Global lessons: developing military trauma care and lessons for civilian practice

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Abstract

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. Implementation of the medical plan is harmonious with the NHS trauma pathway, and is key to ensuring effective delivery. Military anaesthetists have a long pre-deployment training pathway starting with a Certificate of Completion of Training (CCT) in anaesthesia and/or critical care, and with an emphasis on military skills related to their specific role. Pre-deployment training includes additional skill training, team training and finally whole hospital collective training. This pathway ensures ongoing and continuing competence on an individual basis, and assurance that hospital management systems and clinical staff can function effectively as a deploying unit.

Key words: military; simulation training; trauma

Hippocrates said that “War is the only proper school for a surgeon”. The medical advances during the recent conflicts in Iraq and Afghanistan have highlighted that the same is true for anaesthesia. In 2011 we showed that casualties were surviving their injuries when they were expected to die,1 and that year on year over the conflicts, there was an improvement in survival for any given injury severity (Fig. 1).2

It is difficult to determine what specifically these impressive results can be attributed to. It is unlikely to be any one significant factor; rather improvements are likely to be multifactorial and sequential. Figure 2 depicts how, when resources and skills are limited, even small improvements in infrastructure, logistical support and technical skills can make a significant improvement in outcomes. However, in a well-resourced, highly skilled environment such as the military medical efforts in Afghanistan and Iraq, a cumulative number of small, incremental improvements are required to deliver a substantial effect on outcomes.

Over the course of the conflicts there were a number of incremental innovations and improvements in clinical techniques and attitudes that contributed to the overall effect, and a significant effort in defining, preparing for and implementing a coherent plan for deployed trauma care. In this article we highlight three major clinical lessons and focus on the training and assurance pathway before deployment.

Catastrophic haemorrhage: the ABC paradigm shift

Haemorrhage is the biggest cause of death in military trauma,4 and the second biggest cause of death in civilian trauma after...
head injury.\textsuperscript{5} Death from haemorrhage is potentially survivable, especially if the haemorrhage is from an extremity and therefore amenable to compression.\textsuperscript{6}

In 2006 the Defence Medical Services (DMS) evolved the standard ATLS style, sequential ABC approach to trauma, to a more "simultaneous" approach with a focus on stopping catastrophic haemorrhage as a priority before focusing on the airway.\textsuperscript{7} Pre-hospital use of tourniquets was reintroduced to all military personnel and topical haemostatics issued to frontline medics. Mandatory annual training for all military personnel included battlefield casualty drills focusing on the\textsuperscript{\textless}C\textsuperscript{\textrangle}ABC approach, specifically in stopping compressible haemorrhage.

**Fig 1** From Penn Barwell et al.\textsuperscript{2} Year on year improvement in predicted probability of survival compared by the New Injury Severity Score. Shaded regions indicate the 95\% CIs for the predicted values. Reproduced with permission from reference 2. Copyright Wolters Kluwer Health, Inc.

**Fig 2** Representation of the effect of improvements in resources and skills on survival in low and well resourced medical treatment facilities. Reproduced with permission from reference 2. Copyright John Wiley and Sons.
and application of tourniquets. Undoubtedly this led to an increased number of injured casualties entering the medical chain and therefore being allowed a chance of survival. Such was the success of this paradigm shift, that a review of UK casualties who died of wounds (casualties who died after entering a military medical treatment facility) demonstrated that the majority of deaths were now as a result of head injury and not haemorrhage.

Medical emergency response teams and rapid access to surgery

The DMS adopted two key principles applicable to effective trauma care: early, senior experienced decision making is key, and bleeding can only be definitively treated by early access to surgery. The Medical Emergency Response Team (MERT) was an innovation from early in the Iraqi conflict, when it was decided to install senior decision making as part of prehospital care. The MERT is a team that includes consultants in anaesthetics or emergency medicine alongside paramedics and emergency nurses. The MERT was able to offer full pre-hospital anaesthesia, blood transfusion and sedation. In Afghanistan, the MERT was exclusively delivered by helicopter, but the concept applies to air or land delivered teams. The introduction of MERT was shown to improve survival, particularly in those with an injury severity score between 20 – 29 when compared with other prehospital systems. It is difficult to determine specifically which aspect of the MERT capability was responsible for the improvements in survival, highlighting the issue that small, sequential improvements deliver significant clinical effect (Fig. 2).

Once casualties arrived in the emergency department there was the option to move straight to the operating room, especially if the patient was in extremis and the clinical situation demanded it. This move to the operating room allowed immediate surgery as part of the resuscitative process before a full suite of diagnostic tests had been completed.

Evolution of transfusion support

In recent years there has been increasing use of major haemorrhage protocols and “haemostatic resuscitation” during trauma resuscitation. There remains debate about which ratio of blood, plasma, platelets and fibrinogen is best, or even whether resuscitation should base itself around targeted therapy using manufactured blood products. However, it is generally accepted that the use of large amounts of crystalloid solutions, and ignoring haemostatic changes associated with trauma is a mistake. There is now a body of opinion that supports the use of whole blood, plasma, platelets and fibrinogen is best, or even whether the use of crystalloid solutions was minimised and 1:1 plasma:colloid unit resuscitation was followed. The use of fibrinogen in the form of cryoprecipitate and of platelets increased in part because of the targeting of therapy using point of care viscoelastometry monitoring of coagulation. In order to achieve this a deployed platelet apheresis capability was developed and encouragement of the use of fresh whole blood donations from emergency donors during the most extreme resuscitations.

Associated with the increased use of blood products was increased use of adjuncts, for example tranexamic acid adopted after the CRASH 2 trial, and attention to the details of treatment mainly related to the metabolic storm resulting from massive transfusion.

History comes around full circle

None of these three lessons are new. During the 18th Century, Sir Gilbert Blane, Physician of the Fleet 1779–1783, introduced the use of tourniquets. He made “each man carry about him a garter or piece of rope yarn, in order to bind up a limb in case of profuse bleeding”. Rapid access to surgery and senior decision making is also not a novel idea. During the Napoleonic wars Baron Larrey deployed “flying” ambulances where he put a surgical facility on the back of a horse drawn carriage and took the surgeon to the battlefield. During the first and second world wars it was well noted that crystalloid solutions were poor resuscitation fluids when used in isolation, that plasma alone was a temporary solution to be used when logistical supply of blood was unavailable, and that whole blood was the ideal solution.

Why, therefore, did we have to relearn these lessons? During the latter part of the 20th century, the defence medical services (DMS) was not heavily involved in conflict. Military clinicians practised in civilian institutions and adapted civilian practices into their own standard of care. For example, civilian practice deemed that tourniquet use was dangerous and should be avoided. Most trauma care was delivered without immediate surgery available, and the use of enhanced diagnostics means that modern clinicians want imaging before proceeding to surgery. Blood products were supplied by blood banks configured for effective management of blood stocks and not for massive, rapid bleeding. The idea of moving away from whole blood resuscitation towards component blood products is based on maximising donated blood products for use in non-trauma situations and aiding blood stock management, rather than focusing on the needs of the bleeding patient. Civilian, non-trauma specific standards, practices and techniques are not always directly applicable to the military environment. Indeed, military trauma systems should define their own standards and philosophies and not constrain themselves to universally applying civilian standards.

In order not to forget these lessons and to prepare military clinicians, lessons from conflict must firstly be identified and learnt, and secondly, and perhaps more importantly, planned for, trained and rehearsed, as is best articulated by the well-known phrase: “proper planning and preparation prevents poor performance”.

The plan

In order to achieve satisfactory results there must be a good and fully integrated plan, from injury prevention, effective coordinated training and rapid access to highly skilled and motivated people. For the DMS this plan is known as the Operational Care Pathway (Fig. 3). Arguably there is a “pre-pathway” addition of “prevention” and a post-pathway addition of “rehabilitation”.

The operational care pathway talks about care at the point of injury in the “hot zone”, where troops are still fighting with the enemy, and medical care is limited and is described as “care under fire”. As soon as possible, the casualty is evacuated to a more permissive environment where they will receive “tactical field care” from professional medics. This is followed by tactical evacuation to a forward surgical facility (deployed hospital care forward) where damage control resuscitation will occur, before strategic evacuation to definitive care.
Prevention

Over the years personal protective equipment has improved enormously based on forensic examination of all battle injured personnel. In 2003 body armour was limited, protection of the neck and pelvis was not present, eye protection was not mandated and vehicles had less protection from roadside bombs. By the end of the campaign these had been addressed, implemented and shown to reduce the incidence of injuries.

Self-help/buddy-buddy aid

At the time of injury there is unlikely to be professional medical help immediately available. All military personnel have mandatory, yearly first aid and battlefield first aid training. Troops are taught catastrophic haemorrhage control using pressure, elevation and, if required, tourniquets and simple airway manoeuvres and assessment of breathing and circulation. This ensures that troops are competent at applying their own first aid, and also applying first aid to their colleagues, so called “buddy-buddy” aid. This training is backed up by practical, pass/fail assessment. In addition, every fourth member of a team has advanced “team medic” training. Team medics should be available within 10 min of wounding. This ensures that rapidly after injury, injured service personnel are receiving advanced first aid.

Expert help

After early, rapid evacuation from the hot zone to the more permissive “warm zone”, a casualty will see a professional medic or if possible a doctor in less than one hour from injury, although in practice the system is designed to be faster. More advanced medical training and equipment is available with the emphasis being on haemorrhage and airway control and stabilisation for tactical evacuation.

Hospital care

Hospital care is divided into forward care, with limited facilities, infrastructure and capacity to hold casualties for extended periods. This might be on land or at sea. Forward care is designed around stabilisation of trauma and medical patients with consultant delivered care. Patients will be evacuated from forward care to bigger, better resourced “deployed hospital care (rear), and finally back to the UK “role 4” hospital in Birmingham Fig. 3.

Rehabilitation

The final phase of a casualty’s journey is rehabilitation. All injured service personnel are rehabilitated at the Defence Rehabilitation Centre at Headley Court in Surrey, where they have access to physical and psychological rehabilitation. The rehabilitation of wounded service personnel has been exemplary and has managed to return a proportion of patients back to service and even to the front line.

Civilian translation

On the face of it, the military system is unique to conflict zones in austere and dangerous environments. However, excepting the care under fire aspect of casualty care, the military system and UK civilian systems are harmonious. If you compare the operational care pathway (Fig. 3) with the NHS plan (Fig. 4), they are remarkably similar. It is often said that military patients are young and fit ASA I and that UK patients are often older and sicker. This was not true in the 1990s in the UK where most trauma was in the under 45yr age group. A recent study looking at UK trauma patient characteristics describes a more recent shift from young men suffering road traffic accidents to the over 75yr olds falling from heights of less than two metres. The principles of some of the lessons from the military can still be applied, although certain aspects, for example

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**Fig 3** The operational care pathway depicts the medical response to a battle casualty. Point of injury occurs under fire in the “hot zone” where minimal lifesaving “care under fire” treatment occurs. The casualty is evacuated back towards deployed hospital care receiving ever-increasing levels of medical care. Reproduced from Reference 16.
volume resuscitation, might need to be adjusted to take into account different compliances in the elderly cardiovascular system.

This shift in patient characteristics illustrates how the "plan" is working. If in the 1990s road traffic accidents were a major cause of UK trauma deaths in young men, then prevention by the wearing of seatbelts, altered car design and lower speed limits reduced the risk such that in 2013 the proportion of road traffic accidents making up the trauma population has decreased. The plan has worked, and now the system needs to adapt to take account of changing patient characteristics.

The civilian plan also incorporates self-help and buddy-buddy aid. There are increasing number of schemes to prepare the general public for their role as the first attendees after trauma such as volunteer Ambulance Community Responders, resulting in a greater chance of good first aid care occurring immediately after injury. With increasing numbers of air ambulances, first responders and rapid access to paramedics the new guidelines for ambulance response times are that the most seriously injured should have an ambulance response within seven minutes. The development of the UK trauma system is such that rapid evacuation occurs to trauma units for stabilisation surgery, with onward evacuation to trauma centres, and finally access to the NHS rehabilitation system.

Preparation
In order to effectively deliver any plan, there must be a preparation phase. For a military trauma anaesthetist, this starts as a trainee and continues as a deploying consultant delivering care, who then returns after deployment to train the next generation. This cycle of train, deploy, deliver, recover and educate is well established within Defence with active and rapidly reactive “lessons learned processes”.

In addition to normal anaesthetic training and gaining CCT in Anaesthesia and/or Critical Care, each consultant must undertake specific service training relevant to their job as either Army, Navy or Air Force officers. The revised Royal College of Anaesthetists Higher Military Module is now mandated to qualify as a military consultant before attending the Armed Services Consultant Appointment Board, the military consultant interview. Before deployment they undertake role specific training on the Military Operational Surgical Training course (MOST), and finally undertake collective training for the entire deploying unit during the assessment and validation phases of the hospital exercises (HOSPEX). The MOST course and HOSPEX are described in some detail below to illustrate the level of training required to deliver effective deployed trauma care.

Military operational surgical training
In 2009 the Military Operational Surgical Training Course (MOST) began at the Royal College of Surgeons of England. Originally conceived as a purely surgical skills course for military surgeons about to deploy, the course rapidly evolved to provide multi-disciplinary training for the entire trauma team. The course is held over five days and now provides training for (DMS) emergency medicine physicians and nurses, anaesthetists, operating department practitioners, theatre nurses, general surgeons, orthopaedic surgeons, plastic surgeons and most recently, maxillofacial surgeons.

Separate, role specific training streams exist for the different specialties to learn specific skills that are relevant to military trauma. These clinicians with newly acquired skills are integrated into multidisciplinary trauma teams allowing them to participate in several aspects of collective resuscitation, thus delivering a common model of operation. For the duration of the course these trauma teams are based on teams that will be deployed together in order to start developing team cohesion and common mental models. The course utilises different modalities of training that includes lectures, small group work, workshops for equipment familiarisation and practical operative training using cadavers. Simulation is used extensively to deliver and reinforce learning outcomes from elsewhere on the course.

The following discussion will focus on the course delivery for anaesthetists and their interactions with the multi-disciplinary trauma resuscitation team.

The course purpose
Defence anaesthetists, when not deployed are placed in NHS Trusts throughout the UK in order to maintain their clinical skills. The content of the MOST course is designed to bridge the gap between civilian practice and the deployed military clinical environment. It achieves this by encapsulating and delivering current best practice in trauma resuscitation and anaesthesia as applied to the military environment. It also delivers core components of the higher module in military anaesthesia as part of the CCT in Anaesthetics.

As the military draw down from Afghanistan occurred, the course shifted focus from a specific land-based military operation onto the so-called “return to contingency”. The term “contingency” describes the generic preparation for military operations, the nature of which cannot be accurately predicted. Defence anaesthetists could find themselves deploying in support of maritime, land or air operations, possibly in austere and remote environments with their associated constraints on medical resources. Learning the lessons of Iraq and Afghanistan and...
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severely injured trauma casualties and the application of this
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military anaesthesia was recently reviewed by a working
group from all three Services and significant changes were
made to reflect likely future contingency operations.22 As a
direct result, changes have been made to the MOST course con-
tent to ensure mapping to the new level 3 CPD matrix. The final
aim of the MOST course is to act as CPD for consultants as part
of their three-yearly updates in order to remain operationally
prepared.

Course content and delivery
The course pays significant attention to the key developments
from recent conflicts, namely the haemostatic resuscitation of
severely injured trauma casualties23 and the application of this
to the damage control resuscitation and damage control surgery
(DCR – DCS) sequence.24 In common with the rest of the course,
this content is delivered by a mixture of didactic sessions inter-
spersed with small group work and reinforced during high fidel-
ity simulations of trauma resuscitation scenarios.

The configuration of deployed military anaesthetic equip-
ment differs from the configuration found in typical NHS hospi-
tals. Whilst all equipment is available and used in the NHS, it
may be different from the specific device found in any one con-
sultant’s host NHS trust. Therefore, familiarisation with military
equipment is one of the course’s primary aims. It is highly likely
that in a resource constrained contingency deployment draw
over anaesthesia apparatus will be used. The DMS currently
uses the Tri-Service Anaesthetic Apparatus and refresher train-
ing is included during an equipment familiarisation workshop.
Also demonstrated are infusion pumps, airway equipment,
vascular access (large bore venous, central venous and intra-
osseous), rapid infusion devices and equipment for thromboe-
lastometry used to guide the correction of coagulopathy.

The anaesthetic aspects of the course are integrated into
training with the entire multi-disciplinary team, particularly
around key decision moments. The scenarios are based on real
scenarios adapted to highlight specific learning objectives. This
approach is illustrated by the thoracic injury and thoracotomy
session. Lectures and discussion on cardiorespiratory arrest in
trauma and the management of thoracotomy are followed by the
entire course moving to the cadaveric laboratory. A “trauma alert”
is given of a casualty with a penetrating wound to the thorax. The
formed trauma teams then discuss roles and responsibilities and
prepare to receive the “casualty”. Faculty then guide the teams
through the clinical scenario. An emergency physician acting as
the trauma team leader coordinates the team. The anaesthetists
are encouraged to intubate the cadavers as they would in a real
casualty. As the clinical scenario unfolds, surgical intervention
through left anterolateral thoracotomy progressing to clamshell
thoracotomy is required. The whole team is able to interact and
discuss the case and the operative management including poten-
tial difficulties such as timing of surgical intervention, lack of
lung isolation, communication in emergency high tempo surgery,
postoperative pain management and critical care. Particular
attention is paid to the shift in leadership roles within the sce-
nario, and to key decisions and how they might impact on the
other members of the team.25

As an example of training for shifting priorities, a multi-disci-
plinary interactive workshop session is held to discuss airway
management scenarios. Suggested management algorithms are
highlighted and are used to facilitate further discussion within
trauma teams.26 A discussion around “failure to intubate drills”
occurs. During the scenario, the decision is made to perform an
emergency surgical airway. The focus of the discussion shifts
from performing a standard rapid sequence induction by the
anaesthetist, to the interaction with the surgeon who is now
taking on the airway role, and the operating department practi-
tioner who has to shift their focus from helping the anaesthetist
to helping the surgeon. The team will then practise this drill on
the cadavers focusing on the choreography that needs to occur
to ensure success.

Human factors and non-technical skills
Human factors in the context of clinical care have been
described as “enhancing clinical performance through an understand-
ing of the effects of teamwork, tasks, equipment, workspace, culture
and organisation on human behaviour and abilities and application of
that knowledge in clinical settings”.27 Non-technical skills can be
regarded as “the cognitive, social and personal resource skills that
complement technical skills and contribute to safe and efficient task
performance”.28 The importance placed on a sound understand-
ing of these so-called soft skills and the impact of human fac-
tors in medical care on deployed military operations has been
described.29 As a consequence, the role of clinical human factors
in promoting better team performance is stressed throughout
the course. In particular, this occurs during the facilitated
debrief after fully immersive, high fidelity simulated trauma
resuscitation scenarios. The scenarios are designed to reinforce
key learning outcomes elsewhere in the course and to highlight
the impact of human factors in a resource limited environment
with difficult and variable capacity for casualty evacuation.
The simulation takes place in the context of a fictionalised
multi-national military deployment to assist the host nation in
conducting counter-terrorism operations (this is evolved and
briefed throughout the week to participants). A mock-up of a
tented resuscitation bay with the same equipment as found
don deployment is used in a purpose-built simulation suite.

On the final day of the course, participants undertake a
“hybrid simulation” scenario. Beginning in the trauma bay
mock-up with a SimMan 3G mannequin, the scenario is paused
once a formal plan for surgery has been decided. The team is
then taken to a mock theatre in the cadaveric laboratory, pre-

sent with a fresh frozen human cadaver patient, and asked to
continue as planned with the surgical intervention. Real-time
monitoring is displayed, and investigations provided by the fac-
ulty on request. This hybrid simulation facilitates the entire
team’s engagement in the execution of DCR and DCS.

The final aspect of the preparation phase is to insert surgical
teams within the hospital management infrastructure. It is
pointless a surgical team operating in isolation of the manage-
ment decisions around beds, blood stock, the tactical situation
on the ground and the availability of evacuation assets. Likewise,
there is no point in the management operating a
highly efficient hospital if the net effect is no ability to operate.
Whilst the MOST course delivers military medical competency
beyond NHS practices, individuals and trauma teams also
require an understanding of, and an ability to train in, the envi-
ronment in which they are to deploy. This complex interaction
is rarely exercised in the NHS, but is crucial within the military
environment. This aspect is known as “collective training” and
occurs in two phases. There is an assessment phase six months
before deployment where areas for improvement are high-
lighted. Immediately before deployment a validation phase

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occurs where the entire facility is assessed in its ability to deliver safe, effective care.

Collective training

Collective training is delivered within the Army by the Army Medical Services Training Centre in York. A small team of exercise planners are able to deliver “whole hospital” exercises either in the field or in a bespoke hospital trainer where teams can train together in a fully immersive, simulated environment. Collective training exercises provide opportunity to understand and train system processes through the use of both clinical and military scenarios.

Whilst there is no singular definition of collective training, we adopt the four component model in how it is delivered:

1. Supportive Information – mental models and cognitive strategies
2. Part-task practice – “drill” “snow-balling”
3. Just in time info – corrective feedback, coaching, mentoring
4. Whole training tasks

Each of these components is a feature of the exercise construct. As an example, there are scenario based training serials to rehearse checklists, part task training such as reinforcing the surgical airway skills learned on the MOST course, and application of clinical guidelines supported by corrective feedback by subject matter from expert exercise support staff. There is also whole system training such as major medical incident rehearsals, which are standard for the NHS, but also situations such as fire drills, especially when you have patients on the operating table or in ICU. How do you reconfigure your small clinical team when they are involved in a major resuscitation in the operating room, and then there is a patient with anaphylaxis on the ward, another trauma patient coming in and a suicide bomber in the hospital? Some scenarios may be specific to the military, but the process around the management of these scenarios is directly relevant to the NHS and rarely rehearsed in such detail.

Validation and assurance

Training itself does not deliver assurance on its own. In order to deliver effective healthcare, potentially into very austere environments, there is a requirement to assure the training delivered. Assurance ensures systems are fit for purpose, and where risk is identified, this can be understood by stake holders and mitigated where possible. Clinical assurance is conducted alongside assurance of the medical material and logistic demands of deploying a field hospital. Assurance is attained in part through a review of competencies and training, in part through reviewing manning and equipment, and in part through the conduct of a validation exercise. The validation exercise derives assurance through testing and observation against prescribed key performance indicators, themselves derived from the collective training objectives and tailored to the mission.

Recognising the unique requirements of military trauma, and through the delivery of a validated training and assurance pathway, we can best prepare for the future, taking with us the lessons of the past. This system is highly adaptable. Recently whole hospital systems were required to develop, evaluate train and assure decontamination procedures involved in the deployment of a field hospital to deliver healthcare during the Ebola crisis in Sierra Leonne. This was achieved within three weeks of notification of the task. Applying the same principles learnt during the Iraq and Afghan Campaigns, this shift from trauma to infectious disease was rapidly achieved and was highly effective, proving that getting the planning and preparation correct ensures outstanding performance.

Conclusions

The Defence Medical Services have developed rapidly over recent conflicts. Many of the “lessons learnt” were in fact “lessons ignored”. An understanding of the differences in NHS and military practices ensures development of a coherent medical plan from point of wounding through to definitive surgery. This plan is rehearsed by all personnel involved as individual skills, small team dynamics and finally whole hospital system training. By the time a military anaesthetist deploys they are fully competent and assured to deliver trauma care.

AMATEURS TRAIN UNTIL THEY GET IT RIGHT, PROFESSIONALS TRAIN UNTIL THEY CAN’T GET IT WRONG

Authors’ contributions

Study design/planning: all authors
Study conduct: all authors
Data analysis: all authors
Writing paper: all authors
Revising paper: all authors

Declaration of interest

None declared.

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