Libya 2011

Trauma in War

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INTRODUCTION

Injuries from modern military munitions can be complex and devastating. Their management demands particular anesthetic and surgical skill sets including an understanding of time-critical injury. In addition, casualty management in the deployed military setting is subject to a number of threats and constraints that influence how care can be delivered.

Casualties presenting to the military anesthesiologist or anesthetist will broadly fall into a number of groups:

1. The ill, multiply injured casualty with time-critical injuries
2. The injured casualty needing surgery for wound care who is stable and can wait
3. Casualties needing follow-up procedures for wound and injury care
4. Routine problems such as appendicectomies
5. Civilian patients (adult and child) falling into the above groups

All of these would have differing requirements in the setting of a large, well-resourced civilian hospital.

ENVIRONMENT

There are differences between military and civilian application of Advanced Trauma Life Support (ATLS). This includes constraints of the military environment to the Medical personnel. These constrains include: Threat, austerity of Environment, limitation of supply, Casualty density (1).

1. Threat
Medical units, personnel, and vehicles have expected protection under the Geneva conventions, provided they do not engage in hostile acts outside their humanitarian function (2). Unfortunately, in most of the previous conflicts medical facilities and personnel have been, and are, deliberately targeted. According to the fact that medical response cannot be dissociated from the prevailing security situation and casualty care has to be modified accordingly.

Current United Kingdom (UK) military Battlefield Advanced Trauma Life Support (BATLS) (3) considers care under the headings of: Care under Fire, Tactical Field Care, Field Resuscitation, and Advanced Resuscitation.
a) Care under Fire
This emphasizes the need to win the fire fight and deal with the threat. Medical intervention – if any – is limited to:

- Control of catastrophic haemorrhage with a tourniquet
- Rolling the casualty face down to minimize airway obstruction
- And placing an (Asherman) Chest Seal

The imperative is to manage the threat and get to the next level of care, calling for additional help or evacuation depending on the available communication system (radio or other) and the state of the battle. The response to this request depends on what other military tasks are already in hand. For isolated units or individuals, help may take some time to arrive.

![Figure 4 Asherman Chest Seal](image)

b) Tactical Field Care
Tactical field care is when the immediate threat has been dealt with but the environment is still not safe. You need to do:

- Rapid Casualty assessment
- Hemostasis
- Basic manual airway maneuvers and use of nasopharyngeal airway
- Needle decompression of tension pneumothorax, control of non catastrophic bleeding sites, limited fluid resuscitation

![Figure 5 Asherman Chest seal on patient](image)
c) Field Resuscitation
Field resuscitation is usually at the Regimental Aid Post (mobile unit). It is the point at which the casualty meets a medical officer who can perform a more thorough examination and some invasive procedures. This level of care is constrained by lack of diagnostic equipment and limited medical supplies. The Regimental Aid Post has to be a mobile asset to keep up with the forces being supported. The aim is to evacuate the casualty back to a higher level of care.

d) Advanced Resuscitation
The casualty will meet a trauma team that will usually include an emergency physician and an anesthesiologist. There will be diagnostic capability including X-ray and ultrasound. Some of these facilities will have the capability of performing surgery. Even advanced resuscitation facilities may need to be mobile, which imposes constraints on care.

2. Austerity of Environment
Medical personnel will be forced to work in an environment where the local infrastructure has been damaged, if not destroyed. The military system will attempt to create its own infrastructure to sustain the operation. This will include creation of a medical infrastructure, but with compromises which depending on:
- State of the battle,
- Duration of the military deployment (i.e., whether it is a new or a “mature” deployment)
- Competition with other military priorities

Within austerity comes the concept of mobility. A mobile medical facility has to move its personnel, shelter, food, water, and fuel, as well as medical supplies. All are competing for space and lift. Mobile facilities rely on evacuation of patients or they may become “fixed” in place. So, if a mobile surgical facility knows it will be moving in an hour, can they start a laparotomy which may take two hours?

Mobile surgical teams have previously quantified their supplies and equipment, for example, performing 20 cases prior to resupply. This fails to differentiate between the casualty with one wound and the multiply injured casualty who will use up consumables very quickly. It may be better to describe capability in terms of “wounds” or “body cavity surgeries” that can be dealt with. Use of the term “cases” and linking this with resupply also confuses military planners: if a particular mission is predicted to cause 20 casualties, they may not appreciate that a single surgical team has to operate on them one at a time.
3. Limitations of Supplies
Medical supplies have to compete in the military logistic system with other supplies and consumables. As the supply chains are more vulnerable, there is a greater need to conserve materials and use them carefully.

Some items (such as blood and drugs) need a “cold chain” for their safe transport and have a limited shelf life. Others are more robust. The availability and quantity of medical supplies will influence what clinical procedures can be performed and, in turn, what triage and resuscitation protocols should be followed.

4. Casualty Density
A facility treating war wounded must be prepared to receive large numbers of casualties. The casualty load may increase steadily or a large number may arrive suddenly\(^4\). When the number of casualties outstrips resources, *tria ge* is initiated. This situation may arise with few or many casualties depending on the facility and resources.

*Triage* may be defined as: “Sorting casualties and the assignment of treatment and evacuation priorities to the wounded at each echelon of medical care”. For any individual patient, triage priorities for first aid, surgery, and evacuation are likely to be different and will change according to how that individual responds to treatment\(^5\).

**HOW THE MILITARY APPROACHES DEPLOYED MEDICINE AND SURGERY**

The military have a number of approaches to deployed medicine and surgery. These include:

1-Deploying medical facilities with equipment and standards to allow medicine, surgery, and anaesthesia at or close to western clinical practice by modularized operating theatres and intensive care unit. The movement of these facilities and their ongoing support is resource intensive.

2-Deploying independent mobile teams
These are less resource intensive but are more limited in the service they can provide.

3-Deploying military teams that may work alongside or with host nation medical personnel in local hospitals.
POPULATIONS BEING CARED FOR

The military population at risk tends to be young and fit, and some prediction of likely injuries and casualty numbers can be made by using casualty templates from similar conflicts. The situation is more complicated if a civilian population is being cared for as will happen on disaster relief operations or when civilian casualties are entering the military system during war fighting and insurgency\(^6\).

When nongovernmental organizations and intergovernmental organizations or the military are treating the local population, they may find they are attempting to deal with chronic health conditions and fill gaps in the local health care system as well as manage acute injury.

The situation becomes even more complicated when casualties are being transferred between health care systems when they have had their initial surgery in the other system.

RECEIVING CASUALTIES

Medical facilities need to prepare well before receiving casualties. This preparation will include:

- **Logistic Preparation**
- **Clinical Preparation**
- **Passage of Information and Task Allocation**

a) Logistic Preparation

- Casualties exposed to chemicals or other noxious agents will need decontamination before entering the hospital.
- Where casualties are arriving by helicopter, trained teams must be there to meet the aircraft and receive the casualties.
- In a military field hospital this preparation will include putting a system in place to safely remove the casualty’s weapons and ammunition.
- Where there is a threat of terrorist attack, including suicide bombing, screening and searching of some casualties and relatives for explosive vests and ordinance will be necessary.

b) Clinical Preparation

- Activating the trauma team and notifying other key personnel.
- Key personnel include translators for civilian patients, administrative staff for patient tracking and documentation, x-ray technicians, and laboratory staff.
• A hospital receiving trauma patients needs to define what criteria will initiate *trauma team activation*. These criteria can be based on a combination of history, vital signs, and injuries.
• Many systems include any gunshot wound as an activation criterion. In field hospitals, this criterion may be augmented to include blast- and mine-related injuries.

c) Passage of Information and Task Allocation
• The trauma team needs to be briefed with any pre-hospital information that is available.
• The running of the team is aided by an effective and organized *team leader* and clear allocation of tasks and roles to the team members in advance of the casualty arriving.
• UK military use the MIST handover:
  M = Mechanism of injury
  I = Injuries sustained
  S = Signs and symptoms
  T = Treatment given

SPECIAL CONSIDERATIONS FOR DIFFERENT PATIENT GROUPS

Civilian Patients
With civilians, one must be beware of undeclared long-term medical illnesses and surgical histories. In conflict environments, disruption of the health care service will often mean that acute and chronic health conditions have not been managed and this will complicate resuscitation and anaesthesia.

Children
The main practical issue with children is estimating age and weights such that drug and fluid doses can be adjusted accordingly.
Use a system such as the Broselow tape (Armstrong Medical Industries Inc, Lincolnshire, Illinois) to get the child’s weight and appropriate drug doses and tube sizes and to calculate the child’s blood volume and likely fluid requirements.

If the resuscitation tables are covered in disposable sheets, these calculations can be written on the sheets as memory aids, using indelible markers, and then transposed into the clinical notes.
**Figure 1** Measuring child with Broselow tape

**Figure 2**: Broselow tape
Receiving from another Health Care System
Some physicians experience receiving postoperative casualties from civilian and allied military health care systems with poor documentation of the treatment given. Clinicians need to take an objective look at each patient transferred in and undertake a thorough examination and investigation.

RESUSCITATION OF THE BALLISTIC CASUALTY

The principles that guide resuscitation of the ballistic casualty are essentially those described in the ATLS and BATLS 2005.

Casualties from Improvised Explosive Device (IED)
Casualties suffering from improvised explosive device (IED) (roadside bomb) attacks often have a combination of penetrating and blunt trauma complicated by burn injury. These casualties often have multisystem, multicavity injury and need rapid resuscitation and surgery.

Casualties from Sniping
Casualties from sniping attacks may have various injury patterns depending on whether helmet and body armor was worn at the time of the attack and whether armor-piercing rounds were used in the attack.
CATASTROPHIC HAEMORRHAGE

The UK BATLS 2005™ course teaches the paradigm “<C> ABC” where “<C>” is for catastrophic haemorrhage, “A” for airway, “B” for breathing, and “C” for circulation. This is in recognition of the high incidence of limb injuries and junctional injuries (groin, axilla) in ballistic casualties associated with devastating rapid blood loss. Many of these injuries are survivable if the bleeding is rapidly controlled (7). Catastrophic haemorrhage should have been dealt with by prehospital providers, prior to the casualty arriving at a treatment facility. If tourniquets are present, one must check that they are working, and that ongoing resuscitation has not raised the patient’s blood pressure and overcome the tourniquets. If tourniquets are not in place and are needed, they are applied. Pressure dressings and hemostatic materials are used as needed.

AIRWAY AND CERVICAL SPINE CONTROL

Simple First
Ensuring oxygenation, suction, jaw thrust, nasopharyngeal airway, oropharyngeal airway. Give oxygen.

Cervical Collars
In the absence of neurological deficit, the bony cervical spine is likely to be stable in those with penetrating trauma (8). The same does not hold true for blunt injury where 70% of unstable cervical injuries have no immediate neurological signs. The incidence of neurological complications increases with time if the spine is not immobilized and imaged. In the ballistic casualty, cervical spine immobilization should be undertaken in the presence of blunt injury (road accidents), combined blunt and penetrating injury (IEDs), but not in penetrating ballistic injury alone (if there is no neurologic injury). In ballistic injury, cervical collars can conceal developing hematomas, tracheal deviation, or penetrating occipital injury (9).

Collars were used for keeping dressings in place over neck wounds and minimizing head and neck movement in the presence of neck vascular injury, to assist in stabilizing vessel injury prior to surgery rather than preventing neurologic injury. Use of a cervical collar is a balance of risk and benefit, to accept and understand whatever decisions the field providers had made, and to place immobilization in ballistic neck injury until the exact nature of the injury had been determined by using computed tomography (CT) imaging.
Laryngoscopy and Collars
In the presence of a cervical collar, laryngoscopy becomes more difficult\(^{(10)}\).

Endotracheal intubation when a cervical collar is in situ
i. Explain and confirm the airway management plan with all team members.
ii. Allocate roles.
iii. Have an assistant provide manual in-line immobilization of the cervical spine.
iv. Remove the equipment stabilizing the cervical spine (in the case of collars, this may mean unfastened and opened rather than completely removed).
v. Preoxygenate the patient (ideally 2 to 3 minutes, but this depends on the patient’s condition).
vi. Have a separate assistant apply cricoid pressure.
vii. Perform rapid sequence induction (RSI), intubate the trachea, and confirm the position of the endotracheal tube (direct vision, auscultation and capnography).
viii. Reapply the stabilization devices.

In this situation management must include appropriate equipment and a rehearsed plan for dealing with a Grade 2–3 laryngoscopy and failed intubation. A gum elastic bougie and a small-diameter endotracheal tube should be available.

Tracheal Compression
Survivors of penetrating trauma to the neck are at risk for tracheal compression from haemorrhage.
If this is suspected, the trachea should be intubated early under controlled conditions rather than as an emergency when the airway is compromised, narrowed, or displaced.
Partial severance of the trachea is a rare but potentially disastrous situation and attempted endotracheal intubation may complete the disruption.
Management options include:
- Fiberoptic intubation
- Surgical airway sited below the injury
- Careful direct laryngoscopy and intubation using a small endotracheal tube.

BURNS
Burns of the head and neck represent a potential major airway hazard. If there is any doubt about the possibility of developing airway compromise, then early endotracheal intubation is required especially if patient transfer is anticipated.
In the absence of anesthetic training, drugs and equipment to achieve this, or in other situations where endotracheal intubation is not possible or has failed, an urgent surgical airway is required eg surgical cricothyroidotomy. The aim is to secure the airway and provides a definitive airway through which the patient can breathe or receive intermittent positive pressure ventilation
BREATHING

Diagnosis of chest injury in patients with major trauma can be difficult. This is especially true in the noisy field environment or during transport in an ambulance or helicopter. Approximately 15 percent of low-energy transfer ballistic injuries to the chest will require emergency surgery; the remainder can be managed by the placement of a chest drain.

The mortality associated with high-energy transfer wounds is significantly greater, and those casualties that survive to reach a medical facility may have significant tissue destruction and loss.

The elastic composition of lung makes it relatively resistant to the effect of high-energy transfer and cavitation, unlike the solid abdominal organs, but large wound tracts in the lung can still be a source of significant bleeding.

Penetrating chest trauma may result in an open or sucking chest wound. These can be managed by the application of an Asherman™ Chest Seal. Following this a chest drain should be inserted.

CIRCULATION/HAEMORRHAGE CONTROL

Recognition

Detection of the clinical signs of hemorrhagic shock are essential in assessing the injured patient. These include:

- Visible bleeding
- Tachycardia
- Poor peripheral perfusion
- In later stages a decreased level of consciousness.

Visible bleeding should be controlled quickly by direct pressure, elevation, and/or tourniquets.

Broadly, haemorrhage can be differentiated into:

1. **Compressible haemorrhage** that can be controlled by direct pressure or limb splinting. When this bleeding is controlled (i.e., the “tap” turned off), and in the absence of cavity bleeding, the casualty can receive fluid resuscitation with near-normal blood pressure as the goal.

2. **Noncompressible haemorrhage** (e.g., bleeding into the abdomen or chest) that requires urgent surgical intervention, i.e., the tap cannot be turned off in the resuscitation department. Current views are that management of this situation may involve hypotensive resuscitation.
Hypotensive Resuscitation
Hypotensive or minimal volume resuscitation to a systolic blood pressure of approximately 80–90 mmHg is increasingly being advocated in trauma resuscitation. This approach is based on the belief that giving excess fluid may raise the blood pressure, disrupt clots, cause rebreeding, and increase blood loss\(^{(11)}\).

This technique is not applicable for all trauma patients\(^{(12)}\) and is not recommended in those enduring a prolonged entrapment or who have a head injury where it is vital to maintain an adequate cerebral perfusion pressure to ensure the best outcome from the cerebral injury.

Consensus guidelines for prehospital trauma care state that fluid should not be given to trauma patients before haemorrhage control if a radial pulse can be felt. In penetrating torso trauma, the presence of a central pulse may be considered adequate.

In the absence of a radial pulse, 250-mL of normal saline may be given but stopped temporarily once the pulse returns\(^{(11)}\), with monitored for subsequent deterioration. This strategy requires rapid definitive surgical control of haemorrhage and the timing of surgery rather than the volume of fluid transfused that is the defining issue.

Fluids
The choice of fluid (crystalloid, colloid, blood, or hypertonic hyperosmotic solutions) will be influenced by its clinical effect and unwanted effects. In the military, factors such as weight, ease of transport, and storage characteristics must be considered.

Hemostatic Resuscitation
The resuscitation protocols being developed by the U.S. military are pushing the envelope beyond current “damage control surgery” concepts\(^{(13)}\). Critical casualties would receive Group O blood, freshly thawed plasma, in accordance with a “massive transfusion protocol” and rFVIIa in the emergency room.

The rFVIIa was given in accordance with a United States Army Institute of Surgical Research approved protocol\(^{(14)}\). The massive transfusion protocol at the hospital allowed for the immediate release of four units of blood and two units of freshly thawed plasma to the emergency room.

Subsequent products were released as blocks of six units of blood, six of freshly thawed plasma, ten of cryoprecipitate, and six of platelets. The “6/6/10/6”, this order could be modified by the clinical staff in consultation with the laboratory as dictated by the patient’s clinical response and laboratory results.
In some situations a “walking donor” panel (prescreened volunteer donors) may be the only source of clotting factors where the infrastructure for blood collection, component separation, and storage does not exist.

The goal is to:
- Recognize critically injured patients early by understanding the mechanism of injury, the anatomic injuries sustained
- Early signs of deranged physiology (such as acidosis, base excess, and coagulopathy).

The resuscitation of these patients was managed with:
- Early blood and blood component therapy (blood: fresh-frozen plasma [FFP] given in a 1:1 ratio)
- Limited crystalloid resuscitation, and
- Monitoring of blood gases, electrolytes, blood sugar, and early correction and management of abnormalities.

**DISABILITY**

**CNS**
Casualties who sustain a high-energy transfer wound to the head do not survive to medical care\(^{(15)}\).

If they survive, the primary head injury can be compounded by secondary injury as a result of hypoxia and hypotension. The avoidance of hypoxia, hypercapnia, and hypotension is the fundamental principle of initial resuscitation for CNS. There is an obvious conflict between the need to maintain blood pressure and cerebral perfusion pressure and the need to avoid uncontrolled bleeding from the abdomen and chest (Hypotensive resuscitation).

Military penetrating brain injuries frequently arise from fragments rather than from bullets. In this situation casualties who survive to reach medical care are a preselected group who generally has received low-velocity fragment injuries, and the outcome for both survival and rehabilitation in this group is good\(^{(16)}\), except when very rapid evacuation systems bring live casualties with non-survivable brain injuries to the medical facility within minutes of injury.
ENVIRONMENT

Ballistic casualties, especially those that received their injuries on a battlefield, may be markedly hypothermic on arrival at the medical facility due to climatic conditions, transport times, and the severity of injury.

Hypothermia compounds coagulopathy and is associated with increased mortality. During resuscitation and in theatre, active measures including warm air blankets, environment control, and warmed fluids should be routinely employed.

FIELD AND MILITARY ANAESTHESIA

Patients are likely to present for anaesthesia in two broad phases:

Early
   1. As part of the patient’s resuscitation, including anaesthesia for surgical control of haemorrhage and damage control surgery.
   2. Anaesthesia for early wound debridement and major fracture stabilization.

These “acute” interventions will usually take place in a casualty, the patient is usually shocked, cold, and likely to be at risk for pulmonary aspiration. Successful management depends not only on technical skills but also on the ability to continually reassess patients whose clinical condition may be subject to rapid and unexpected deterioration.
Figure 6 Example of massive transfusion protocol. A whole-blood drive could be called if the attending surgeon or anesthesiologist decided this was appropriate. Injury patterns of two limbs plus a body cavity were an indicator that whole blood would probably be needed as was ongoing transfusion of greater than 20 units of packed cells, 20 units of plasma, and other components. pRBC, packed red blood cells; FWB, fresh whole blood; FFP, fresh-frozen plasma; cryoppt, cryoprecipitate; CSH, combat support hospital; DCCS, Damage Control Casualty Station; CSH, Combat Surgical Hospital.
Late
This includes anaesthesia for relook and delayed procedures:
- Anaesthesia in this situation will depend on the patient’s overall condition and commonly will involve intensive care patients where the surgery will be a necessary part of their ongoing management.
- Anesthetic for delayed primary suture in a single-limb injury in a well-resuscitated patient several days postinjury is more likely to be similar to a straightforward day case anesthetic.

<table>
<thead>
<tr>
<th>General Principles of Emergency Anesthesia*</th>
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<tbody>
<tr>
<td>1. Perform preoperative assessment of patients. This may be very brief and amount to simple triage.</td>
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<tr>
<td>2. Undertake appropriate resuscitation. Appropriate may mean “hypotensive” depending on the situation and type of injury.</td>
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<td>3. Explain to the patient what is happening and what is planned and ask for their consent. This will often be done via a translator in NGO/IGO work and consent may involve relatives or societal elders.</td>
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<td>4. Check anesthetic equipment and drugs, including the availability of suction apparatus and the ability to tilt the operating table or stretcher.</td>
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<td>5. Preoxygenate the patient where possible if oxygen is available, but remember it may need to be rationed. Oxygen sources include cylinders and concentrators.</td>
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<td>6. Confirm the plan with the anesthetic assistant. When working with NGOs the training of operating theatre helpers may have to be brief and to the point.</td>
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<tr>
<td>7. Perform airway protection for the patient with endotracheal intubation (or a surgical airway) if indicated and if possible. In general, battlefield trauma casualties should be treated as having full stomachs and being at risk for aspiration.</td>
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<tr>
<td>8. Monitor the patient during anesthesia and surgery. The ideal situation is a trained and alert anesthetist working with reliable electronic monitors. For field work the anesthetist must also be trained and experienced in monitoring by physical signs only and in using manual monitoring such as stethoscope and sphygmomanometer.</td>
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<td>9. Agree on realistic and appropriate surgical goals.</td>
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<td>10. Safe recovery of the patient. This may have to be in the operating theatre. In the absence of ITU facilities or postoperative ventilation patients need to be able to breathe for themselves soon after operation.</td>
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Table 1. On deployment, be aware of the current military situation and any constraints this imposes on clinical care. NGO, nongovernmental organization; IGO, intergovernmental organization; ITU, intensive care unit. From: Cantelo R, Mahoney PF. An introduction to field anaesthesia. Curr Anaesth Crit Care 2003;14:126–30.
Planning Anaesthesia
Casualties injured by modern munitions are likely to have multiple penetrating injuries to different body areas\(^{(17)}\) and may need frequent repositioning\(^{(18)}\), therefore the theatre team must be prepared for the surgeon to convert an abdominal operation into a thoracic one and vice versa.

What Type of Anaesthesia Can Be Provided?
This depends on a number of factors and includes:

1. The training and background of the anaesthesia providers
2. The facilities and personnel for patient preparation, recovery, and postoperative care
3. A relatively secure environment to work in
4. Infrastructure. This includes electricity, water, shelter, laboratory support, and availability of blood. Most elements can be worked around if absent. Examples are generators instead of mains electricity, hand ventilation instead of mechanical ventilators, head torches if light sources are unreliable, walking blood donors if there is no banked blood supply, and stored water if there is no running water supply.
The lack of resources imposes restrictions on how anaesthesia and surgery can be achieved and influences the anesthetic technique used for a particular operation.

Anesthetic Techniques
Field anesthetic techniques can be divided into:
1. local
2. regional
3. general
4. combinations of all of these.

General may be a single agent such as ketamine, or a combination of intravenous and inhalational agents.

General Anaesthesia Using Volatile Agents
In the field environment medical gas supplies cannot be guaranteed, hence the use of drawover techniques\(^{(19)}\) with air as the carrier gas and oxygen supplemented from concentrators or cylinders. The use of compressors and oxygen concentrators has simplified the provision of compressed gas supply.
Drawover system can be used with spontaneous ventilation, as a manually controlled intermittent positive pressure ventilation system, or with a mechanical ventilator.

Total Intravenous Anaesthesia (TIVA)
The use of intravenous anaesthesia in war was criticized\(^{(20)}\). However, a number of different intravenous techniques have been described by UK military anesthetists.
These range from ketamine increments\(^{(21)}\) to mixtures of agents given alone or in combination with a volatile anesthetic. Some mixtures have been described such as:

- Using a maintenance mixture of ketamine, midazolam, and vecuronium delivered by a syringe pump for intubated patients whose lungs were being ventilated with air
- ketamine/midazolam
- propofol and alfentanil
- ketamine, midazolam, and alfentanil supplementing the inhalation of isoflurane in oxygen enriched air
- Propofol/remifentanil infusion is also suitable for field use with ventilated patients.

Potential disadvantages for infusion-pump-based IV anaesthesia include:
1. Servicing and maintenance of the pumps and batteries
2. Supply of the necessary consumables and disposables from the logistic chain.

But intravenous anesthetics and anesthetic/analgesic mixtures can be injected into bags of compatible intravenous fluid and titrated to effect.

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**Example of Anesthesia Recipe**

An infusion of 4 mg of propofol, 2.5 mg of ketamine, and 2.5 \(\mu\)g of fentanyl per milliliter of solution is easily administered.

To mix the solution,
- 40 mL of 1% propofol,
- 250 \(\mu\)g (5 mL of 50 \(\mu\)g/mL) of fentanyl
- 250 mg of ketamine (5 mL if using 50 mg/mL concentration)
- Added to 50 mL of saline

Using a standard 20 drop/mL drip set and assuming an 80-kg patient,

**One drop per second equates to a propofol infusion rate of 150 \(\mu\)g · kg\(^{-1}\) · min\(^{-1}\) (or 9 mg · kg\(^{-1}\) · hr\(^{-1}\)).**

**One drop every three seconds equates to a propofol infusion rate of 50 \(\mu\)g · kg\(^{-1}\) · min\(^{-1}\) (or 3 mg · kg\(^{-1}\) · hr\(^{-1}\)).**

For most soldiers, these rates provide good starting points for a range of anesthetics, and the infusion rates are easily titrated as needed, based on the patient's response (or lack thereof) to ongoing surgical stimuli. This infusion can be terminated at the end of the case, or continued in the intensive care unit at lower rates to provide sedation and analgesia.
The impression is that, as the propofol is rapidly redistributed from its effect site and spontaneous ventilation returns quickly, the pharmacokinetics of ketamine and fentanyl results in a slow return to full arousal\(^{(22)}\).

Another modification of the TIVA mixture involves substituting an equipotent amount of sufentanil for fentanyl. The faster elimination of sufentanil allows for a more speedy return to full arousal.

**Regional Anaesthesia**

These vary from simple infiltration of local anesthetics to nerve conduction blocks and spinal anaesthesia\(^{(23,24)}\).

The advantages of a pure regional anesthetic are that the patient is spared a general anesthetic and is awake and protecting his own airway. This is particularly advantageous in a combat setting, where nursing care may be limited. Other advantages are familiar to the nonmilitary practitioner, including:

- Avoiding a potentially difficult airway
- Avoiding risk of aspiration
- Decreased sore throat
- Decreased postoperative nausea
- Decreased postoperative pain
- Potentially decreased blood loss.

Complications are predictable and include:

- Hypotension in underestimated hypovolemia
- Nerve injury – usually sensory changes that resolve – occurs at rates of 0.1 percent, and life-threatening complications are very rare
- Multiple penetrating injuries to different body areas needing repositioning during surgery
- Regional anaesthesia has only limited use as a sole technique in these patients but may have a major role to play in postoperative care and evacuation.

In the patient with a traumatized extremity, one must be careful to monitor for the development of *compartment syndrome*. The diagnosis of compartment syndrome in the absence of compartment pressure monitoring depends on evaluation of pulses, paresthesias, paralysis, pallor, pain on passive range of motion, and extreme pain out of proportion to the injury.
Regional Anaesthesia in Combat Casualties and Thromboprophylaxis
Postoperative immobile patients are at risk of developing deep vein thrombosis and pulmonary embolism. Patients undergoing prolonged evacuation are also at risk. Postoperative combat casualties at the 10th Combat Support Hospital received thromboprophylaxis.

The choice of regional technique and of thromboprophylaxis medication used was a balance of risk and benefit based on American Society of Regional Anaesthesia (ASRA) guidelines\(^{(25)}\). Accepting that patients being evacuated would not be as easy to monitor and assess for complications in the back of an aircraft compared with a standard postoperative care unit, the aim was to provide optimum analgesia and thromboprophylaxis but minimize potential bleeding complications from continuous catheter sites. The current ASRA guidelines do not make specific recommendations concerning peripheral blocks and thromboprophylaxis\(^{(26)}\).

CONCLUSION

Anaesthesia for the multiply injured casualty is challenging. Anaesthesia for the same casualty in a deployed environment is even more so. The practitioner working in this environment needs to understand the constraints imposed and be able to provide anaesthesia by drawing on a variety of different techniques. This does not mean that the standard of care given to the casualty is reduced. Military practice is constantly looking at new technologies, new techniques, and new evidence to ensure that the best possible care can be delivered to casualties whatever the circumstances.
REFERENCES


