Modern warfare and its effects on 21st century medicine

Health & Medicine

Throughout history warfare has, despite its human costs, been one of the biggest drivers of the evolution of technologies and nowhere else is this more prevalent than in medicine, specifically in the treatment of trauma wounds. This is because the types of wounds found in warzones are typically on the more severe and extreme end of the spectrum of injuries due to the hostile environment and the manner and weaponry with which modern warfare is now fought. This pushing of injuries to the extremes of human survival results in greater innovations which often can be transferred back to civilian medicine.

In this essay I will be reporting on several examples of medical developments made as a result of medical treatment of trauma injuries in combat, specifically in more recent conflicts such as Iraq and Afghanistan. In conjunction with this I will be discussing the various difficulties found in the waging of modern warfare.

The Hazardous Environment of the Modern Warzone

The majority of major modern warzones are found in the Middle east. Military personnel in these theatres typically are exposed to incredibly variable fluctuations of temperature, ranging from freezing at night to 45°C+ on hot days; this is accompanied by dry and arid, dusty climates1. When soldiers operate in these environments a high standard of cleanliness is often difficult to attain, often increasing the risk of infection.

The manner of injuries found in modern combat

Currently the wars being fought nowadays are predominantly counter insurgency. This has resulted in a massive increase in injuries created by

explosives owing to the current tactic of using IED’s (Improvised explosive devises) carried out by insurgency fighters. Compared to the more traditional manoeuvre warfare this is a very visible difference, 61% of injuries due to fragmentation compared to 48% found by the US marine corps as the Iraq war transitioned to counter insurgency from manoeuvre warfare2. This is again echoed by the report that of the 2, 201 UK personnel admitted to a field hospital in which a trauma team were required due to combat injuries during operation Herrick in Afghanistan, 1st of April 2006 – 30th November 2014, 1, 164/53% of the injuries were caused by explosions (IED’s and Mines) and 974 were caused by small arms fire (Gunshot wounds and grenades)3. The main issue with these types of injury is the massive haemorrhaging, such that exsanguination (blood loss) is the leading cause of combat death4; because of this, many medical technologies created by the military are primarily designed to reduce blood loss until a patient can reach a site with adequate medical care. The secondary issue with IED warfare is that the explosion fills the wound site with various contaminants from dirt containing antibiotic resistant bacteria to chemicals left over from the IED itself as well as the shrapnel used to cause the injury in the first place4. This has resulted in the development of new techniques in cleaning wounds (debridement)

Stopping blood loss through the use of Tranexamic acid

Tranexamic acid (TXA) is synthetic analogue of Lysine, an inhibitor to the enzyme plasminogen which binds to fibrin and degrades it5, because of this property TXA can be used to prevent the breakdown of blood clots at the sight of trauma injuries in order to extend the time it takes for a trauma

patient to bleed out, increasing their chances of making it to a hospital in time.

TXA is not the only drug that has these effects, other alternatives include Recombinant factor VIIa or Aprotinin are available but have proved to be either vastly too expensive, ineffective or due to their increasing the likelihood of strokes and liver damage to dangerous to use for patients10.

Initially a civilian study, the Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage 2 (CRASH-2)6. CRASH-2 was funded by the UK NIHR (National institute for health research) and a variety of private pharmaceutical companies. It took place in several hundred hospitals in 40 countries.

After the Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage 2 (CRASH-2) study in 2010 became bogged down in controversy due to the techniques of randomisation such as badly written guidelines for when doctors taking part in the study should administer TXA and other short fallings in the handling of the study7. The UK and US military took part in the Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) study in 20128. This was a much more conclusive and statistically useful study carried out in a role 3 echelon surgical hospital in camp bastion Afghanistan from January 1st 2009 to December 31st 2010. The patient cohort in the study was 896 patients made up of NATO coalition military personnel and afghan police military and civilians who went through the hospital and required one or more unit of packed red blood cells PRBC (approximately 350mL, of which Red Blood Cell

RBC volume is 200-250mL). Patients who required over ten units of blood were assigned to a Massive Transfusion MT sub cohort). The Matters results show that the TXA group had a lower unadjusted mortality 17. 4% than the no TXA group 23. 9% with the difference being 6. 5%, despite the TXA group having a higher average injury severity score ISS9, 25. 2 against 22. 5; the MT sub cohort had even more positive results for TXA, with the TXA groups mortality rate at 14. 4% compared to non TXA at 28. 1%, a difference of 13. 7% reduction in mortality.

Because of these attributes and the clinical proof of its effectiveness TXA is now in use by many military forces around the world, particularly the US Army and British Army; but is also being pushed into more common place use for civilian first response teams and paramedics saving lives all around the world.

Stopping blood los with XSTAT applicator

RevMedX11 is a US medical technology company with strong links to the US military. In the last ten years they have worked on a product for the US military called Xstat. Xstat is a haemostatic sponge applicator syringe which can be used to directly inject a large number of small sponges into a penetrating wound such as a gunshot or shrapnel wound. These sponges will expand in contact with blood and seal up the wound, controlling blood loss.

This is an incredibly effective tool for a modern military medic as it allows rapid control over blood loss due to its well tested12 and clever design. RevMedX make two different applicators for different size wounds, the larger Xstat30 and smaller Xstat12. Applicators are kept in a sealed bag and

contain respectively and approximately 92 and 38 cellulose sponges, each of these sponges expands rapidly when it absorbs blood, giving the added bonus of applying internal pressure to the wound to restrict even more blood flow. The sponges are marked with a X shaped radiopaque marker which shows up under x-ray making removal of all sponges during debridement in hospital easier. The sponges also contain chitosan, a clotting agent commonly found on haemostatic dressings, this improves the sealing of the wound.

Unfortunately, it can only be applied to junctional wounds on the groin or axilla where a tourniquet cannot be used as easily and has not yet been proved by testing in other areas of the body. As it can cause unnecessary damage when applied elsewhere due to applying to much pressure to major blood vessels and organs. Xstat has not been tested for use on the extremities as the use of a tourniquet is a preferable method of controlling blood loss.

Xstat has been approved for use in the US by the FDA and is now currently in use in the US army. Xstat is being pushed for use in other armed forces around the world, including the British army. Xstat is also being slowly adopted for use with civilian paramedics13 especialy in the US due to the large rate of gun crime.

Only recently in 2016 the company confirmed that Xstat had been used on a human for the first time, saving the life of a coalition soldier who was shot in the left thigh, opening up the femoral artery, shattering the femur and creating a large cavity. Once the soldier had reached a forward operating

base, the surgeons present spent seven hours attempting to stop residual bleeding to no avail. Finally, the Xstat devise was used to stop the bleeding and stabilise the soldier until they could be moved to a better equipped facility where more could be done14.

Haemostatic dressings

Haemostatic dressings are wound dressings designed to by antihemorrhagic16, meaning that they not only seal the wound but stop the bleeding. The ability to do this is incredibly useful to military personnel working on the front line when potential blood loss from a wound could kill someone before they can be moved to a hospital.

The two main types of Haemostatic dressing used in various militaries are Chitosan and kaolin dressings. These where both developed for use in military but have since filtered down into common use within the civilian trauma medicine market due to the high effectiveness.

Chitosan is an organic topical agent created by the deacetylation then crushing up of chitin found in crustacean shells16. Chitosan is impregnated into a dressing and works by activating a different coagulation pathway by interacting with red blood cells and platelets to form a gel like clot in the wound17, sealing it up and stopping blood flow. This does not change or involve the normal clotting pathway for the body so is not affected by regularly used anticoagulants such as heparin19. Increasing its effectiveness as a trauma haemostat, Chitosan has been found to have both antimicrobial21 and pain reducing properties as it can block nerve endings in burn wounds22.

Chitosan was first tested for trauma in 2003 on swine15 where it was found to be incredibly effective. Chitosan is used in Gauzes such as Celox Haemostatic gauze which has been used by various militaries around the world and has now been selected in 2018 by the UK ministry of defence to be the UK armed forces primary haemostatic dressing20.

The main alternative to Chitosan dressings is Kaolin, an inorganic clay derivative that is impregnated into gauzes such as QuikClot25. It works by activating factor XII24 a protein which initiates the bodies natural coagulation cascade, (the chain reaction process of coagulation23). QuickClot was initially chosen by the US military as an effective combat gauze in preparation for the US military response following the 9/11 attacks. QuikClot initially was impregnated with Zeolite which was then replaced by Kaolin due to Zeolite reacting exothermically and giving patients second degree burns.

On the civilian market Chitosan dressings are now being deployed into a clinical setting for operations involving patients on anticoagulants such as heparin e. g. during heart lung bypass. This means that in the event of a catastrophic bleed during surgery, instead of the patient bleeding due to difficulties stopping blood that won’t coagulate at the wound, surgeons can use chitosan to trigger the alternative coagulation pathway and stop the bleeding.

Tourniquets are being brought back into the civilian world

The use of tourniquets has for many years been a cause of dispute, over correct usage and potential complications arising from incorrectly fitted or

unnecessarily fitted tourniquets. This has created much confusion in the world of trauma medicine, so much so that for many years tourniquet use was almost entirely eliminated in the civilian world. On the other hand, tourniquets have been heavily used and developed in the military world due to the larger requirements for stopping catastrophic bleeds only commonly found in armed conflicts.

Recently developed devices have taken over the military market such as the Combat Application Tourniquet CAT26 which is designed to be carried by every soldier, it is small, lightweight and designed to be easily fitted with one hand to yourself or someone else. The CAT is now in use with several major NATO militaries, including the UK and US.

With the advent of the CAT and a higher level of first aid training for non-medical military personnel such as the use of a tourniquet; many civilian trauma departments have started reintroducing the tourniquet and increasing levels of understanding of correct tourniquet use among their personnel25.

Portable blood salvage and autotransfusion

Alternatively, there are many medical innovations being transferred from the civilian world to the military world. An example of this is the portable blood salvage and autotransfusion machine27 being developed by a group of Biomedical engineers at the university of Strathclyde, Glasgow. This as yet unnamed device is a portable and durable version of the Cell saver devise commonly found civilian hospital operating rooms all around the country.