

Anaesthesia Safety in War Zones

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Abstract

Many countries (and populations) all over the world currently find themselves in armed conflict situations.

The administration of anaesthesia in these situations is difficult, challenging and may be limited, in terms of drugs, equipment and facilities. This review highlights some of these potential difficulties, as well as the effects that working in a conflict zone may have on anaesthetists.

INTRODUCTION

Globally, anaesthetists play a key role within the emergency medical management of humanitarian disasters. This review will focus on anaesthetic safety in areas of conflict. Conflict, like natural disasters inevitably results in disruption of health systems, collapse of essential medical supply chains, breakdown of social and economic systems, an exodus of health care workers, and a concurrent increase in traumatic injuries, epidemics and starvation.¹ The World Health Organisation (WHO) estimates that 1.8 billion people live in conflict-affected areas worldwide.² Climate change has and will continue to result in significant natural disasters and with global temperatures increasing faster than predicted³, the unsurprising scarcity of fresh water and the international push for green energy transition has predictably provided one of the many catalysts for the recent increase in armed conflict, which is likely to accelerate with the rise in global temperature.

This increase in conflict within the 21st century has posed new challenges to the humanitarian surgical response, including changing security requirements; access to patients and communities in need; limited deployable surgical assets; resource constraints; and the requirement to address both traumatic injuries as well as non-injury-related emergency surgical needs of the population.³ Such conflicts can lead to mass casualty events that potentially overwhelm local medical resources and prevent them from delivering definitive medical care.^{3,4}

HOW WAR SURGERY DIFFERS

War wounds differ in the extent of tissue destruction and contamination seen compared with most civilian trauma practice, confounded by the fact

that timely patient presentation may be delayed. Working conditions during war are radically different from those in peacetime. Resources are limited and surgeons are often obliged to improvise or make compromises in their management decisions. Their aim should be to bring the best care possible to their patients under these circumstances, not the best care possible in ideal circumstances. War surgery is a surgery of mass casualties. The logic of war triage has little to do with the routine emergency department triage of a major civilian trauma centre. War surgery involves the staged surgical management of the wounded, often at different echelons of care and provided by different surgeons, especially in a military context. Even in a humanitarian context, such as International Committee of the Red Cross (ICRC), several surgeons deployed on short missions may participate in the treatment of a single patient.⁴ Patterns of injury encountered are complex and may be foreign to many clinicians yet to work in such circumstances: blast; burn; chemical biological radiological and nuclear (CBRN); penetrating injury with high velocity projectiles of differing natures (MP, API, BALL, Depleted Uranium etc).⁵

PROGRESSION OF MEDICAL CARE IN WAR

From the bombing of Pearl Harbour, Hawaii, to the day Japan's emperor signed the surrender, more than 400,000 U.S. service members were killed during World War II.⁶ About 70% of those were combat-related, and the rest were accidents or illnesses. More than 670,000 were wounded. Battlefield medicine improved throughout the course of the war. At the beginning, only plasma was available as a substitute for the loss of blood. By 1945, albumin had been developed, which is saline with serum albumin –

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Figure 1 – Dual-operating tables at a US Forward Surgical Team (FST) in Afghanistan c. 2010

it was formulated in 4.5% and 25% solutions. Whole blood was also used.

Also, this was the first major war in which air evacuation of the wounded became available. During the war, surgery techniques such as removing dead tissue resulted in fewer amputations than at any time. To treat bacterial infections, penicillin or streptomycin were administered for the first time in large-scale combat. Because of improvements like these and others, the survival rate for the wounded and ill climbed to 50% during World War II from only 4% during World War I.⁶ Battlefield medical advances continued after the war. By 2016, a service member wounded in Iraq or Afghanistan had about a 92% chance of making it home alive.⁶

CONTEMPORARY CONTEXT

Middle East:

The wars in Iraq and Afghanistan have helped to shape the modern Defence Medical Services. Many lessons were learnt including the need for rapid haemorrhage control, senior decision-making and the evolution of deployed transfusion support. These changes were implemented simultaneously with a coherent, end-to-end medical plan from point of wounding through to rehabilitation. A relatively new characteristic, further compromising healthcare delivery, is the lack of respect for the sanctity of healthcare structures and the staff working in them (with notable incidents in Kunduz in Afghanistan, Aleppo in Syria, and Saada in Yemen): if in previous armed conflicts the healthcare system was mainly affected due to the absence of human resources and difficult supply lines, nowadays it is more and more a target by itself, and suffers the destruction of facilities and killing of staff.⁷

Russia-Ukrainian War:

Humanitarian NGOs and foreign press alike have reported at least 226 direct and indirect attacks by Russian military on Ukrainian health facilities to date with the maternity hospital in Mariupol being most widely publicised amongst the international media.⁸ This demonstrates a specific targeted approach towards health



Figure 2 – Narkomed anaesthesia unit at a US FST facility in Afghanistan c. 2010

infrastructure, whilst also highlighting the inherent danger for medical professionals working in areas of conflict. No longer is the painted red cross on the rooftop of hospitals a stop sign like it once was but perhaps nowadays it more likely represents a bullseye.

Role of the anaesthetist:

Following disasters such as Haiti the WHO produced the Emergency Medical Team (EMT) Classification Process, which provides the minimum standards for such teams responding to humanitarian disasters.⁴ This classification specifies the technical and logistical capabilities that each team must possess. Team classification is as follows: Level 1 – outpatient emergency care; Level 2 – inpatient surgical emergency care; and Level 3 – inpatient referral hospital with an ICU.³ The majority of anaesthetists will be stationed at a Level 2 field hospital, which must be able to operate fully independently (i.e. structure often tented, generators and provision of its own water and food). And must be capable of providing emergency medical, surgical and obstetric care with an ability to stabilise critically ill patients for transfer to Level 3 facilities. Any Level 2 field hospital must have a medically qualified anaesthetist to avoid the shortfalls in perioperative and critical care management that have previously occurred prior to implementation of the WHO classification system.⁴

Off the floor or in the absence of a floor:

A significant challenge for anaesthetist is working in a range of clinical areas they may have limited or no experience in. Often there is at least one area of medicine that they do not encounter during daily clinical practice. As part of the EMT anaesthetists must be able to manage HDU/ICU care for patients with crush injury, burns, paediatrics and neonatal resuscitation in addition to more common presentations: Obstetric emergencies; perioperative care and pain medicine for trauma patients, including acute and chronic pain from neuropathic pain arising from nerve injuries. In many settings the anaesthetist may be the senior critical care specialist, providing emergency medical services including triage and resuscitation prior to operative intervention. The constraints on all aspects of care extend to those of triage. As surgical needs overwhelm the surgical



Figure 3 – Operating room with Drager anaesthesia machine at a Role 3 NATO medical facility in Afghanistan



Figure 4 – Paediatric surgery in progress at a Role 3 NATO medical facility in Afghanistan

capacities, triage must be implemented. Triage in armed conflicts and disasters differs considerably from triage used in routine settings: with the main goal being to provide the best possible surgical care to the highest number of casualties, with limited resources. When working in this context it is important to accept there are limits inherent to surgical care, while always upholding the principles of medical ethics.⁸ Anaesthetists must be prepared to take on a number of secondary tasks for which they have little or no experience, including but not limited to: pharmacy skills; infection control and sterilisation, and laboratory pathology and interpretation.

PROVISION OF SAFE ANAESTHESIA

Set Up:

Provision of safe anaesthesia presents unique challenges with logistical issues being as significant, if not more so than the clinical presentations. Set up for the conduct of anaesthesia and resuscitation for the operating theatre, emergency, delivery, and recovery rooms including the HDU all fall within the anaesthetists remit. At its core this may include constructing furniture and setting up/fashioning oxygen concentrators, suction devices, airway equipment and anaesthetic delivery systems. They may need to procure and stock anaesthetic consumables, pharmaceuticals, paperwork and protocols for antibiotic, venous thromboembolism prophylaxis and development of acute pain protocols. (BJA/WHO)

CONDUCT

General Anaesthesia

Inhalational Anaesthetic Agents

In the conflict setting there are considerable issues with access to compressed gases, including oxygen, such as the weight of cannisters and the inherent risk of carriage and storage of such gases in an area prone to the use of high and low explosive ordinance. Therefore, oxygen concentrators are preferred. However, these require electricity to function and deliver oxygen at just over one bar (not sufficient for Boyles type anaesthetic machines). Draw-over can be advantageous in this context: this continues to work in the absence of electricity, economical oxygen consumption (1L/min-1 = FiO₂ of 0.3), it is not possible to give a hypoxic mixture so inspired O₂ monitor is less vital, and they are non-rebreathing circuits so agent monitoring is

not essential.⁹ Unfamiliarity with such equipment can be addressed with pre-deployment training.

I.V. Anaesthesia

Total intravenous anaesthesia (TIVA) has logistical and pharmacological benefits over inhalational anaesthetic agents in areas of conflict. Logistically, TIVA requires very little equipment to administer a general anaesthetic. Whether using a bolus technique or a continuous infusion through a pump, TIVA can be employed without the use of an anaesthetic machine.¹⁰ Most anaesthetists from well-resourced health care systems are familiar with running TIVA on a daily basis. Several syringe infusion pumps available on the market are quick to set up, and simple to operate. Most run reliably on batteries for several hours and are easily packed into a backpack. Battlefield trauma patients often require multiple surgical interventions with intermittent intensive care stabilisation. With TIVA the battlefield trauma patients can be maintained on the same intravenous medications, although at decreased doses, throughout the intensive care unit period. Although the majority of resource wealthy clinicians administer propofol TIVA via a target-controlled infusion technique (TCI) or infusion protocols, propofol has many undesirable pharmacologic and pharmacodynamic properties in these settings. Propofol anaesthetics require quite a large volume of propofol that must be transported to the conflict zone. Limitations on its safe exposure time due to the high lipid content and microbial proliferation may result in iatrogenic infections and waste in resource poor settings. Propofol causes respiratory depression and apnoea is common in contrast to ketamine. This becomes important when the electricity and therefore oxygen supply is unreliable. In addition, owing to the narrow therapeutic index between hypoventilation and apnoea this may pose unnecessary risk to the patient when teams are frequently working alongside local anaesthetic nurses and officers who have a lot of experience monitoring people receiving ketamine anaesthesia but not propofol and do not always have the skills to reliably recognise and manage airway obstruction, hypoventilation and apnoea. The same points apply to the recovery room. In contrast, ketamine comes in high strength ampoules one of which will be sufficient for several anaesthetics. Ketamine remains one of the preferred options for intravenous anaesthesia in undesirable situations¹¹⁻¹⁵: it has analgesic effects that avoid the use of opioids



Figure 5 – NATO surgical team in action at a Role 3 medical facility in Afghanistan

during the surgical intervention; it can be used for almost all types of surgery; and as laryngeal reflexes are not totally suppressed, it allows performing some interventions without intubation (e.g. where anaesthesia providers are not highly skilled, TIVA with ketamine and without intubation is used for Caesarean sections). It should be acknowledged that the main concern in disasters and armed conflicts is haemorrhagic shock (from trauma, obstetric or visceral origin), and the effects of ketamine on the cardiovascular and respiratory systems can only be positive in this setting. Finally, ketamine also provides good postoperative analgesia whereas propofol does not. This is important as transport of opioids into conflict zones can be delayed because of customs restrictions. For all these reasons most experienced disaster response teams (such as MSF and the ICRC) rely heavily on ketamine anaesthesia.^{11,15} During the MSF response to the Haiti earthquake 90% of general anaesthetics were carried out under ketamine with only 10% of patients receiving inhalational general anaesthesia.⁷ Trauma patients often remain intubated following damage control surgery through the resuscitation and may be transferred to higher level care or remain in an ICU setting prior to return to the operating theatre. Continuous infusions of anaesthetic agents, analgesics and relaxants enables safe transfer of these patients with stability and comfort with minimal equipment. The advantages of TIVA over inhalational anaesthesia in the combat setting have been summarised by the “Four S’s”: simple, safe, scientific, and small logistical footprint. Importantly, most anaesthetists from high resource settings will not have had much experience with ketamine anaesthesia so pre-deployment training is required.

Regional Anaesthesia:

Consent: Given the likelihood of language barriers in areas of conflict it is important that a local speaker is present and reasonably prepared to explain the risks and side effects of regional techniques to avoid patient concern regarding the loss of sensation and function post regional and also equally important throughout the case to ensure the patient is not experiencing pain.

Spinal:

Spinal anaesthesia should be considered for any patient requiring surgery below the umbilicus, who is not shocked. If performed correctly, it is safe and effective and oxygen availability is not an absolute requirement. However appropriate resuscitation equipment and expertise must be available in the event of an adverse outcome.

Epidural:

In Afghanistan where significant numbers of bilateral amputations were seen in military trauma, the use of epidural analgesia allowed anaesthetists the ability to extubate trauma patients in country. This reduced the requirement for ventilation during transport to higher levels of care reducing the risk of pulmonary injury along with the added advantages of post op pain relief and potential benefits in psychological care and reduction of chronic pain.¹⁶

Regional blocks:

Regional anaesthesia is safe, effective and efficient, and doesn't require oxygen therapy. It is however underused in many settings despite its obvious utility in surgical management of limb trauma. Its increased use has been advocated by several reports and clinician experience,^{17,18} access to appropriate needles and ultrasound are likely confounding factors in its scarcity at present. Surgeries may be performed under regional block alone, although the nature of the injuries covering more than one site often means that it needs to be combined with general anaesthesia. It is still very useful in this context however as it reduces the amount of general anaesthesia required with speedier, safer recovery, whilst also improving post operative analgesia.

Postoperative analgesia

Logistical supply chain and customs issues can result in restricted supplies of analgesic medications and inadequate patient monitoring as a result of overwhelming patient numbers in massive casualty events. Regional techniques as previously mentioned are underused, but their efficacy and safety are well established.^{16,17,18} The WHO/ICRC recommends such techniques for management of limb injuries and most EMT deploy with ultrasounds. (BJA)

Pre-deployment:

Military anaesthetists have a long pre-deployment training pathway starting with their respective fellowship, and with an emphasis on military skills related to their specific role. Pre-deployment training includes additional skill training and team training. This pathway ensures ongoing and continuing competence on an individual basis, and assurance that team management systems and clinical staff can function effectively as a deploying unit.¹⁹ Training and drills to incorporate CBRN threat should be addressed where a credible threat exists.

Deployment:

Safety of Anaesthesia providers:

Working in these environments is extremely risky not only for the patients but also for those who deploy in order to provide medical assistance. Such risks should be acknowledged and mitigated by deploying organisations. Most western militaries have robust processes to deal with this issue, including but not limited to: pre-deployment training, situational briefings, an understanding of the belligerents (aims, tactics, languages spoken, religious and ideological foundations) and non-combatants customs (those to abide by and those to avoid), security and safety of staff deploying in country and rigorous rehearsal prior to putting boots on the ground. Simple measures can enhance the ability of medical teams to function well whilst also avoiding unnecessary risks. Certain theatres will also

have specific endemic disease which deploying teams should be vaccinated against where possible, have appropriate pharmacological and non-pharmacological prophylaxis when required and the appropriate knowledge of how to manage such disease in the native population. Any clinician deploying should have a list of questions for their respective organisation: is there someone on the team with responsibility for safety and security; what are the identified risks for this context; what has been done to mitigate these risks; what is the plan if one of these risks occurs; and does the benefit of the team being deployed outweigh these risks? If your deploying organisation is unable to answer these questions then you should think carefully before deploying. Potential risks depending on the context include: infectious diseases, transportation accidents, natural disasters, robbery, kidnap, and violence against the team as collateral damage and intentional targeting of the team.

Returning Home:

The psychological impacts of working in such contexts can be significant and although experiences may vary, so do the responses to a specific event between clinicians. It is well documented amongst returning soldiers that there is often a stress reaction to returning to their pre-conflict existence. Many military organisations use a multipronged approach to address this inevitable phenomenon, including decompression time at an intermediary location away from the stress of deployment but not at the home location, psychological health programmes pre, intra and post deployments. The content of these programmes should include specific briefing for the deployment (expectations), education on how to minimise stress and maximise resilience on deployment and management of re-entry, post-deployment debriefing (immediate and delayed), recognition of abnormal stress reactions and routes for getting help.

CONCLUSION

Conflict results in significant logistical challenges for anaesthetists and EMTs alike. Geographical, social, cultural, and local health care infrastructure circumstances are unique to different theatres of war as are the prevailing injury patterns seen for a given conflict. Although the more things change, the more they stay the same and the recognition and immediate management of catastrophic haemorrhage and timely access to life saving surgery remains universal. Preparation for the different contexts that anaesthetists may be utilised in, is vital for an effective response. Well-established programmes such as the WHO EMT initiative and readily deployable Military forward surgical teams have improved the speed, coordination and quality of the international response to humanitarian crises. Clear standards of the logistics, capability of deploying teams and adequate preparation and accreditation enhance the performance of such teams. As anaesthetists have a key role in many aspects of the EMT response in areas of conflict, especially at Level 2 facilities, deploying anaesthetists should receive training for the wider scope of practice when responding to these challenging situations. Ongoing data collection and audit of these processes will help inform improvements in the international medical response to conflict, another role that the deploying anaesthetists will likely fulfil.

REFERENCES

1. Craven RM. Managing anaesthetic provision for global disasters. *Br J Anaesth*. 2017;**119**(suppl_1):i126-i34.
2. Organisation WH. Building peace in fragile and conflict settings through health 2023 [Available from: <https://www.who.int/activities/building-peace-in-fragile-and-conflict-settings-through-health>].
3. Chu E, Lubis N, Alcock R. Improving mass casualty planning in low resource settings: Médecins Sans Frontières and International Committee of the Red Cross perspective. *Br J Anaesth*. 2022;**128**(2):e92-e6.
4. Giannou CB, M. War Surgery - Working With Limited Resources In Armed Conflict And Other Situations Of Violence 2020. Available from: <https://www.icrc.org/en/publication/4105-war-surgery-working-limited-resources-armed-conflict-and-other-situations-violence>.
5. Giannou C, Baldan M, Molde Å. War Surgery: Working with limited resources in armed conflict and other situations of violence. Geneva, Switzerland: International Committee of the Red Cross; 2013. Available from: <https://www.icrc.org/fr/doc/assets/files/publications/icrc-002-4105.pdf>.
6. Vergun D. Medical Improvements Saved Many Lives During World War II 2020 [Available from: <https://www.defense.gov/News/Feature-Stories/story/Article/2115192/medical-improvements-saved-many-lives-during-world-war-ii/>].
7. Trelles Centurion M, Van Den Bergh R, Gray H. Anesthesia Provision in Disasters and Armed Conflicts. *Curr Anesthesiol Rep*. 2017;**7**(1):1-7.
8. Conflict SHI. Protecting Health Workers, Services and Infrastructure 2015 [Available from: <https://www.safeguardinghealth.org/about-coalition>].
9. Graves MW, Billings S. Draw-over Anesthesia Bringing the "Dark Art" Back Into the Light. *J Spec Oper Med*. 2018 Fall;**18**(3):125-133. doi: 10.55460/CBVV-A67P. PMID: 30222851.
10. Graves M. Total Intravenous Anesthesia in Disaster Medicine: Essentials of Disaster Anesthesia. June 2020; pp32-41. DOI:10.1017/97813161814454.005.
11. Mulvey J, Qadri A, Maqsood. Earthquake injuries and the use of ketamine for surgical procedures: the Kashmir experience. *Anaesth Intensive Care*. 2006;**34**:489-494.
12. Craven R. Ketamine. *Anaesthesia*. 2007;**62**(S1):48. doi: 10.1111/j.1365-2044.2007.05298.x.
13. Svenson J, Abernathy M. Ketamine for prehospital use: new look at an old drug. *Am J Emerg Med*. 2007;**25**:977-980. doi: 10.1016/j.ajem.2007.02.040.
14. Morris C, Perris A, Klein J, et al. Anaesthesia in haemodynamically compromised emergency patients: does ketamine represent the best choice of induction agent? *Anaesthesia*. 2009;**64**:532-539. doi: 10.1111/j.1365-2044.2008.05835.x.
15. Mercer S. The drug of war – a historical review of the use of Ketamine in military conflicts. *JR Nav Med Serv*. 2009;**95**(3): 145-150.
16. Beard DJ, Wood Paul. Pain in complex trauma: lessons from Afghanistan. *BJA Education*. 2015; **15**(4): 207-212. doi: <https://doi.org/10.1093/bjaceaccp/mku035>.
17. Buckenmaier C, Lee E, Shields C, et al. Regional anesthesia in austere environments. *Reg Anesth Pain Med*. 2003;**28**:321-327.
18. Stojadinovic A, Auton A, Peoples G, et al. Responding to challenges in modern combat casualty care: innovative use of advanced regional anesthesia. *Pain Med*. 2006;**7**(4):330-338. doi: 10.1111/j.1526-4637.2006.00171.x.
19. Wren SM, Wild HB, Gurney J, Amirtharajah M, Brown ZW, Bulger EM, et al. A Consensus Framework for the Humanitarian Surgical Response to Armed Conflict in 21st Century Warfare. *JAMA Surg*. 2020;**155**(2):114-21.