Action Stations! 100 years of trauma care on maritime and amphibious operations in the Royal Navy

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Abstract

Over the past century trauma care within the Royal Navy (RN) has evolved; wartime experiences and military medical research have combined to allow significant improvement in the care of casualties. This article describes the key maritime and amphibious operations that have seen the Royal Navy Medical Service (RNMS) deliver high levels of support to wherever the Naval Service has deployed in the last 100 years. Key advancements in which progress has led to improved outcomes for injured personnel are highlighted – the control and treatment of blood loss, wound care, and the prevention and management of organ failure with optimal resuscitation.

Historians often point out how slowly military medicine progressed for the first few thousand years of its recorded history, and how quickly it has progressed in the last century. This reflective article will show how the RNMS has been an integral part of that story, and how the lessons learnt by our predecessors have shaped our modern day doctrine surrounding trauma care.

The First World War

The First World War centenary issue of this Journal reprinted some of the more interesting articles from the war years accompanied by a comparison with present-day practice. The experiences reported in HMS LION during the Battle of Jutland depict how trauma care was delivered in action (1). The medical organisation described bears some resemblance to today’s format, with the primary and secondary positions for medical headquarters, and casualties being cared for in locations distributed throughout the ship. The management of the casualties at these locations was very much along the lines of the Care under Fire and Advanced Field Care doctrine of current Battlefield Advanced Trauma Life Support (BATLS), with the Senior Officer cabins providing areas where the equivalent of Role 2 Advanced Resuscitation and Damage Control Surgery could take place (2). The casualty evacuation (CASEVAC) chain was complete with transfer of the wounded to the Role 3 Hospital Ship PLASSY for definitive care and repatriation to the United Kingdom (UK) (1).

Parnell, in 1915, stressed the importance of efficient training of naval ratings in first aid (3). He pleaded for the subject to be compulsory training for all naval ratings and stated that there should be a mandatory first aid examination, failure of which would prevent promotion. It was his intention that all personnel should become familiar with wound cleaning, dressing and splintage. The value of in-situ training was stressed, something that is gaining momentum in the present day with a maritime BATLS course being undertaken on HMS BRISTOL and the new Core Maritime Skills annual training requirement (4). Parnell also recognised the importance of haemorrhage control:

“Life can be saved by the arrest of haemorrhage and by the prevention of shock.”

It was the tourniquet that was utilised as an effective means when dressings alone would not suffice (3).

Trench warfare and the widespread use of machine guns, high explosives, land mines, grenades and mortars resulted in an assortment of high-energy injuries that had previously not been seen. Temporary Surgeon General George Turner, RN, noted that the clinical opportunities of the Royal Army Medical Corps (RAMC) were abundant (5):

“The opportunities of the Army surgeon have been and continue to be much greater than those of his naval brother, but at any time it is possible that a huge mass of acute surgery may fall after a big naval action on the latter’s hands.”

It was for this reason that the numerous surgical advancements made in the Casualty Clearing Stations were adapted and translated for naval use. Antoine Depage, a Belgian Army Surgeon, is credited with recognising the importance of adequate debridement of combat wounds.
Blood transfusions became possible because of the work of Oswald Hope Robertson (7-8). Laparotomies were first performed in the First World War for abdominal injuries (although mortality remained high due to inadequate resuscitation), and X-ray machines facilitated the localisation of foreign bodies, allowing enhanced wound debridement (9). Hypovolaemic shock became better understood in 1915 following work published by the Medical Research Committee of Great Britain (10). The changes in peripheral vasculature that follow haemorrhage and the importance of plasma loss, haemoconcentration, and increased capillary permeability were identified, allowing for the development of physiologically-driven resuscitation. The concept of delayed primary closure for wound management was developed, and has been described as perhaps the greatest advancement made in military surgery during the First World War (11). The requirement for rapid surgical care of war wounds was also confirmed - there was a mortality rate of 10% if evacuation occurred within one hour, compared to 75% if evacuation occurred after eight hours; another example of how our present day doctrine has been defined by lessons learned in the past (12).

Between the wars

Wound infection has been a persistent problem for combat surgeons, but this was revolutionised by the introduction of antibiotics. The 1930s saw the introduction of sulphonamide as the first antimicrobial agent, but it was initially mass-produced under uncontrolled standards resulting in unwanted side-effects and deaths (13). The discovery of penicillin by Alexander Fleming in 1928 marked the real revolution in infection control (14), but it was not until the subsequent work of Howard Florey at Oxford University that mass production of antimicrobials was possible (15). The RN played a significant role in the large-scale military distribution of penicillin by constructing the world’s first mass production factory in 1943 - based at the Royal Navy Medical School in Clevedon (16). The RN had been producing cholera and typhoid vaccines for many years, and had significant expertise in the subject (Figure 1). Initially Florey was against the RN manufacturing its own penicillin; however, he went on to recognise the contribution being made at Clevedon by directing new antibiotic research there. In 1949, the factory was taken over by the Medical Research Council, chaired by Florey, in order to develop further antimicrobial agents, most notably cephalosporin (16).

The Second World War

The Second World War is littered with examples of massive-scale operations and advances in medical care. One example, Operation NEPTUNE, the Allied invasion of Normandy in June 1944, remains the largest amphibious operation in history. The invasion fleet, under the command of Admiral Sir Bertram Ramsay, RN, was drawn from eight different navies comprising 6,939 vessels and 195,700 naval personnel; 156,000 troops were landed over a 50-mile stretch of the Normandy coast (17). The assaulting men landed under heavy fire from machine-gun emplacements; the shore was mined and covered with obstacles, making advancement difficult and dangerous. It was inevitable that there would be a large number of casualties, and indeed casualty estimates were 2600, with 10,950 expected over the following week (18). Emergency medical care was provided by a combination of the RNMS and the RAMC. Medical planners had decided that the majority of casualties would be evacuated to the UK for definitive care in the same crafts from which the troops were landed, the Landing Craft Tanks (LCTs), depicted in Figure 2 (19). Hospital ships were available, although there was nowhere to come alongside; moreover, the Germans had already shown disregard for the Geneva Convention by sinking two in 1940 (20).

The RNMS was responsible for manning 40 of the 70 LCTs, providing a surgeon, an anaesthetist, and a medical officer trained in resuscitation, as well as sick berth attendants in each craft. The remaining 30 craft were manned by RAMC personnel. Each LCT was modified for the purpose of casualty evacuation and supplied with medical equipment, drugs, resuscitation apparatus and blood products. Emergency operating theatres were constructed at the...
rear of each craft to allow critical surgery to be performed during the return to the UK, providing a modern-day Role 2 afloat equivalent (19).

With no medical foothold ashore at the beginning of the assault, the RNMS personnel on each of the LCTs took responsibility for care up to the shoreline. Treating and collecting casualties from the water meant that they were constantly under sustained enemy fire (18). Surgeon Lieutenant Airth wrote in his diary on the day of the invasion (21):

“This has indeed been D-Day; Dawnd- Day, Death-Day, Destruction-Day, Disappointment- and Disillusion-Day. I have seen men die suddenly, horribly. I have twice been near death myself, so near that I desperately wish to forget but probably will never do so.”

Despite the seeming chaos, RNMS personnel managed to successfully treat and save the lives of hundreds of casualties. Op NEPTUNE provided a setting where the RNMS could put into practice the advances made in trauma care over the preceding years. In the first stages of the campaign, from 6 June to 20 June 1944, British casualties totalled 13,572, yet only 1,842 of these died (18). The use of improved methods of resuscitation, including a reliable supply of blood and blood products, the availability of antibiotics to prevent and treat infections, and improved means of transportation over land, air and sea between treatment facilities, allowed for significantly improved medical care.

The post-war period
After the Second World War, economic constraints and hardship forced a reduction in the size of the RN. Despite this, several RN warships, including an aircraft carrier, were on station throughout the Korean War (1950–1953). This conflict saw casualties being airlifted from the battlefield to Mobile Army Surgical Hospitals (MASHs), resulting in reduced times from point of injury to definitive medical care. US Army helicopters evacuated a total of 21,658 casualties during the fighting and contributed significantly to achieving the lowest mortality rate for the wounded in any war to that time (2.4%) (22). The performances of the MASHs in Korea confirmed that surgical treatment should be conducted as rapidly (and therefore as far forward) as possible to reduce the time from point of wounding to surgical intervention (between two and four hours was achieved) (12). Other notable advancements made in Korea included the introduction of techniques of vascular repair, with direct anastomosis and vein grafts resulting in a reduction in limb amputation rates (9). Haemodialysis was used to treat severe acute kidney injury in trauma patients for the first time (23). The Vietnam War (1959–1975) allowed continued advancement in the management of combat casualties, with helicopter evacuations further reducing times from point of wounding to surgical care to between one and two hours (12).

The Falklands War
In 1982 Argentine forces invaded the Falkland Islands. The subsequent campaign to recover them committed the RNMS to support an operation 8,000 miles from the UK on a scale unknown for a generation. The Deputy Medical Director General (Navy) at the time, Surgeon Commodore GJ Milton-Thompson, RN, gives a detailed account of the role of the RNMS during the Falklands Campaign (24). Medical Service doctrine had developed in the light of the experience of others, particularly the Americans in Korea and Vietnam. At least one medical officer with supporting medical assistants would be required in every ship providing Role 1 and primary healthcare support; surgical teams were stationed in capital ships and Royal Fleet Auxiliaries (RFAs) providing Role 2 care. Commando-trained medical officers and medical assistants with surgical teams would

Figure 2. LCT Mark III © IWM (A 10061)

Figure 3. The disused refrigeration plant at Ajax Bay that was used as a field hospital by British forces © Crown copyright.
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support 3 Commando Brigade (3 Cdo Bde) ashore – the heroic accounts of the Red and Green Life Machine medical treatment facility at Ajax Bay are well documented (Figure 3) (25). The overall aim was to provide early resuscitation of casualties, ensuring the ready availability of blood, the effective treatment of burns and the rapid evacuation of patients to achieve emergency surgery within six hours (24). These aims were all achieved.

Milton-Thompson noted the importance and value of hospital ships. Effective casualty care could only be established by setting up a hospital at sea, near the conflict, to allow stabilisation of casualties before repatriation to the UK. SS CANBERRA and UGANDA were, therefore, taken up from trade and used as medical facilities; the latter at the time was a P&O educational cruise liner taking school children around the Mediterranean (24). At the time, no clear picture existed as to what was required of a hospital ship, although much was known of the staffing and storing on HMHS Maine during the Korean war; but medicine had advanced since then. Stores were based in the Army’s 200-bed field hospital, to which specialist essential items were added by respective departments. 792 units of blood were transferred to UGANDA and the QUEEN ELIZABETH 2 as they proceeded south (24), and an additional 1,000 half-litre bags were collected from troops on CANBERRA during the early part of the deployment (25). The operational plan positioned UGANDA within helicopter range of the dressing stations and the medical treatment facility at Ajax Bay. Hecla-class survey vessels would then transfer stabilised patients from UGANDA to Montevideo, from where they would be transported back to the UK by the Royal Air Force (24).

The transit to the South Atlantic allowed time for preparation, and the traditional reluctance to release men for first aid training receded (24). Preparations at sea included sorting and adding to medical stores and equipment, checking the health of the ship’s company, training personnel, both medical and non-medical, in first-aid, and setting out the health of the ship’s company, training personnel, both medical and non-medical, in first-aid, and setting out the medical organisation for action (24). Major David Wheen, Royal Marines, (RM), later wrote:

“...each man learned the treatment for trauma, wounds, burns; and having spent the winter in Norway was well aware of the treatment for all cold weather injuries. We also practiced treating everyday injuries as well as battle wounds and learned how to suture.” (26)

The embarked surgical teams undertook additional specialist training in the form of regular tutorials. Videos and excerpts from a consignment of Vietnam and Korean War medical training films were viewed; these provided practical and realistic advice of managing battlefield trauma (25).

During the conflict, the casualty figures were lower than expected; 105 killed and 145 wounded in the RN, 26 killed and 112 wounded in the RM (24). Almost all of those who were injured and reached medical attention survived. Of the 508 British casualties received at Ajax Bay, only three subsequently died, which demonstrates a real measure of the quality of medical support provided by the RNMS (25). The principles of trauma surgery that were first learned in the First World War were reinforced, with early surgical debridement and delayed primary suture practiced in earnest. Other lessons learnt about the management of severe trauma and burns, particularly the value of adequate fluid resuscitation, blood transfusion and of intensive care, were also applied to good effect.

The Gulf War

The first Gulf War, Op GRANBY (1990-1991), saw the RNMS deploy on board RFA ARGUS for the first time as a medical capability, and also resulted in a humanitarian mission in Northern Iraq, led by 3 Cdo Bde medical elements. Thankfully the casualty load was light, but important lessons were learnt about the Primary Casualty Receiving Facility (PCRF), which led to a major refit and improvement in capability before it deployed again in anger (27).

Recent conflicts

For the last decade the RNMS has been engaged in operations in Iraq and Afghanistan, along with more recent operations in Libya and maritime counter-piracy in the Indian Ocean. Much of the work undertaken has been in support of deployed Army field hospitals, although the RNMS deployed again as the PCRF on ARGUS during Op TELIC 1, and led three medical operational deployments in support of 3 Cdo Bde tours on Op HERRICK 5, 9 and 14.

The Care under Fire and Advanced Field Care elements of BATLS now re-iterate attending to the basics of medical treatment in order that a casualty may survive until transfer to a higher level of care. Through combat experience the traditional Airway-Breathing-Circulation (ABC) assessment system has been modified to <C>ABC (where <C> denotes catastrophic haemorrhage) (28). Change has focused on achieving haemostasis by using the tourniquet and modern haemostatic agents in order to prevent exsanguination (29). In today’s RN, all medical and non-medical personnel are trained in the use of tourniquets, acting as a primary responder at the point of wounding, utilising a simple device (the combat application tourniquet, CAT) that has been proven to save lives.

A further advancement has been in fluid resuscitation and the practice of permissive hypotension until formal surgical control of haemorrhage can be obtained (29). Although commonly utilised during the Vietnam conflict, and subsequently adapted to civilian practice in Advanced
Trauma Live Support (ATLS) courses, there has never been evidence that demonstrates a survival advantage when administering large volumes of crystalloid to trauma patients in the pre-hospital setting (30). Indeed, aggressive crystalloid administration may cause haemodilution and elevation of blood pressure causing the clots to dislodge, resulting in re-bleeding. Current BATLS doctrine teaches that fluids should only be administered in the event of the casualty losing palpable peripheral pulses, which equates to a systolic blood pressure of approximately 90mmHg (29).

Since the 1830s fluids have been administered intravenously, but in the severely-shocked patient it is not always possible to gain intravenous access. An alternative used during the First World War was the rectal route, although never on a large scale (31). With increased understanding of the concept of resuscitation, the importance of obtaining quick and reliable vascular access has become apparent. Drinker first documented the intrasosseous (IO) route for vascular access in 1922, confirming that substances infused into the bone marrow are quickly absorbed into the central circulation (32). IO infusions in adults were used extensively during the 1930s and 1940s, when a sternal puncture kit for bone marrow infusions was a common component of emergency medical supplies (33). During the Second World War, IO infusion was used by medical personnel to resuscitate patients in haemorrhagic shock (34); however, after the war the use of the technique declined when those with the requisite skills to teach it returned to civilian life (35). IO access has subsequently seen a resurgence during modern day conflicts (36), and since 2006 the Defence Medical Services have been successfully using the EZ-IO and FAST1 devices as a means of obtaining circulatory access (37-38). This has now translated into civilian practice, with most civilian pre-hospital and emergency services employing this capability.

We have learnt over the last 100 years that rapid evacuation from point of wounding to the next level of medical care is vital in improving survival rates. The use of helicopters as casualty evacuation platforms in recent conflicts was paramount, due to the difficult terrain and asymmetrical war fighting. The UK employed a Medical Emergency Response Team (MERT) for in-country evacuations during the Afghanistan campaign, allowing advanced resuscitation of the patient to be initiated at the earliest possible moment. In order to address the lethal triad, the MERT provided aggressive intervention with blood products to prevent shock and acidosis, administration of fresh frozen plasma to correct coagulopathy and casualty warming to prevent hypothermia (39). Evidence from the MERT demonstrates that the presence of a physician-paramedic team, skilled in airway management, working alongside a trained trauma team, with the availability of blood products, improves outcomes for injured personnel (40). This has now been adopted for maritime use with the concept development of Maritime in-Transit Care (MiTC), which has now been used on operations for the first time on Op GRITROCK, based on RFA ARGUS and co-located with the PCRF.

After a decade of operations in Iraq and Afghanistan, the knowledge and abilities of the surgeons in the RNMS are at a high point. The concept of damage control surgery has been adopted, drawn from the maritime environment where damage control is the emergency management of a situation that may cause the sinking of a ship. In damage control surgery, priority is placed on control of haemorrhage, with prevention of contamination and debridement of devitalised tissue (39). In an editorial in this Journal, it was highlighted that the introduction of thromboelastometry (ROTEM) and the use of tranexamic acid as an adjunct to massive blood transfusion protocols have now successfully been implemented, contributing to a significant improvement in the care of major trauma patients (41). Focused damage control operative procedures, coupled with optimal damage control resuscitation, have allowed patients who might previously have died to survive and be repatriated to the UK for definitive care.

Conclusion

During the last century, RNMS personnel have deployed repeatedly and consistently to provide medical care for UK and Allied military forces, tasked with missions ranging from all-out war to regional conflicts and humanitarian operations. The doctrine surrounding trauma care has not changed substantially over the past 100 years, with emphasis on rapid control of haemorrhage, safe and quick evacuation from point of wounding, and timely damage control surgery. Doctrine is viewed as the fundamental belief about the best way to complete a task or perform a mission. It is what one generation teaches the next, and is therefore strongly rooted in history. We, the present-day RNMS, should take note of the experiences of our predecessors over the past century, as we have contributed to a significant improvement in trauma care. It is vital that this progression is continued over the next century to ensure that maritime medical support is delivered both afloat and ashore to the highest possible standard.

References
33. Morrison GM. The initial care of casualties. Am Practitioner 1946;1:183-84

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