid respiratory compromise. Extremity injuries from blast mechanisms and bullet wounds are among the most common types of battlefield trauma. Adequate pain control from severe injuries is critical, both for immediate stabilization and for enduring evacuation. RA methods, like as single-shot nerve blocks and continuous peripheral nerve block (CPNB) catheters, provide targeted analgesia without the risks associated with high-dose opioids, such as respiratory depression or hemodynamic instability. Buckenmaier and Bleckner's case series during Operation Enduring Freedom (Afghanistan) reported successful use of RA in 111 combat victims, including femoral, sciatic, brachial plexus, and lumbar plexus blocks. [5]

The introduction of portable ultrasonography devices and tiny nerve block kits has been a major driver of this RA resurgence. Ultrasound guidance has dramatically increased block success rates and safety, even under austere conditions, by allowing a real-time view of anatomy and local anesthetic dissemination. The US Army supplied handheld ultrasound equipment to deployed anesthetists, allowing them to perform quick diagnostic tests (e.g., e-FAST) and precision-guided nerve blocks. [8]

Clendenen et al. (2021) reviewed recent conflicts and strongly advocated for routine integration of RA into combat casualty care, highlighting that continuous nerve block catheters can provide days of analgesia and may even reduce the risk of chronic pain syndromes in wounded warriors:

- For severe limb damage or amputations, continuous CPNB is recommended to relieve stump discomfort.
- Rib fractures require thoracic epidural or paravertebral blocks.
- Fascia iliaca blocks are used to treat hip fractures and pelvic injuries.
- Awake surgery is for individuals who are at high risk of requiring general anesthesia.

To treat agitation, a ketamine infusion is commonly used in combination with low-dose benzodiazepines or antipsychotics (e.g., haloperidol). Dubose et al. developed a realistic "sedation bundle" for PFC, consisting of low-dose ketamine on basis of need, augmented periodically with midazolam or haloperidol, and OTFC for breakthrough pain. [7]

Combat anesthetists prioritize multimodal analgesia, which includes systemic, regional, and nonopioid drugs. This technique eliminates opioid dependence, adverse effects, and enhances long-term results.

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Evidence suggests that such measures not only improve short-term survival and comfort, but also reduce the prevalence of chronic pain and post-traumatic stress-related disorders in injured soldiers. [2]

Analgesia and sedation in war zones have developed into sophisticated, evidence-based practices. Anesthetists use ketamine, regional anesthetics, multimodal adjuncts, and rigorous sedation protocols to guarantee that casualties receive humane, effective, and safe pain treatment even in the most arduous conditions.

Effective battlefield analgesia follows the structured Tactical Combat Casualty Care (TCCC) protocol, which tailors pain control strategies to patient stability and operational feasibility (**Table 2**). Regional anesthesia and multimodal regimens further enhance patient comfort and survivability in austere environments.

The recommended stepwise use of acetaminophen, meloxicam, OTFC, and ketamine is shown in **Table 2**.

Table 2: Tactical Combat Casualty Care (TCCC) Analgesia Protocols

Clinical Situation	Recommended Analgesia
Mild–Moderate pain (functional soldier)	Acetaminophen + Meloxicam (Combat Wound Pack).
Moderate–Severe pain, hemodynamically stable	Oral transmucosal fentanyl citrate (OTFC) "lollipop."
Severe pain in shock/instability	Ketamine (IV/IM) for analgesia and sedation (preferred over opioids).

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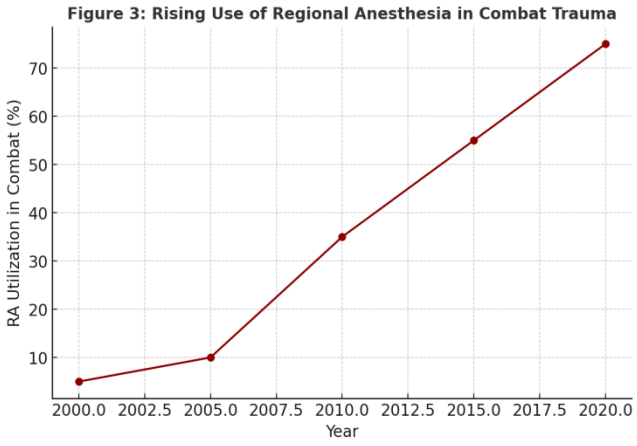
But performance of regional analgesia in battlefield is riddled with challenges. Maintaining sterility in tents or bunkers, managing infusion pumps while transporting, and ensuring adequate block technique training for people are just to name a few.

As a result of inclusion of regional analgesia in the arsenal of combat anesthetist the injured military personnel may experience better pain control, increased hemodynamic stability, and a speedier recovery time. The steady increase in adoption of regional anesthesia techniques across recent conflicts is illustrated in *Figure 3*.

Figure 3. **Increasing utilization of regional anesthesia in combat trauma care, reflecting evidence-based adoption since 2000.**



Role of Point-of-Care Ultrasound (POCUS)

In battle zones, anesthetists and critical care clinicians rely on point-of-care ultrasound (POCUS) because advanced imaging (CT/MRI) is not available at forward-deployed facilities. Handheld and portable ultrasonography instruments are becoming standard in deployed medical kits. [8]

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The eFAST exam (extended Focused Assessment with Sonography for Trauma) is the most essential trauma application. It quickly detects intraperitoneal or pericardial free fluid and pneumothorax, directing decisions on emergent surgery or decompression. Ultrasound can help monitor volume status (IVC collapsibility, ventricular contractility), vascular access, and airway management such as localization of the cricothyroid membrane in deformed anatomy.[8]

Ultrasound also aids regional anesthesia (RA) in the field. Portable probes have enhanced block success rates, boosting the safety and feasibility of RA in severe conditions. According to Inaba et al., combat anesthetists can use POCUS for cardiac, thoracic, and abdominal assessments, guiding fluid administration and detecting problems like tamponade or hemothorax. [8]

POCUS has been referred to as a "force multiplier" in prolonged field care: successive lung and abdominal scans aid in monitoring splenic damage, ARDS, or hemothorax during delayed evacuation. Its portability allows it to accompany anesthetists to the battlefield. With a greater emphasis on training and Joint Trauma System guidelines, POCUS is likely to become more integrated across all roles of care.

7. Resuscitative endovascular balloon occlusion of the aorta (REBOA)

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) has developed as a cutting-edge treatment for managing non-compressible thoracic bleeding. REBOA stops distal bleeding while maintaining central circulation by inflating a balloon catheter in the aorta. [9]

The military uses REBOA as a temporary "internal clamp" to maintain coronary and cerebral circulation until surgery can be performed. Reports from both war and civilian trauma suggest that REBOA elevates systolic pressure and creates a stability window for surgical management. [9,10]

However, REBOA is periled with risks: ischemia of distal organs, limb problems, and reperfusion injury necessitate cautious coordination. The anesthetist's role is crucial, since they manage proximal hypertension during inflation, avoid collapse during deflation, and coordinate hemodynamics around surgical management. In a case series from Afghanistan, anesthetists directed vigorous resuscitation with whole blood and vasopressors during occlusion, resulting in effective pelvic trauma stabilization with REBOA with favorable outcomes. REBOA, when used correctly, can be a life-saving tool in some military conditions [9,10]

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8. Prolonged Casualty Care (PCC).

Prolonged casualty care (PCC), also known as prolonged field care, is the management of critically injured patients in the field for 12 to 72 hours while evacuation is delayed. As peer or near-peer conflicts become more common, anesthetists face particular demands.

Anesthetist adapt ICU-level abilities to harsh unfamiliar environments:

- Sedation and analgesia bundles (low-dose ketamine, haloperidol, or midazolam).
- Improvised monitoring (capillary refill, mental status, urine output, and portable ultrasound).
- Resource stewardship (rationing oxygen, conserving fluids, and providing pressure area care).
- Basic ICU tasks (antibiotics, wound care, enteral feeding if more than 24–48 hours). [7]

Telemedicine is increasingly being used for difficult conditions. In essence, the anesthetist in PCC becomes an improvised intensivist, providing physiology-driven treatment with minimum equipment.

9. Training and Deployment Readiness.

The increase in anesthetist duties has required extensive pre-deployment training. The current curriculum should emphasize on:

- DCR and Whole Blood Transfusion like walking blood bank, 1:1:1 strategy [3,4]
- Airway under fire: RSI in shock, surgical airways, and video laryngoscopy [12]
- Regional anesthetic and POCUS include ultrasound-guided blocks, FAST, and heart and lung ultrasounds
- Prolonged Casualty Care Drills: 24-48 hr. simulation with restricted supplies (24/7). [5, 6, 8].
- Field craft and leadership skills include wearing protective gear, conducting resuscitation in chaotic situations, and triaging under fire. [11]

Point-of-care ultrasound (POCUS) has become indispensable in combat zones, guiding airway

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management, vascular access, and rapid trauma assessment through eFAST, cardiac, and thoracic scans. Its integration across all Roles of Care is depicted in **Figure 4**, which illustrates the expanding diagnostic and interventional scope of POCUS within combat anesthesia.

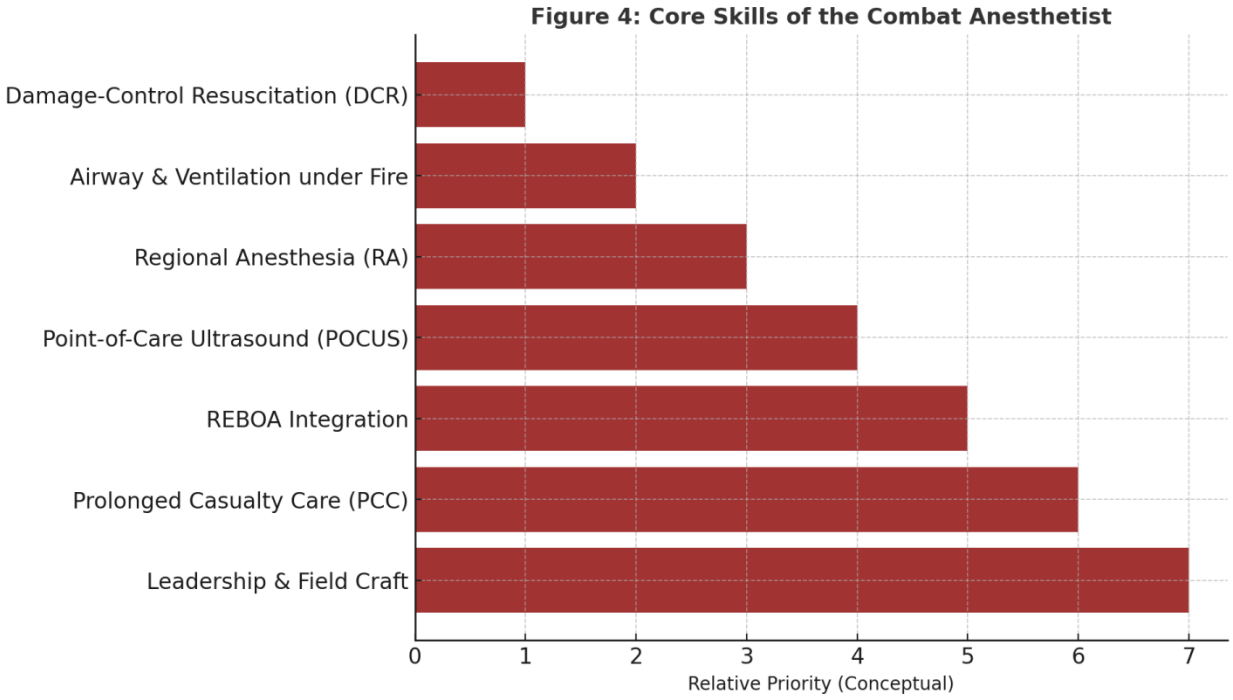

Figure 4: Core Skills of the Combat Anesthetist

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