
Some areas of military trauma care are years ahead of civilian medicine (Parish 2008) and so practitioners in both areas of practice should keep up to date with evidence-based practice derived from military research (Salomone and Pons 2007).

This article describes a case study, right, of a young man who received a penetrative wound that resulted in major exsanguination, or extreme blood loss. It compares his treatment by civilian medical services, starting at the point of injury to the point of surgical intervention, with military practice and investigates whether different handling could have saved his life. Finally, the article discusses potential changes in civilian practice for managing major limb haemorrhage.

In highlighting the similarities of injuries treated in military and civilian, Marcus (2008) notes that trauma is the first cause of death and second cause of death, respectively. While civilian patterns of trauma are different to those observed in military settings, there is still much that can be learned from battlefield medicine (Middleton 2009), so it is important that these lessons are taken on board to focus and simplify civilian response efforts to traumatic injuries (Rhyne 2005).

Discussion

Use of tourniquets The appearance and application of tourniquets have changed little since they were used by the ancient Romans (Doyle and Taillac 2008) and today they are often applied by the military to control limb haemorrhage.

The use of tourniquets in the civilian sector is controversial (Rhyne 2005, American College of Surgeons (ACS) 2008), however, and there is anecdotal evidence that their application can cause nerve damage and limb ischemia.

The preferred way to control bleeding is to use direct pressure and elevation, although the ACS Committee on Trauma (2010) states that these techniques could make underlying injuries worse and that, unless there is compelling evidence to the contrary, tourniquets should be applied instead.

American military research from 2003 shows that more than 57 per cent of injuries sustained on the battlefield are penetrative and that almost
Case study

A 25-year-old man was attacked by an unknown number of assailants and sustained multiple stab wounds to the anterior and posterior areas of both thighs. An ambulance was called, and a doctor and critical-care paramedic attended to the patient promptly.

The patient was found to be in cardiac arrest, most likely due to exsanguination, so he was intubated and given cardiopulmonary and intravenous fluid resuscitation.

After about 40 minutes, the patient’s spontaneous circulation returned, a local trauma unit was alerted and the patient was transferred there. During the transfer, which took about ten minutes, staff at the trauma unit mobilised their massive transfusion protocol to ensure blood products would be available on the patient’s arrival.

Shortly after the patient arrived at the unit, he went into ventricular tachycardia arrest, secondary to hyperkalaemia (blood potassium concentration = 9.0mmol/L), but responded well to cardiopulmonary resuscitation, direct current cardioversion and insulin glucose infusion. He then received 18 units of packed red blood cells, three units of fresh frozen plasma and one pool of platelets.

By this time about one hour had passed since his injury. He was found to have an international normalised ratio of 3.4 and a fibrinogen level of 0.4g/L, and was grossly acidic.

Following discussions between the unit’s trauma team and vascular surgeons at a nearby major trauma centre (MTC), it was decided to transfer the patient to the MTC as soon as his condition was stable. Four hours after his injury, the patient arrived at the MTC and a second primary survey was undertaken. He was transfused with one unit of packed red blood cells and four units of cryoprecipitate.

The trauma team decided that he was stable enough to transfer to the computed tomography (CT) scanner, which revealed he was still bleeding from his left superficial femoral artery. The CT head images also revealed a diffuse brain injury, likely to have been caused by hypoxia.

The patient was taken to theatre for exploration of his wounds, the most significant of which was a severed left superficial femoral artery and vein, mid thigh. These vessels were ligated and a large haematoma was evacuated. There had been so much swelling to his leg that the man had developed compartment syndrome, so a fasciotomy was also performed.

The patient was transferred to an intensive trauma unit in the MTC, where his condition deteriorated and he died.

50 per cent of such injuries involve the upper and lower extremities (Heiskell et al 2007).

Marcus (2008) suggests that 7 per cent of US military deaths during the Vietnam War could have been prevented by timely and effective application of tourniquets; Bellamy (1984) puts this figure at nearer 38 per cent.

Kragh (2011) investigated the effectiveness of tourniquet application in 2,838 patients with limb trauma in a military field hospital in Baghdad during the Iraq conflict that began in 2003. Kragh (2011) concludes that the technique is strongly linked to increased survival rates for people with limb haemorrhage and cites five cases in which death was most likely due to failures to apply tourniquets.

Similarly, Rtshiladze et al (2011) state that, while there are risks involved with tourniquet application, they are outweighed by the benefits. They suggest that about 57 per cent of patients who died as a result of haemorrhage secondary to traumatic injury would have survived if tourniquets had been applied to their injuries pre-hospital.

In civilian settings, especially rural environments, uncontrollable limb haemorrhage can be life threatening and tourniquets can be used to good effect (Walters 2005, Marcus 2008).

There is still considerable debate about how the application of tourniquets should be introduced into wider civilian healthcare settings (Marcus 2008). Although tourniquets are found in the major haemorrhage control kits used in UK ambulances, in the author’s experience ambulance crews are reluctant to use them, in part because they think they have not been trained adequately to do so.

In advanced trauma life support, particularly in mass-casualty scenarios or dangerous environments, the traditional airway, breathing, circulation (ABC) model is being replaced by the <C>ABC model, in which <C> stands for control of catastrophic haemorrhage (Marcus 2008, Middleton 2009, Walters 2005, Marcus 2008).
ACS Committee on Trauma 2010) because such control is regarded as a time-critical life-saving intervention that should take priority over the other tasks in the model (Lerner et al 2010).

The patient in the case study had received a violent traumatic injury that resulted in major exsanguination. There was a large amount of blood on the ground and obvious stab wounds to both lower limbs, but no active bleeding. It was later speculated that this was because he had lost most of his circulating volume.

Although the ambulance crew taking the patient to a local trauma unit for stabilisation carried tourniquets similar to those used by the British military, they were not applied. As a result, there was no definitive haemorrhage control and, on his arrival at the trauma unit, the patient was massively hypovolaemic and hypothermic. He was not moved to definitive care for more than four hours, during which time he became coagulopathic.

As studies cited in this article suggest, had a tourniquet been applied early to the patient discussed in the case study, his life may have been saved.

Alternatives to tourniquets In civilian settings, direct pressure on wounds is regarded as the first step in controlling haemorrhage. Such pressure compresses blood vessels and reduces the size of the opening through which blood can flow out (ACS Committee on Trauma 2010, London Trauma Office 2012). However, in busy trauma units or emergency departments there are rarely enough personnel to apply pressure on wounds for long periods of time (Doyle and Taillac 2008, Middleton 2009).

A new generation of haemostatic agents, available in granular form or as liquids impregnated in gauze or on the surface of dressings, has become available over recent years.

The British military mainly uses zeolites, which are microporous minerals derived from volcanic rocks, and chitosan, a complex carbohydrate derived from crushed shellfish (Marcus 2008, Cox et al 2009). Zeolites absorb and react to water exothermically, potentially reaching a temperature of about 58°C, which can damage surrounding tissues (Marcus 2008, Cox et al 2009). Chitosan, meanwhile, produces no exothermic reaction and has no reported side effects.

Cox et al (2009) state that such agents are best suited to non-limb haemorrhage, where tourniquets cannot be applied. Although battlefield data show that haemostatic agents are rarely used, this could be attributed to a lack of pre-hospital documentation (Marcus 2008, Cox et al 2009).

The patient in the case study did not have any haemostatic dressing or granules applied during his care. Had they been applied in conjunction with a tourniquet, they could have served as a useful haemorrhage control.

Massive transfusion protocols A combination of factors increases the mortality rate in exsanguinating patients (Riskin et al 2009, Sweeney 2013). Often referred to as the ‘lethal triad’, these factors are acidosis, hypothermia and coagulopathy. Research suggests that about one in four patients with traumatic injury is coagulopathic on admission (Spinella and Holcomb 2009).

Sweeney (2013) states that the rate of mortality associated with massive haemorrhage would be reduced if emergency practitioners managing critically bleeding patients were guided by protocols on massive transfusion. However, because hospitals tend to follow their own such protocols, there is no consensus on one of their most important features, namely blood product-transfusion ratios (Young et al 2011).

Spinella and Holcomb (2009), citing military data, state that the best resuscitative fluid for trauma patients is fresh or whole blood with a 1:1:1 ratio of platelets, fresh frozen plasma and packed red blood cells. Blood with this ratio of components is
rarely available, however, and so blood component products are used instead (Stansbury et al 2009).

According to Fraga et al (2010), trauma patients who receive more fresh frozen plasma and packed red blood cells, but fewer platelets, are more likely to survive than those who receive the 1:1:1 ratio of components. Devlin and Gutierrez (2010) claim, however, that Fraga et al (2010) did not interpret their data correctly.

Riskin et al (2009) demonstrate that the time to transfusion is more important than the ratio of transfusion products. Zink et al (2009) show that patient outcomes improved when multiple units of blood products were transfused within six hours of injury.

Sweeney (2013) states that good patient outcomes depend on early recognition and treatment of haemorrhagic shock. Similarly, Stansbury et al (2009) say that the time between injury and transfusion is critical to improving outcomes.

In 2005, a pan-European multidisciplinary group called the Task Force for Advanced Bleeding Care in Trauma was formed to develop a comprehensive guideline for the management of patients who are bleeding following trauma. Updated in April 2013, the guideline makes several recommendations for fluid resuscitation in patients demonstrating hypovolaemic shock (Spahn et al 2013).

In developing the guideline, the task force drew on the findings of ten relevant studies, two of them from military settings. Most of these recommend the administration of multiple units of blood products but none is a randomised control study, so the task force based its guideline on dosing and continual monitoring rather than ratios of blood products.

The patient in the case study did not receive any blood products for about an hour after injury and, when he did receive them, they were not in a 1:1:1 ratio. Research suggests that he would have benefitted from early administration of transfusion products containing more clotting elements instead of the packed red blood cells he received.

**Hospitals and trauma networks should share knowledge to ensure that the care they provide is standardised, definitive and up to date**

Nessen et al (2007) describe this model as ‘damage control resuscitation’ and state that patients should be transferred to the next tier of care as soon as they are stable enough.

Hettiaratchy (2010) reviewed the UK military’s approach to systemised care and found six components that could be applied to civilian trauma networks in the UK, including front-line medical advances and adoption of a common training model.

The patient in the case study was swiftly attended by a paramedic and a doctor, and later by a critical-care paramedic, before being taken to a nearby trauma unit for initial treatment and then a trauma centre for vascular services. These staff and services can be described as a trauma network and, as Sussex Managed Clinical Networks (2012) has demonstrated, 20 per cent more patients have survived severe trauma since the relevant networks were set up. There is a question, however, about whether the patient was taken to the right location first. According to the London Trauma Office’s (2012) major trauma decision algorithm, the first destination of trauma patients should be the nearest major trauma centre (MTC). Had the patient been taken to the nearest MTC instead of a trauma unit, the drive would have taken about 40 minutes, which is less than the recommended maximum transfer time of 45 minutes but 30 minutes longer than the drive to the unit.

It is uncertain whether transfer directly to the MTC would have helped the patient, but quicker transfer from the trauma unit to the MTC would have been beneficial.

**Conclusion**

This article concludes that the patient described in the case study may have survived if he had:
- Received better haemorrhage control.
- Been transfused more quickly and received multiple units of blood products.
- Been transferred to definitive care sooner.

The length of time the patient was at the scene of injury before resuscitation is unknown, and the amount of time between initiation of care by medical responders and return of spontaneous circulation was about 40 minutes. Given the patient’s injuries, therefore, he was unlikely to have survived.

**Treatment location**

Schoenfeld (2012) discusses the US military’s five-tier model of treatment and evacuation, in which treatment begins at the point of wounding and soldiers with advanced training in first aid support airways, control major haemorrhage and initiate evacuation proceedings. Wounded personnel are evacuated to tier-two aid stations and tier-three combat-support hospitals, and then out of the theatre of war to tier-four and tier-five centres.
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While such injuries are rare in civilian life, they are often seen in theatres of war. The vast amount of clinical data collected from the military can help save the lives, not only of service men and women, but also civilians with similar patterns of injury.

New equipment is being introduced into pre-hospital settings and it is imperative that hospital staff keep up with the latest developments in trauma care. Hospitals should have their own haemorrhage-control packs and should refer to evidence-based practice to stock the most suitable adjuncts, including tourniquets and haemostatic dressings. Regular training programmes should be introduced to ensure that trauma practitioners can use relevant equipment safely and appropriately (Armstrong 2013), and major transfusion strategies should be implemented to allow rapid access to multiple blood products.

Above all, knowledge and training should be shared between hospitals and services in trauma networks to ensure that the care they provide is standardised, definitive and up to date.

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Conflict of interest
None declared

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